



BUILDING SYSTEM STANDARDS AND DESIGN GUIDE

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General

Division 01 – General Requirements

Division 02 – Existing Conditions

Division 05 – Metals

Division 07 – Thermal and Moisture Protection

Division 08 – Openings

Division 09 – Finishes

Division 10 – Specialties

Division 11 – Equipment

Division 14 – Conveying Equipment

Division 21 – Fire Suppression

Division 22 – Plumbing

Division 23 – Heating, Ventilating, and Air Conditioning (HVAC)

Division 25 – Integrated Automation

Division 26 – Electrical

Division 27 – Communications

Division 28 – Electronic Safety and Security

Division 32 – Exterior Improvements

Division 33 – Utilities

Division 41 – Material Processing and Handling Equipment

Appendix A – Laboratory Design Standard 2024

Appendix B – Telecommunications and Data System Components

Appendix C – Luminaire Standards



TABLE OF CONTENTS
Section Number and Title

Page No.

I.	GENERAL	1
	A. Introduction	1
	B. Definitions.....	2
	C. Processing of Work – Prime Professional	3
	D. Processing of Work – Prime Contractor.....	4
	E. Drawings and Specifications Format.....	5
	F. Submission Requirements	7
	G. Climate and Sustainability.....	9
	H. Conservation of Energy.....	10
	I. Construction Waste Management and Disposal	13
	J. Noise and Vibration Control	15
	K. Temperature Control Requirements	17
	L. Utilities	18
	M. Abandoned Equipment and Materials	20
	N. General Considerations – Prime Professional	21
	O. General Considerations – Prime Contractor.....	24
	P. Design Build Projects.....	29
	Q. Pre-Purchased Equipment	29
	R. Space Management	32
II.	DIVISION 01 – GENERAL REQUIREMENTS	33
	01 24 13 Value Engineering.....	33
	01 35 00 Special Procedures	33
	01 45 33 Code-Required Special Inspections and Procedures	33
	01 56 26 Temporary Fencing: Construction Fence Screen Mesh Fabric.....	33
	01 58 00 Project Identification: Construction Project Sign	34
	01 79 00 Demonstration and Training.....	34
	01 91 00 Commissioning.....	35
III.	DIVISION 02 – EXISTING CONDITIONS	39
	02 24 00 Environmental Assessment	39
IV.	DIVISION 05 – METALS.....	41
	05 12 00 Structural Steel Framing.....	41
	05 51 33 Metal Ladders.....	41
	05 52 13 Pipe and Tube Railings.....	41
V.	DIVISION 07 – THERMAL AND MOISTURE PROTECTION	42
	07 05 53 Fire and Smoke Assembly Identification	42
	07 13 00 Sheet Waterproofing.....	42
	07 26 00 Vapor Retarders.....	43
	07 27 00 Air Barriers.....	43
	07 52 16 Styrene-Butadiene-Styrene Modified Bituminous Membrane Roofing	43
	07 71 00 Roof Specialties.....	43
	07 72 13 Manufactured Curbs	44
	07 84 00 Firestopping.....	44
VI.	DIVISION 08 – OPENINGS.....	46
	08 71 00 Door Hardware	46
VII.	DIVISION 09 – FINISHES	54
	09 51 00 Acoustical Ceilings.....	54
	09 62 00 Specialty Flooring	54
	09 68 13 Tile Carpeting.....	55
	09 91 00 Painting	55



TABLE OF CONTENTS
Section Number and Title

Page No.

VIII.	DIVISION 10 – SPECIALTIES	56
	10 14 19 Dimensional Letter Signage	56
	10 14 26 Post and Panel/Pylon Signage	56
	10 18 00 Informational Kiosks	56
	10 28 00 Toilet, Bath, and Laundry Accessories	56
	10 44 16 Fire Extinguishers.....	57
IX.	DIVISION 11 – EQUIPMENT	58
	11 53 00 Laboratory Equipment.....	58
	11 53 13 Laboratory Fume Hoods.....	58
X.	DIVISION 12 – FURNISHINGS	60
	12 35 53 Laboratory Casework	60
XI.	DIVISION 14 – CONVEYING EQUIPMENT	61
	14 08 20 Commissioning of Elevators	61
	14 20 00 Elevators.....	63
XII.	DIVISION 21 – FIRE SUPPRESSION	65
	21 00 00 Fire Suppression	65
	21 05 48 Vibration and Seismic Controls for Fire-Suppression Piping and Equipment	67
	21 05 53 Identification for Fire-Suppression Piping and Equipment	67
	21 08 00 Commissioning of Fire Suppression.....	68
	21 10 00 Water-Based Fire-Suppression Systems.....	71
	21 13 16 Dry-Pipe Sprinkler Systems	72
	21 13 19 Preaction Sprinkler Systems.....	72
	21 20 00 Fire-Extinguishing Systems.....	72
	21 31 13 Electric-Drive, Centrifugal Fire Pumps.....	72
	21 31 16 Diesel-Drive, Centrifugal Fire Pumps	75
XIII.	DIVISION 22 – PLUMBING	80
	22 05 00 Common Work Results for Plumbing	80
	22 05 13 Common Motor Requirements for Plumbing Equipment.....	81
	22 05 19 Meter and Gages for Plumbing Piping	82
	22 05 29 Hangers and Supports for Plumbing Piping and Equipment	83
	22 05 48 Vibration and Seismic Controls for Plumbing Piping and Equipment	84
	22 05 53 Identification for Plumbing Piping and Equipment.....	84
	22 07 19 Plumbing Piping Insulation	85
	22 08 00 Commissioning of Plumbing	86
	22 11 16 Domestic Water Piping	88
	22 11 19 Domestic Water Piping Specialties	89
	22 13 16 Sanitary Waste and Vent Piping.....	90
	22 15 19 General Services Packaged Air Compressors and Receivers	91
	22 33 00 Electric Domestic Water Heaters	98
	22 34 00 Fuel-Fired Domestic Water Heaters	99
	22 42 00 Commercial Plumbing Fixtures.....	100
	22 45 00 Emergency Plumbing Fixtures	101
	22 47 00 Drinking Fountains and Water Coolers	102
	22 61 00 Compressed-Air Systems for Laboratory and Healthcare Facilities.....	102
	22 62 00 Vacuum Systems for Laboratory and Healthcare Facilities	108
	22 63 00 Gas Systems for Laboratory and Healthcare Facilities.....	110
	22 67 00 Processed Water Systems for Laboratory and Healthcare Facilities	111
XIV.	DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)	116
	23 01 30.51 HVAC Air Distribution System Cleaning	119
	23 05 00 Common Work Results for HVAC	119
	23 05 13 Common Motor Requirements for HVAC Equipment.....	120
	23 05 16 Expansion Fittings and Loops for HVAC Piping	122
	23 05 19 Meters and Gages for HVAC Piping.....	123



TABLE OF CONTENTS
Section Number and Title

Page No.

23 05 29	Hangers and Supports for HVAC Piping and Equipment	124
23 05 33	Heat Tracing for HVAC Piping.....	125
22 05 48	Vibration and Seismic Controls for HVAC.....	127
23 05 53	Identification for HVAC Piping and Equipment	139
23 05 93	Testing, Adjusting, and Balancing for HVAC.....	140
23 07 13	Duct Insulation	141
23 07 16	HVAC Equipment Insulation	142
23 07 19	HVAC Piping Insulation	143
23 08 00	Commissioning of HVAC	145
23 11 23	Facility Natural-Gas Piping.....	148
23 21 13	Hydronic Piping	149
23 21 16	Hydronic Piping Specialties	157
23 21 23	Hydronic Pumps.....	159
23 22 13	Steam and Condensate Heating Piping.....	160
23 22 16	Steam and Condensate Heating Piping Specialties	168
23 23 00	Refrigeration Piping	170
23 23 23	Refrigerants	170
23 25 00	HVAC Water Treatment	171
23 31 00	HVAC Ducts and Casings	173
23 33 00	Air Duct Accessories.....	176
23 33 19	Duct Silencers	178
23 34 13	Axial HVAC Fans	178
23 34 16	Centrifugal HVAC Fans	178
23 34 23	HVAC Power Ventilators.....	180
23 36 00	Air Terminal Units	181
23 36 00.1	Fume Hood and Laboratory Fume Hood Controls	181
23 36 00.2	Air Quality Monitoring System.....	182
23 37 13	Diffusers, Registers and Grilles.....	184
23 38 13	Commercial-Kitchen Hoods.....	185
23 38 16	Fume Hoods	186
23 41 00	Particulate Air Filtration.....	186
23 52 00	Heating Boilers.....	187
23 57 00	Heat Exchangers for HVAC.....	189
23 63 13	Air-Cooled Refrigerant Condensers	190
23 64 16	Centrifugal Water Chillers	191
23 64 26.13	Air-Cooled, Rotary-Screw Water Chillers	191
23 65 00	Cooling Towers	192
23 72 00	Air-to-Air Energy Recovery Equipment	193
23 74 13	Packaged, Outdoor, Central-Station Air-Handling Units	194
23 74 33	Dedicated Outdoor-Air Units	196
23 75 13	Custom-Packaged, Outdoor, Central-Station Air-Handling Units	196
23 81 23	Computer-Room Air-Conditioners.....	197
23 81 26	Split-System Air-Conditioners	197
23 81 46	Water-Sources Unitary Heat Pumps.....	198
23 82 14	Chilled Beams	199
23 82 16	Air Coils	201
23 82 19	Fan Coil Units	203
23 82 36	Finned-Tube Radiation Heaters.....	203
23 82 39	Unit Heaters.....	203
23 84 13	Humidifiers.....	204



TABLE OF CONTENTS
Section Number and Title

Page No.

XV.	DIVISION 25 – INTEGRATED AUTOMATION	206
	25 00 00 Integrated Automation.....	206
	25 05 48 Vibration and Seismic Controls for Integrated Automation	207
	25 08 00 Commissioning of Integrated Automation	207
	25 12 00 Integrated Automation Network Gateways	209
	25 35 00 Integrated Automation Instrumentation and Terminal Devices for HVAC.....	212
	25 50 00 Integrated Automation Facility Controls	216
XVI.	DIVISION 26 – ELECTRICAL	222
	26 05 00 Common Work Results for Electrical	222
	26 05 48 Vibration and Seismic Controls for Electrical Systems.....	226
	26 05 53 Identification for Electrical Systems	227
	26 08 00 Commissioning of Electrical Systems	227
	26 09 23 Lighting Control Devices	230
	26 13 26 Medium-Voltage Metal-Clad Switchgear	232
	26 29 23 Variable-Frequency Motor Controllers	234
	26 32 13 Engine Generators	235
	26 32 13.13 Diesel-Engine-Driven Generator Sets	237
	26 32 13.16 Gas-Engine-Driven Generator Sets	246
	26 41 00 Facility Lightning Protection.....	256
	26 51 00 Interior Lighting	256
	26 51 19 LED Interior Lighting	257
	26 52 13.16 Exit Signs	258
	26 56 00 Exterior Lighting	258
XVII.	DIVISION 27 – COMMUNICATIONS	260
	27 05 28 Pathways for Communication Systems	260
	27 05 48 Vibration and Seismic Controls for Communications Systems.....	264
	27 40 00 Audio-Video Communications.....	264
XVIII.	DIVISION 28 – ELECTRONIC SAFETY AND SECURITY	266
	28 05 48 Vibration and Seismic Controls for Electronic Safety and Security.....	266
	28 16 13 Access Control Interface to Intrusion Detection	266
	28 46 00 Fire Detection and Alarm	270
XIX.	DIVISION 32 – EXTERIOR IMPROVEMENTS	272
	32 05 23 Cement and Concrete for Exterior Improvements.....	272
	32 33 00 Site Furnishings	272
	32 33 23 Site Trash and Litter Receptables.....	272
	32 33 43 Site Seating and Tables	273
	32 84 00 Planting Irrigation.....	273
XX.	DIVISION 33 – UTILITIES	274
	33 05 00 Common Work Results for Utilities	274
XXI.	DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT	275
	41 22 00 Cranes and Hoists.....	275
XXII.	APPENDIX A	A
	Laboratory Design Standard 2024	A
XXIII.	APPENDIX B.....	B
	Telecommunications and Data System Components.....	B
XXIV.	APPENDIX C	C
	Luminaire Standards.....	C



I. GENERAL

A. Introduction

This Building System Standards and Design Guide (hereinafter referred to as the Guide) has been prepared to familiarize the Architects and Engineers (A/E), Consultants, and Contractors retained by Drexel University with the (1) present sources of energy available for use on campus, (2) utility operating characteristics, (3) standard University design requirements and procedures, and (4) prohibited or preferred systems and materials.

The Guide serves to consolidate the extent of institutional knowledge retained by the Staff of the Planning, Design & Construction (PD&C), Facilities Management, Maintenance Services, Environmental Health & Radiation Safety, Information Technology, and Public Safety departments. It is intended to be updated bi-annually, although more current individual sections or supplements may be distributed or posted on an as-needed basis. Items in [blue](#) text represent these bi-annual updates. In addition, an Adobe PDF version of the document is available for download on the Planning, Design & Construction section of Drexel University Real Estate and Facilities Department Web Page at <http://www.drexel.edu/facilities/design/standards/>.

Nothing within this Guide shall be construed as limiting the design innovation of the A/E and Consultants. The University recognizes the need to maintain design flexibility, to assure a systematic design process that results in completed projects that are functional, energy efficient, code compliant and congruent with the intent of the project program.

The University, through its design review procedures, comments and recommendations, does not release or alleviate the A/E and/or Consultants from their responsibility and legal liability relating to equipment, materials, code compliance, serviceability of systems, capacity, Guide compliance, budget, site observation of the work in progress, system operation, shop drawing review, contract document interpretation, schedule, errors, omissions and/or all other non-delegable duties and obligations as a Professional.

It is the duty of the Prime Professional, as well as all Consultants, Sub-Consultants, etc. to ascertain that the entire Mechanical, Plumbing, Fire Protection and Electrical Systems can be installed, maintained, serviced, and replaced without the removal, relocation or disturbance of unrelated systems or building structure, or impact any part of the building structure for the entrance and exit of equipment.

Furthermore, it is the duty of the Prime Professional to directly contact the University's Project Manager for related project program requirements, design conditions and/or existing conditions, which will render the above requirements unattainable or impractical. All communication to the University shall be made through the Project Manager. All communication from the University shall be made through the Project Manager, who will relay the information to the Prime Professional.

All codes listed in this version of the Guide shall be superseded as required to meet the latest applicable codes as approved by the City of Philadelphia Licenses and Inspections. It is the Prime



Professional's and Contractor's responsibility to confirm which version is approved and comply with all City of Philadelphia applicable codes.

The University is the sole entity with the authority to waive the requirements of this Guide and it only exercises such authority through the execution of proper procedures in the submission of documents as detailed herein.

The Prime Professional and/or Contractor shall submit in writing all questions concerning this Guide to the University's Project Manager. The Project Manager shall refer the questions to all affected University offices for clarification or modification. However, no modifications to the Guide will be made without the express written approval of the University Architect, University Engineer, or a duly appointed designer.

B. Definitions

The University or University: Drexel University.

University's Project Manager: A designated University Employee and/or Project Manager who shall function as an interpreter of this document and the focal point for the transfer of all information between the various Departments within the University and the A/E, Consultant and/or Contractor. Additionally, the Project Manager shall ascertain that the University's interests and program are being properly served as the project progresses.

User: Any of the various Departments within the University who will receive beneficial use of the completed project and who have a vested interest in its timely and successful completion.

User's Representative(s): Designated employee(s) or consultant(s) of the University who shall function as the focal point for the transfer of information between the University's Project Manager and affected or interested Departments. User's Representatives generally include the occupants of the space being built or renovated and members of the Facilities Management Department, who are responsible for the maintenance of the equipment. Also involved may be representatives from the Safety and Security Departments.

A/E: Architect/Engineering Team consisting of the Prime Professional and all Consultants and Sub-Consultants engaged to provide services on a particular project.

Prime Professional: The A/E of record with whom the University enters into a formal agreement for design services.

Consultants, Sub-Consultants: Professionals and/or other firms with specialized experience engaged by the Prime Professional, or a third party engaged by a firm under contract with the Prime Professional, i.e. Commissioning Authority.

Prime Contractors: Construction professionals with specialized experience with whom the University enters into a formal agreement for construction services.



Sub-Contractors: Construction professional with specialized experience engaged by the Prime Contractor, or a third party engaged by a contractor under contract with the Prime Contractor.

Basic Services:

1. Pertains to the following disciplines, at a minimum:
 - a) Program Validation.
 - b) Architecture.
 - c) Civil Engineering.
 - d) Structural Engineering.
 - e) Mechanical.
 - f) Electrical.
 - g) Plumbing.
 - h) Fire Protection – Performance spec.
 - i) Information Technology.
 - j) Cost Estimating.
 - k) As Constructed Record Drawings.
 - l) Code Analysis.

C. Processing of Work – Prime Professional

1. The programming, design and construction of facilities are a cooperative procedure involving many persons within the University. The A/E, as an agent of the University, is required to work with the University's Project Manager and to call upon him/her for authoritative answers on all matters.
2. The University, in conjunction with a User Group, generally prepares a program listing the Project requirements, goals and objectives. This Guide supplements the requirements set by the program and is an integral part of this program. The program cannot be altered in any way by the A/E without the written consent of the University's Project Manager. Changes will not be addressed which are based solely upon the request of a User.
3. Immediately after the selection of and approval of the A/E, the University's Project Manager will schedule a Kick-Off Meeting, for the purpose of discussing the general requirements of the program, the schedule of the work, responsibility for keeping minutes and submitting drawings, specifications, materials, memos or letters, contacts protocol and emergency lists, etc. It is mandatory that the complete A/E Team and the User's Representatives attend the Kick-Off Meeting.
4. Submissions of design documents are required at various stages. The University's Project Manager, upon receipt and distribution of the documents, will schedule a review meeting between the Prime Professional, appropriate A/E Team members and the Users' Representatives. Upon satisfactory completion, review and approval of a particular design stage, the Project Manager will notify the A/E to proceed with the next stage of project design and documentation.
5. It is the responsibility of the A/E to confirm that all approved manufacturers listed in the specifications for products, equipment and accessories are indeed equivalent to the Basis of



Design listed in the schedules on the drawings. Any discrepancies are to be brought to the University Project Manager.

6. Generally, the A/E will be required to submit design documents at each of the following progress stages:
 - a) Schematic Design.
 - b) Design Development.
 - c) Construction Documents.
7. Submissions of these progress documents shall be made to the University's Project Manager for distribution to the various in-house Departments responsible for the review of the documents. The quantity of documents and distribution of such will be determined during the Kick-Off Meeting.
 - a) After an initial in-house review period, the University's Project Manager will schedule a Joint Review Meeting. Attendance by the A/E Team is mandatory. During this meeting, the Prime Professional of record for each discipline will present his/her portion of the project and address questions from the University. Project Manager will determine if the size of the project warrants an in-person meeting. Alternatively, the University may provide a written review of documentation and request written response.
 - b) The Prime Professional will record all questions in the minutes of the Joint Review Meeting, with appropriate responses and any resolution or action taken at the meeting. If any issues cannot be resolved during the Joint Review Meeting, they will be noted in an "Action" section of the minutes, and a schedule for response or action duly noted. If some of the agreed upon resolutions conflict with the Program of Requirements or this Guide, the Prime Professional will highlight them for the record.
 - c) Work beyond the specific design review stage will not take place until all comments have been addressed to the satisfaction of the University, at which time notice to proceed with further documentation will be issued by the University's Project Manager.
 - d) Within seven (7) working days of any Meeting, a memorandum containing a complete summation of the meeting shall be prepared by the Prime Professional and distributed to all those in attendance. Meeting memoranda shall be numbered in consecutive order and include the University's project identification number as well as the Prime Professional's project number. The summation of events will be in outline form, with numbered paragraphs.
8. Division 01 information described in this Guide is to be reviewed by the A/E with revisions made to the A/E specifications as required. It is not intended to be a complete replacement of a Division 01 specification.

D. Processing of Work – Prime Contractor

1. The construction of facilities is a cooperative procedure involving many people within the University. The Lead Contractor is required to work with the University's Project Manager and to call upon him/her for authoritative answers on all matters.
2. Immediately after the selection of and approval of the Contractor, the University's Project Manager will schedule a Kick-Off Meeting, for the purpose of discussing the general



requirements of the construction, the schedule of the work, responsibility for keeping minutes and submitting shop drawings, submittals, materials, memos or letters, contacts protocol and emergency lists, etc. It is mandatory that the complete Contractor Team Representatives attend the Kick-Off Meeting.

3. Submissions of shop drawings and submittals shall be made to the University's Project Manager for distribution to the various in-house Departments responsible for the review of the documents.
4. The Prime Contractor will provide a copy of all acquired permits to the University Project Manager.
5. The quantity of documents and distribution of such will be determined during the Kick-Off Meeting.
 - a) The Prime Contractor will record all questions in the minutes of the Construction Meeting, with appropriate responses and any resolution or action taken at the meeting. If any issues cannot be resolved during the Construction Meeting, they will be noted in an "Action" section of the minutes, and a schedule for response or action noted. If some of the agreed upon resolutions conflict with the Construction Requirements or this Guide, the Prime Contractor will highlight them for the record.
 - b) Work beyond the specific construction documents will not take place until all comments and associated costs have been addressed to the satisfaction of the University, at which time notice to proceed with further construction will be issued by the University's Project Manager.
 - c) Within seven (7) working days of any Meeting, a memorandum containing a complete summation of the meeting shall be prepared by the Prime Contractor and distributed to all those in attendance. Meeting memoranda shall be numbered in consecutive order and include the University's project identification number as well as the Prime Contractor's project number. The summation of events will be in outline form, with numbered paragraphs.

E. Drawings and Specifications Format

1. This section will provide the requirements for documentation for archiving all University Project Documents.
2. University Drawing Format is as follows:
 - a) Drawings: AutoCAD 2023 and PDF on individual (24x36) or (30x42) sheets for each discipline with, at a minimum, the following document identification:
 - (1) Project Title.
 - (2) Drawing Title.
 - (3) Project Location, including Building Address, Building Number and BRT Building Address (OPA).
 - (4) Name, Address and Telephone Number of A/E Firms.
 - (5) Document Submission Date.
 - (6) Revision Dates.
 - (7) Drawing Scale.



- (8) North Arrow, showing true North.
 - (9) Key Plan.
 - b) Drawings will be labeled as per A/E's standard. If A/E does not have a standard or University creates the drawing(s), labeling as follows:
 - (1) Civil: C-1, C-2, etc.
 - (2) Architectural: A-1, A-2, etc.
 - (3) Structural: S-1, S-2, etc.
 - (4) Heating, Ventilating and Air Conditioning: M-1, M-2, etc.
 - (5) Instrumentation: I-2, I-2, etc.
 - (6) Electrical: E-1, E-2, etc.
 - (7) Fire Alarm: FA-1, FA-2, etc.
 - (8) Telecommunication: T-1, T-2, etc.
 - (9) Plumbing and Drainage: P-1, P-2, etc.
 - (10) Fire Protection: FP-1, FP-2, etc.
 - c) Separate drawings are to be used for coversheets, plans, details, schedules, and piping, airflow, BAS, and wiring diagrams. Consolidating on smaller projects is acceptable.
 - d) Symbols and abbreviations must be edited per project. The following type of note "SOME SYMBOLS AND ABBREVIATIONS MAY NOT APPLY" is not acceptable.
 - e) All equipment rooms shall be drawn at scale not less than 1/4" = 1'-0" with all equipment and double-line ductwork, piping (2 inch and larger), and conduit (2 inch and larger).
 - f) All equipment is to be individually scheduled per discipline.
3. University Specification Format is as follows:
 - a) Specifications: Most recent PC-compatible Microsoft Word following The Construction Specifications Institute's MasterFormat™, 2020 Edition.
 - b) Each specification is to have a maximum of five (5) approved manufacturers, except where proprietary manufacturers are noted in this Guide.
 - c) Specifications must be edited per project. The specifications in this Guide are to be used as a basis and the specifications tailored to the project, the Guide shall not be included in the Contract Documents by reference only.
4. Adobe PDF Deliverables:
 - a) Drawings: One (1) consolidated file per discipline bookmarked and layered for CAD export.
 - b) Specifications: One (1) consolidated file per volume bookmarked per specification section and named informatively.
5. Prior to Project Closeout, a CD or thumb drive containing the Project's Construction Documents in Adobe Acrobat PDF and AutoCAD 2023 format shall be provided to the Project Manager. The drawings shall incorporate all revisions, sketches, bulletins, RFI's and addenda issued during the Bidding and Construction Phases. Specifications shall also be included on the CD or thumb drive in Adobe Acrobat format. Refer to section R – Space Management for additional information.
6. Upon Project Completion the Prime Contractor, along with Sub-Contractors, shall produce As-Built documentation in Adobe Acrobat PDF format of work in place of respective systems. Submission requirements may be found in individual Specification sections of the Contract



Documents. At a minimum, all systems listed in the Specification shall be submitted by the Prime Contractor.

F. Submission Requirements

1. General:

- a) Each progress submission shall be covered with a standard transmittal form in which the A/E certifies compliance with the University's Program Requirements and this Guide unless a waiver request form has previously been issued and approved, in which case a copy of the approved and fully executed waiver request must be included in the submission.
- b) If a Program or Guide requirement cannot be reasonably met, for any item not previously agreed to at a Joint Review Meeting, a waiver request form must be executed by the Professional of Record for the discipline, endorsed by the Prime Professional and forwarded to the University's Project Manager for in-house review and approval. Submission of a waiver request form does not constitute acceptance. A formal written response to the waiver must be issued, and an appropriate action indicated on the waiver form. If necessary, a review meeting may be scheduled to address the waiver request. The University's Project Manager will coordinate the scheduling of this meeting. The Prime Professional is responsible for documenting this meeting and copying all parties in attendance.
- c) Prior to the preparation of specifications, the A/E shall obtain guidance from the University on the following subjects and incorporate them into the specifications. The document addresses such items as:
 - (1) Asbestos Abatement and Environmental Remediation.
 - (2) Safety Regulations.
 - (3) Demolition Requirements.
 - (4) Parking.
 - (5) System Shutdown Requirements and Policy.
 - (6) Safety Shutdown for Welding.
- d) The University will review each document submission within ten (10) working days. Larger more complex projects will be fifteen (15) working days. For the large more complex projects the clock will start upon receipt of the hard copies of the documents.

2. Schematic Submission Requirement:

- a) Provide a Basis of Design (BOD) document for the project. BOD to including design criteria and concepts and a list of questions and/or issues requiring University input.
- b) Provide one (1) PDF of schematic level architectural floor plans, elevations, and sections with sufficient detail to determine schematic level cost estimating.
- c) Provide one (1) PDF of schematic drawings showing single line diagrams for all proposed systems and locations of all mechanical, electrical, and telecommunication and data room, along with required size and headroom. For alterations, a floor plan indicating the area of work within the building shall also be included.
- d) Provide one (1) PDF of outline specifications indicating materials and type of systems proposed. Include a description of the design concept, of each mechanical, plumbing, fire protection, and electrical system, the type of fuel used, related code compliance issues, and an understanding of existing conditions.



3. Design Development Submission Requirements:
 - a) A brief written description of project intent and purpose and definition of submittal intent, unresolved issues, and issues needing University input.
 - b) Provide one (1) PDF of 50% complete technical specifications including detailed Sequences of Operation for all mechanical and electrical systems.
 - c) Provide one (1) PDF and five (5) half sized bound copies of 50% complete contract drawings. Drawings shall indicate all necessary equipment service clearances, major electrical feeders, as well as adequate access to all equipment for replacement without disturbing other systems and/or the building structure.
 - d) The drawings must be coordinated and labeled according to Section E part 2.
 - e) Include a detailed description of each proposed system and related code compliance issues.
 - f) Include specific manufacturers' catalog cuts giving a complete description of all proposed equipment.
 - g) Provide explanation of any concept, equipment, or material change from the previous submission.
 - h) Include a Statement of Probable Cost.

4. Construction Document Submission Requirements:
 - a) Revised final Statement of Probable Cost.
 - b) One (1) PDF and five (5) half sized bound copies, complete with general and technical sections, which have been reviewed for proper coordination between trades.
 - c) One (1) PDF and five (5) half sized complete sets of contract drawings, which detail the installation of all equipment and materials to affect a functional system in accordance with the intent of the program.
 - d) Final design drawings must include diagrams of the following but be limited to the details listed for each schematic:
 - (1) Air Flow: Complete diagram showing air handlers (CFM, brake HP, dampers, coils, and smoke detectors), return and exhaust fans (CFM, HP, dampers, smoke detectors), room CFMs, fire, fire/smoke and smoke dampers, ductwork pressure classification designations, distribution systems and duct main sizes.
 - (2) Water Flow: (Cooling, radiation, and others as applicable.) Diagram to show all pumps (GPM, heads, brake HP), valves, strainers, gages, converters, meters (expected demand, meter constants), zoning, locations, and pipe main sizes.
 - (3) Steam Flow: Diagram to show coils, converters, traps, valves, PRV's, meters, with required capacities, demands, constants, and pipe main sizes.
 - (4) BAS and Temperature Controls: Diagrams may be combined with above schematics.
 - (5) Electrical single line diagrams showing points of origin for all feeders, all panels, feeder sizes and over current protection.
 - (6) Plumbing riser diagrams for all water supply, drainage, and vent systems. Risers shall include GPMs, DFUs and pipe main sizes.
 - (7) Natural gas/oil riser diagrams for all supply, return and vent systems. Risers shall include BTUs, GPMs and pipe main sizes.

5. Construction Administration Submission Requirements:
 - a) Contractor shall submit all submittals, shop drawings and RFI's, in PDF format and within a reasonable timeframe, to both the University and A/E for review. The A/E is responsible



for coordinating with the University prior to responding formally to submittals, shop drawings and RFI's.

- (1) A maximum of five (5) working days will be allowed for review and response to RFI's.
- (2) A maximum of ten (10) working days will be allowed for review and response of submittals and shop drawings.
- (3) Contractor shall provide a Submittal Log and Submittal Schedule to the University and A/E for coordination of submittals and shop drawings.
- (4) A Substitution Request Form is required for all products, equipment and accessory manufacturers not listed in the specifications. The form shall provide a detailed comparison between manufacturers, lead time, cost savings, other trades, etc. If the cost savings is \$0 the University prefers that the contractor use the Basis of Design.
- (5) Contractor shall ensure that all submittals are legible, parts are clearly identified, and submittal has been reviewed against the latest set of Construction documents, Addendums and Bulletins prior to submission for review. Submittals consisting of catalog cut sheets/brochures with no selections identified will be rejected and not reviewed.
- (6) If a contradiction between the contract documents and this Guide occurs the Contractor is to bring it to the A/E's and University Project Manager's attention. If a resolution cannot be determined the Guide will take precedence.
- (7) Prime Professional to provide updated construction drawings, which includes addendums, sketches, bulletins, etc. created during the Construction Administration Phase.

G. Climate and Sustainability

1. In 2020, the University created an Office of Climate & Sustainability (OCS) which consists of Faculty and Professional Staff. The OCS is responsible for developing various initiatives covering academics, institutional investment, and civic impact. Additional information can be found on the Climate and Sustainability website, <https://drexel.edu/sustainability/>.
2. The University adopted Green Globes as a comprehensive green rating system for all new construction projects and existing building renovations. The assessment process is an example of the University's commitment to energy efficient and environmentally friendly design. Green Globes System is overseen by the Green Building Initiative, which owns the license to promote and further develop Green Globes in the United States. GBI is an accredited standards developer under the American National Standards Institute (ANSI). The University also pursues Leadership in Energy and Environmental Design (LEED) for new construction projects and existing building renovations.
3. Benchmarks:
 - a) Increase energy efficiency above baseline minimums stated in the 2018 International Energy Conservation Code (IECC) or ANSI/ASHRAE/IES Standard 90.1-2022, "Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings".
 - b) Increase energy efficiency above the benchmarks set by the City of Philadelphia's Philadelphia Code Chapter 9-3400, Energy Conservation and Section 9-3404, Building Energy Performance Policy.



- c) Reduce potable water consumption over baseline 2005 U.S. Energy Policy Act (EPA) Standards.
 - d) Particulate reducing retrofits on construction machinery is required.
4. For new buildings, the A/E shall provide an energy budget to the University, prepared in cooperation with the mechanical and electrical consultants. The budget shall show the estimated use of energy for the structure calculated on a KW and BTU per square foot per year basis. The maximum BTU allotment or maximum allowable energy loads and specific requirements for U-values of walls and roofs for each building must comply with the 2018 IECC which incorporates, by reference, ANSI/ASHRAE/IES Standard 90.1-2016. Refer to the Electrical Sections of these documents for lighting standards and power factors.
 5. Drexel University is a member of the Green Building United and their “Philadelphia 2030 District” initiative, to achieve deep reductions in energy use, water use, transportation emissions, and to improve stormwater management. For more information refer to: <https://greenbuildingunited.org/initiatives/philadelphia-2030-district>.

H. Conservation of Energy

1. The University is dedicated to conserving energy and will scrutinize proposed designs for means of reducing not only initial cost, but also long-range operating costs. The A/E must work in close cooperation with the Owner to design new buildings and to remodel existing buildings to make the most efficient use of building materials and energy sources available.
2. Design and Specification Standards:
 - a) A/E’s and Commissioning Agents are to follow and complete the City of Philadelphia Department of L&I Commercial Energy Code Compliance and Energy Code Checklists. A/E’s and Commissioning Agents are to coordinate with the University Engineer regarding which compliance path option (ANSI/ASHRAE/IES Standard 90.1-2022 or the 2018 IECC) should be followed per project.
 - b) All designs and specifications shall meet and incorporate the requirements ANSI/ASHRAE/IES Standard 90.1-2022 or the 2018 IECC.
 - c) All designs and specifications shall meet and incorporate the requirements of any successor to, or replacement for, ANSI/ASHRAE/IES Standard 90.1-2022 and the 2018 IECC, or more restrictive standards, as required by law.
 - d) All mandatory provisions of ANSI/ASHRAE/IES Standard 90.1-2022 and the 2018 IECC shall be met.
 - e) All prescriptive provisions of ANSI/ASHRAE/IES Standard 90.1-2022 and the 2018 IECC shall be met, except as provided by the Energy Cost Budget Method.
3. Energy Cost Budget Method:
 - a) The energy cost budget method described in ANSI/ASHRAE/IES Standard 90.1-2022 shall be performed for all designs with the following additional requirements.
 - b) Calculations shall be performed for all 8,760 hours of the year.
 - c) Software used for simulation shall meet the requirements of ANSI/ASHRAE/IES Standard 90.1-2022, Section 12 and shall be approved by the University Engineer.



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- d) Climatic data shall be based on ASHRAE Weather Year for Energy Calculations Version 2 (WYCE2) dataset or the US Department of Energy, National Renewable Energy Laboratory's Typical Meteorological Year Version 3 (TMY3) dataset and shall utilize National Weather Service Station data for Philadelphia, PA (Call Sign KIH28, Frequency 162.475).
 - e) Unless otherwise prescribed by law, current purchased energy rates shall be obtained from the University Facilities Management Department. The purchased energy rates shall be utilized for actual fiscal energy budgeting purposes.
4. Efficiency Standards Compliance Documentation:
- a) Efficiency standards compliance documentation shall be prepared by the design professionals.
 - b) All efficiency standards compliance documentation shall be submitted for review to the University Engineer prior to final preparation of project bid documents (or earlier, if practicable).
 - c) The following compliance documents (per the examples shown in the User's Manual for ANSI/ASHRAE/IES Standard 90.1-2022) shall be prepared and submitted for review:
 - i) Building Envelope Compliance Document Part I & II.
 - ii) HVAC Mandatory Provisions Part II.
 - iii) HVAC Prescriptive Provisions Part III.
 - iv) Service Water Heating Compliance Documentation.
 - v) Lighting Compliance Documentation (Space-by-Space Method).
 - vi) Energy Cost Budget Compliance Report.
5. Energy Consumption & Demand Data:
- a) Energy consumption data shall be prepared by the design professionals.
 - b) Energy Consumption data shall be supplied for the typical meteorological year (as described in the Energy Cost Budget Method above) and for design conditions.
 - c) Energy consumption data shall be submitted for review to the University Engineer prior to final preparation of project bid documents (or earlier, if practicable).
 - d) Energy consumption data shall be submitted in a Microsoft Excel spreadsheet file (worksheet, workbook, or comma-separated variable file) showing data for each of the 8,760 hours in the year.
 - e) Energy consumption may be indicated by thousands or millions of units but must be clearly labeled. (KWH, mmBtu, etc.)
 - f) The file shall contain the following data:
 - i) Hourly electricity consumption in watt-hours.
 - ii) Electricity demand data, in watts, based on a 30-minute fixed demand window. The maximum of the two (2) 30-minute demand windows shall be the maximum demand for the reported hour.
 - iii) Hourly saturated steam consumption in British Thermal Units or pounds of steam at a specified pressure.
 - iv) Hourly chilled water consumption in British Thermal Units or ton-hours.
 - v) Space heating system fuel consumption as follows:
 - (1) Natural gas consumption in British Thermal Units or cubic feet at a specified higher heating value per cubic foot for single (natural gas) fuel equipment.



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- (2) Fuel oil consumption in British Thermal Units or gallons at a specified higher heating value per gallon for single (fuel oil) fuel equipment.
 - (3) Total fuel input in British Thermal Units for dual fuel (natural gas & fuel oil) equipment.
 - vi) Process (domestic hot water, kitchens, labs, etc.) heating system fuel consumption as follows:
 - (1) Natural gas consumption in British Thermal Units or cubic feet at a specified higher heating value per cubic foot for single (natural gas) fuel equipment.
 - (2) Fuel oil consumption in British Thermal Units or gallons at a specified higher heating value per gallon for single (fuel oil) fuel equipment.
 - (3) Total fuel input in British Thermal Units for dual fuel (natural gas & fuel oil) equipment.
 - vii) Water consumption in gallons or cubic feet.
 - g) In addition, the simulation software files used to prepare the energy analysis of the building design shall be submitted to the University Engineer for performance monitoring and benchmarking purposes.
6. Energy Modeling and COMcheck:
- a) A/E must create an Energy Model for all LEED and Green Globes projects.
 - b) The University requires COMcheck Compliance documents for new construction and major renovation projects.
 - c) A/E is to notify the University if COMcheck Compliance documents are required for minor renovation projects.
 - d) The University will submit the A/E's Energy Model and/or COMcheck on all new construction and major renovation projects for potential PECO rebates.
 - e) The University requires an Energy Model for new construction and major renovation projects equal to or greater than \$10 million in construction costs.
7. University's energy philosophy is based on the following:
- a) Vision: Comfort, performance, and redundancy with minimum operating cost. Keep future consumption per square foot constant for a period of four (4) years, starting in January 2022, in accordance with the current University plans. Consumption levels are to meet, at a minimum, the 2018 International Energy Conservation Code (IECC). Sustainable designs utilizing Green Globes and LEED, where applicable.
 - b) Mission: Understand historical energy cost and consumption, facility infrastructure, and campus assets.
 - c) Procurement: Directly purchase utility energy and fuels from regulated utility companies at a reduced/fixed rate. Purchase Renewable Energy Certificates (RECs) to offset carbon emissions.
 - d) Procure competitively to minimize unit costs: Continue to competitively bid to 3rd party energy companies for thermal and electrical utilities, when possible.
 - e) Purchase thermal energy: Through existing steam and natural gas utilities.
 - f) Incentives: Implement equipment and system designs that are supported by local, national, and federal programs, i.e. PECO Smart Ideas, Energy Star, etc.
 - g) Maintain fuel source flexibility: Implement dual fuel sources for building backup in the event of a utility failure, when possible.



- h) Conversion: Converting the raw utility energy into a form that can be moved through the distribution system, i.e. steam to heating hot water. Interconnect existing individual heating and/or cooling systems to create a small-scale heating or cooling plant, referred to as pods.
- i) Centralize heating and/or cooling conversion: The University will not create a centralized heating and/or cooling plant dedicated to each campus.
- j) Distribution: The primary utility distributions are electric, natural gas, city water and steam. The secondary distributions are electric, natural gas, chilled water, heating hot water, cold water, and hot water. Primary distributions are conveyed by City utility companies.
- k) Shorten runs: Reduce/eliminate pipe losses from primary distributions and create pods for secondary distributions to become main generation source, i.e. steam to heating hot water exchangers.
- l) Eliminate line losses: Install filters on infrastructure equipment. Possible installation of an electrical loop for multiple services to switch gear, to eliminate power loss to buildings.
- m) Minimize pressure: Size equipment in accordance with the guaranteed minimum natural gas and water pressures as published by the utility companies. Remove excess/abandon pressure reducing valves in steam systems.
- n) Optimize efficiency: Keep future consumption per square foot constant for a period of four (4) years, starting in January 2022, in accordance with the current University's plans. Consumption levels are to meet, at a minimum, the 2018 International Energy Conservation Code (IECC).
- o) End Use: Engineering systems are to be designed with the intent that the selected equipment will be in operation for a long time, for a minimum of 25 years. Sustainable designs utilizing Green Globes and LEED.
- p) Control to minimize units of consumption via Metering: Install sub-meters on main generation sources (electric, natural gas, steam, and water) at entrance of newly constructed buildings for more accurate energy measurements.
- q) Control to minimize units of consumption via Controls and Systems: Upgrade/repair existing building automation systems (BAS) for a more accurate view of system performance, trending, and opportunities for reducing energy. Upgrade/repair existing steam valves, steam condensate valves, steam condensate collection devices, and lighting control via occupancy sensors and/or BAS.

I. Construction Waste Management and Disposal

1. The Contractor and the Contractor's representatives shall comply with the University's administrative and procedural requirements for construction waste management, including the following:
 - a) Salvaging non-hazardous demolition and construction waste.
 - b) Recycling non-hazardous demolition and construction waste.
 - c) Disposing of non-hazardous demolition and construction waste.
2. Definitions:
 - a) Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.



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- b) Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.
 - c) Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.
 - d) Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.
 - e) Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
 - f) Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.
3. Performance:
- a) Salvage/Recycle: Drexel's goal is to salvage and recycle as much non-hazardous demolition and construction waste as possible.
4. Submittals:
- a) Waste Management Plan: Submit plan before the Notice of Award date.
 - b) Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit a copy of report Include the following information:
 - i) Material category.
 - ii) Generation point of waste.
 - iii) Total quantity of waste in weight.
 - iv) Quantity of waste salvaged, both estimated and actual in weight.
 - v) Quantity of waste recycled, both estimated and actual in weight.
 - vi) Total quantity of waste recovered (salvaged plus recycled) in weight.
 - vii) Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
 - c) Waste Reduction Calculations: Before request for Substantial Completion, submit a copy of the calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
 - d) Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether the organization is tax exempt.
 - e) Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether the organization is tax exempt.
 - f) Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 - g) Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 - h) Qualification Data: For Waste Management Coordinator.
5. Refer to the specific Project Specifications for additional construction waste management requirements for degree of quality assurance, content of waste management plan, plan implementation, methods for salvaging demolition waste, recycling general waste, recycling



demolition waste, recycling construction waste, and disposal of waste. This will typically be Section 01 74 19.

J. Noise and Vibration Control

1. Noise and vibration in terms of emission and transmission control is the responsibility of the A/E and must be considered in the design of every building, even though specific requirements may not be stated in the Program. Principal considerations, which must be addressed, include:
 - a) Noise control to provide for maximum usefulness of the facility by maintaining reverberation times and background sound levels within ranges that are appropriate for the intended use of the facility.
 - b) Noise control in compliance with OSHA requirements for the health and safety of building occupants; control shall be for all areas of the facility, particularly equipment rooms, PRV stations, and fan rooms.
 - c) Particular attention is required concerning the noise generated by equipment located on the exterior of the building and its impact upon adjacent properties or facilities, which may contain sensitive equipment (e.g. high-resolution microscopes).
 - d) Vibration control to limit sound produced by equipment and for protection of equipment and the building structure.
2. Interior Acoustic Environment:
 - a) ANSI/ASA Standard S12.60-2010/Part 1 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools” shall be used as the basis for defining goals for appropriate reverberation times and acoustical isolation of various types of spaces, such as:
 - i) The following maximum reverberation times for sound pressure levels in octave bands with mid-band frequencies of 500, 1000, and 2000 Hz for core learning spaces:
 - (1) Enclosed volumes less than 10,000 cubic feet: 0.6 seconds.
 - (2) Enclosed volumes between 10,000 and 20,000 cubic feet: 0.7 seconds.
 - (3) Enclosed volumes greater than 20,000 cubic feet: no requirement.
 - ii) The following minimum sound transmission class (STC) ratings required for single or composite wall, floor-ceiling, and roof-ceiling assemblies that separate the core learning spaces from the following spaces:
 - (1) Corridor, staircase, office, or conference room: STC-45.
 - (2) Other enclosed or open plan core learning space, speech clinic, health care room, and outdoors: STC-50.
 - (3) Common use and public use toilet rooms: STC-53.
 - (4) Music room, mechanical/electrical equipment rooms: STC-60.
 - b) The current edition of the ASHRAE HVAC Applications Handbook shall be used as the basis for defining appropriate HVAC-related background sound pressure levels for various types of spaces.
 - i) Sound pressure level design goals shall be defined utilizing the Room Criteria (RC) Method, which includes a quantitative value and a qualitative suffix. The “N” suffix, indicating a desired neutral quality sound, shall be the design intent. Where system installations or modifications result in an RC rating that exceeds the desired quantitative value or does not achieve a neutral quality sound, it is the responsibility



of the design engineer to revise the design or incorporate sound attenuating measures to achieve the desired goal.

- ii) The following ranges of limits shall be used as the basis of design for all projects, regardless of whether the Program fails to mention acoustical considerations:

Room or Space Type	RC(N) Range
Classrooms and Auditoriums	25 to 30
Residences and Sleeping Areas	25 to 35
Video Teleconferencing Rooms	25 (max)
Private Offices and Conference Rooms	30 to 35
Open-plan Offices	30 to 40
Executive Dining Rooms	30 to 35
Libraries	30 to 40
Laboratories with fume hoods	35 to 55
Public Dining Areas	35 to 40
Corridors and Lobbies	40 to 45
Gymnasiums and Natatoriums	40 to 50

- iii) The current edition of the ASHRAE HVAC Applications Handbook shall be used as the basis for defining appropriate HVAC-related vibration levels for various types of spaces.

3. Exterior Sound and Vibration Transmission:

- a) The operation of any equipment installed on the exterior of a building or installed on inside of a building that results in the discharge of sound outside of a building shall comply with maximum permissible levels stipulated in Chapter 10-400 of the Philadelphia Code, entitled “Noise and Excessive Vibration”.
 - i) §10-403-(3) limits sound from non-residential properties to 5 dB above background sound level measured at the property boundary of the nearest occupied residential property or to 10 dB above background sound level measured at the property boundary of the nearest occupied non-residential property.
 - ii) §10-403-(11) limits vibration levels to 0.15 inches per second beyond any property boundary or 30 yards from any moving source.

4. Control of mechanical, plumbing, fire protection and electrical equipment shall be enhanced by giving attention to the proximity of the noise and vibration generating equipment to areas requiring low sound levels.

5. A post construction sound and vibration test shall be specified to prove the integrity of sound and vibration control where this is critical, and on a random sampling basis in other areas if deemed necessary. Specifications shall require that testing equipment meet the latest ASA/ANSI Standards for sound level meters. The A/E shall review the need for this requirement and make his/her recommendation in the Design Development phase report.

6. An acoustical analysis shall be submitted for all major or critical equipment. The A/E shall define the major and critical pieces of equipment within the documents. A copy of the list



shall be submitted to the University Project Manager for review. The A/E shall review the need for this requirement and make his/her recommendations in the Design Development phase report.

K. Temperature Control Requirements

The Program developed for each project will generally list specific temperature and/or humidity requirements for the facility, which are necessary for the execution of the space function. If no temperature and/or humidity levels are indicated in the program, the A/E shall first follow this Guide and the 2018 IECC and then the latest versions of the ASHRAE Handbook of Fundamentals, ASHRAE Guidelines and ASHRAE Energy Standards. The A/E shall document the design temperature and relative humidity range for each space and include this information in the Schematic Design report for review and approval by Drexel.

Space temperature controls and equipment controls are to be incorporated into Building Automation Systems (BAS) where they are present in existing buildings. New construction controls are to be part of an approved BAS system.

1. In general, all non-critical temperature/humidity areas shall be designed to maintain the following conditions in accordance with the 2018 International Energy Conservation Code:
 - a) Summer periods: minimum 75°F +/- 2°F; 50% RH +/- 5% RH in occupied areas.
 - b) Winter periods: maximum 70°F +/- 2°F; 30% RH +/- 10% RH in occupied areas.
2. Non-laboratory type buildings: The summer period requirements listed above shall be maintained with an outdoor air-dry bulb temperature of 95°F concurrent with a wet bulb temperature of 78°F.
3. Laboratory type buildings: The summer period requirements listed above shall be maintained with an outdoor air-dry bulb temperature of 97.4°F concurrent with a wet bulb temperature of 80.3°F.
4. The winter period requirements listed above shall be maintained with an outdoor air-dry bulb temperature of 0°F. The 0°F temperature provides a built-in safety factor.
5. Mechanical Equipment Rooms and Penthouse temperature shall be designed to maintain the following conditions:
 - a) Summer (cooling): Ventilated 10-15 air changes per hour maximum based on gross volume with a 10-foot maximum height (thermostatically controlled to 85°F db).
 - b) Winter (heating): Ventilated 10-15 air changes per hour maximum based on gross volume with a 10-foot maximum height (thermostatically controlled to 65°F db).
6. Electrical Closet temperature shall be designed to maintain the following conditions:
 - a) Summer (cooling): 86°F db average, 104°F db maximum.
 - b) Winter (heating): 65°F db, minimum.



7. Telecommunication and Data Room temperature/humidity shall be designed to maintain the following condition:
 - a) Setpoint: 71°F db, range 68°F-74°F db; 40-55% RH.
 - b) A/E to coordinate with Drexel IT for final cooling load requirements, but initial HVAC equipment size to be based on a 1.5-ton cooling load per room.
8. Vivarium Facilities: Temperature and humidity requirements are to be designed in accordance with the Guide for the Care and Use of Laboratory Animals, current edition, published by AAALAC.

L. Utilities

1. Prior to initiating the design of a new utility system for a new building or renovation to an existing building that requires new service or connection to, or modification of an existing service, review and approval must be obtained from the University Engineer.
2. Any excavation to facilitate the removal, rerouting, or installation of below-ground must comply with the requirements of the Pennsylvania One Call System. Refer to the Pennsylvania 811 Users Guide for the number of required working days' notice for Construction Phase and number of required working days for Design Stage.
3. Very often, the location of underground utilities or utilities routed throughout each building is taken from public records, documentation associated with previous University projects, and field location of vents, valves, manholes, inlets, etc. The extent, exact location, and depth of underground utilities have not been verified by the University. The Engineer shall determine, or direct the Installing Contractor to determine, the extent and exact location and depth of all existing utilities prior to commencing work:
4. Chilled Water Distribution System:
 - a) The University presently does not have a central chilled water system. However, in many cases it may have a chiller plant serving a building complex. Chilled water is generally operated during cooling season months only (April-October) but enabled for use during the heating season, where applicable.
 - b) Prior to initiating the design of a system intended to interface with the central chilled water system, approval for the interconnection must be obtained from University Engineer and Facilities Management. Consideration for approval requires that the following information be supplied:
 - i) Location of building.
 - ii) Peak load to be imposed upon the system, month, and time of day.
 - iii) Design temperatures (entering water and leaving water), required GPM and design pressure differential.
 - iv) List of anticipated control points to be added to the BAS.
 - c) The basis for approval is the available chiller plant capacity, ability to diversify loads to other plants and anticipated plant capacity modifications.
 - d) Costs attributed to engineering, modification, shut-downs, testing, or the provision of maintenance personnel associated with any chilled water system modifications, shall be the responsibility of the Project requiring the modifications.



5. Steam Distribution System:
 - a) Steam is available throughout most of the University campus at high, medium, or low pressure depending on the location. The high-pressure lines are 150 to 200 PSIG, medium pressure lines are 50 to 90 PSIG, and low-pressure lines are 5 to 15 PSIG. The steam shall be used for humidification where required.
 - b) The use of steam shall be confined to mechanical rooms, laboratories, or areas where process steam is required, except for local humidifiers. Steam shall not be used for perimeter radiation, unless modifying existing steam radiation systems.
 - c) Prior to the initial stages of design, approval for interconnection to the steam system must be obtained from Facilities Management. The following information must be provided for steam system evaluation:
 - i) Location of device requiring steam service (building, floor, room, etc.).
 - ii) Intended point of interconnection to the existing system.
 - iii) The methods of condensate return to the distribution system or removal from the new device or renovated area to the building's sanitary sewer system (with proper cooling devices).
 - iv) Required load in pounds per hour, maximum required pressure, and anticipated annual usage.
 - v) List of anticipated control points to be added to the BAS.
 - d) Where practical, feasible, and beneficial to other building systems, heat from steam condensate shall be recovered prior to discharging to drain.
6. Laboratory Gases:
 - a) Laboratory vacuum is available in the following buildings: Stratton Hall, Disque Hall, LeBow Engineering Center, CAT, and Bossone.
 - b) Laboratory compressed air is available in the following buildings: Stratton Hall, Disque Hall, LeBow Engineering Center, CAT, and Bossone.
 - c) Natural gas is available in the following buildings: Stratton Hall, Disque Hall, and Bossone.
 - d) All other gases shall be stand-alone systems.
7. Potable and Deionized Water Systems:
 - a) Potable water is available within each existing building and must be extended from City of Philadelphia street mains for new buildings or connected to existing water services where practical.
 - b) The City water pressure in the streets varies across the University and throughout the year. It runs between 65 and 80 PSIG, but could be lower under some circumstances, such as summer fire hydrant use. The A/E must contact Facilities Management when connecting to existing building systems. The A/E must contact the City of Philadelphia's Water Department when interconnecting with the street mains. Document provisions for backflow prevention device in all connections to fire protection water supply systems in accordance with the Philadelphia Water Department's requirements.
 - c) All domestic water piping must conform to City of Philadelphia Codes and this Guide.
 - d) Deionized (DI) and reverse osmosis (RO) water systems are dedicated stand-alone systems installed on an as-needed basis.



- e) Distilled water is available in Bossone, CAT, Disque Hall, Nesbitt Hall, New College Building, and Queen Lane.
 - f) Where domestic hot water is not available to a tenant by the Building Owner, such as is the case in One Drexel Plaza, domestic hot water heaters and appropriate safety relief valve devices and piping shall be installed to satisfy the domestic hot water demand of the project.
 - g) Backflow preventers shall be installed where the possibility of cross-contamination exists. Refer to Section 22 05 00 for approved backflow preventers.
8. Sanitary and Storm Sewers:
- a) The City of Philadelphia uses a combined system. All sanitary and storm drainage piping and sewers must be designed and installed in accordance with the City of Philadelphia Plumbing Code, current edition.
 - b) The A/E is responsible for the submission of sanitary and storm drainage design documents to the City of Philadelphia for preliminary approval.
9. Electrical Distribution:
- a) Prior to the initial design stage, University Engineer and Facilities Management must be consulted as to the choice of primary supply voltage, its location, and the available capacity. The A/E should consider that 480/277-volt, three phase electrical service is not available in all buildings and adjust their equipment selection and system design accordingly.
 - b) Emergency power capacity varies throughout the University. Most University buildings are connected to an emergency generator. During the design development phase the A/E shall identify the emergency power loads. These must be reviewed with the University to verify connection to emergency system and availability of power.
 - c) The A/E shall be responsible for investigating the adequacy of power system capacity at all points of connection to existing power distribution systems. The A/E shall develop estimates of the additional load, as well as estimates of the existing peak load, and demonstrate that adequate capacity is available. Estimates of existing peak load shall be based upon metered values and/or calculations that tabulate connected load and appropriate diversity factors. Any proposed power connections to existing systems shall be approved in advance by the University Engineer and Facilities Management.
 - d) On all projects which will increase the electrical load on the existing system by more than 50 KW, perform a load study consisting of installing a KWH meter on the existing system for a period of one (1) week. The A/E will review the need for this during the schematic design phase and if required coordinate with Facilities Management.

M. Abandoned Equipment and Materials

- 1. All equipment, ductwork, piping, conduit, wiring and supports made obsolete by new installation shall be removed and floors, overhead and walls appropriately patched and finished.
- 2. Intentions to abandon-in-place existing equipment, ductwork, piping, conduit, wiring, and supports shall be brought to the attention of the University Project Management for review and approval.



3. Prior to removing abandoned equipment, ductwork, piping, conduit, wiring and supports the contractor must acquire approval from Drexel University's Environmental Health and Radiation Safety and Facilities Departments via the University Project Manager.

N. General Considerations – Prime Professional

1. The A/E is responsible for reviewing all City of Philadelphia Agency's, Philadelphia Gas Works, Philadelphia Electric Co., Philadelphia Water Department, SEPTA, and Amtrak, requirements associated with installing, excavating, and backfilling adjacent to non-University owned underground utilities. The contract documents shall not violate existing compliant conditions. The contractor shall be responsible for all PA One-Call associated coordination.
2. Visits to Site:
 - a) The University understands that all existing conditions cannot be accounted for in renovation and expansion projects, but the A/E is required to visit the site to survey, inspect and gather enough information about the existing conditions to clearly document major impacts to existing systems, the intent of routing and removal of abandoned work as accurately as possible. Construction documents must show routings for new piping, ductwork, conduit, etc. and relocated existing piping, ductwork, conduit, etc.
3. Code review and permitting:
 - a) Prime Professional is responsible for code review and making early submissions to the City of Philadelphia for initial review to determine viability of design intent including separation of alternate proposed work. If a variance is needed A/E would be responsible for representation.
 - b) Prime Contractor is responsible for obtaining construction permits with the City of Philadelphia.
4. Prime Professional and all consultants are responsible for the preparation of a specification section within Division 00 or 01 that addresses and makes clear to the contractors the following below. The University will provide boilerplate sections for Division 00 and 01.
 - a) A brief statement describing the intent of the project.
 - b) A statement describing the scope of work for each discipline.
 - c) A description of the project location.
 - d) A definition of the project construction schedule.
 - e) List of construction documents.
 - f) Define the bidding requirements.
 - g) List all alternates of scope with a numerical designation and coordinated by trade.
 - h) Define the shop drawing review process including the quantity of submittals required, chain of distribution, required review period (Professional and University), and format of submittals for samples, catalog cuts, identification and required contractor review stamps.
 - i) Require the Prime Contractor to submit a list, by C.S.I. designation, of all sub-contractors to be used on the project and a list of intended manufacturers for all equipment to be supplied under this contract.
 - j) Include a statement regarding the diagrammatic nature of the drawings and the contractor's responsibility for the layout and coordination of his work with the various trades.



- Renovation projects shall demand that the contractors visit the site prior to submitting bids to review as-built conditions.
- k) State that the continuity of services to occupied portions of the University is mandatory. Inadvertent interruptions must be corrected immediately. The contractor is responsible for providing all necessary labor, including additional crews and overtime labor, and all materials as required ensuring a prompt resolution at no expense to the University.
 - l) Require a statement regarding each contractor's responsibility for the removal of debris daily. The prime contractor selected as the party responsible for designating the on-site point of disposal for all site generated debris and for the timely removal of the collected debris from the site. Note that the University has adopted strict recycling policies, and construction debris and/or hazardous materials are not permitted in University dumpsters or other trash recycling containers.
 - m) Upon completion of the project all hazardous materials and/or construction debris must be removed immediately. The contractor will be financially responsible for disposal of all hazardous materials and/or construction debris if these materials are left on site and the University must handle the disposal.
 - n) Define the contractor's responsibility to properly notify the Prime Professional of the contractor's desire to deviate from the equipment and materials designated within the contract documents as either the "standard of design" or listed "equivalents". Such notification must be made ten (10) days prior to the bid date and shall be properly documented regarding the equivalency of the substitution. Define the contractor's responsibility for addressing any changes to the remaining systems, equipment and/or materials within the contact documents or any existing conditions that may be affected as result of the equipment and/or material substitution. Notification of all accepted deviations shall be in the form of Addenda to assure an equal bidding basis among contractors.
 - o) Define the contractor's responsibility to unconditionally guarantee, in writing, all materials and workmanship for a period year from the date of final acceptance by the University. The guarantee must include the repair and/or replacement of all equipment and materials in which defects may develop. Guaranties submitted by sub-contractors and equipment manufacturers must be countersigned by the contractually related contractor for joint and several responsibilities. The manufacturer's equipment guaranties or warranties which extend beyond the one (1) year shall likewise be transmitted to the University.
 - p) Define the contractor's responsibility for maintaining an accurate set of as-built drawings to be submitted to University at time of close-out.
 - q) Define the contractor's responsibility for temporary facilities and control with the following sub-sections:
 - i) Scope.
 - ii) Regulations and standards.
 - iii) Offices.
 - iv) Telephones.
 - v) Access to work areas.
 - vi) Scaffolding and OSHA-required fall protection components.
 - vii) Hoisting facilities.
 - viii) Guardrails, handrails and covers for openings.
 - ix) On-site storage.
 - x) Fire Protection.
 - xi) Security and dust enclosures.



- xii) Trash removal.
 - xiii) Toilets.
 - xiv) Water.
 - xv) Electrical.
 - xvi) Heat.
 - xvii) Removal of temporary facilities.
 - xviii) Egress from mechanical spaces must be minimum 7 feet high by 28 inches wide.
 - r) Define the project closeout requirements such as pre-final reviews, substantial completion reviews and a final review of the work. List the contractor's requirements for the submission of data at each stage of review and generally as follows:
 - i) Pre-final review - Professional's site visit to confirm the contractor's punch list of the items which remain to be completed. The contractor-generated punch list shall define the tasks to be completed and shall be arranged to indicate each contractor's responsibility, necessary remedy, and the date of completion. This review shall be in conjunction with University personnel.
 - ii) Substantial completion review - After certification by the contractor that all punch list items have been completed, a site review will be conducted by the Professionals and University personnel to verify satisfactory completion of all punch list items. If all punch list items have been completed to the satisfaction of the Owner and design team, a substantial completion certificate will be issued.
 - iii) Final review meeting - final site review by the Professional Staff to recommend final acceptance by the University and to ascertain that the following have been completed:
 - (1) All remaining punch list items.
 - (2) All building staff and maintenance personnel have been instructed in the maintenance and operation of the systems installed under this contract.
 - (3) Verify that the following data has been received by the University:
 - (a) Guaranties.
 - (b) Final as-built drawings and diagrams, showing all installation changes.
 - (c) Shop drawing files.
 - (d) Three (3) sets of Operating and Maintenance Manuals. Submitted material must include installation manuals, service manuals, repair manuals, and parts manuals.
 - (e) Substantial completion certificates.
 - (f) List of attic stock (paint, flooring, carpet tile, ceiling tile, etc.) for each room from Prime Contractor.
 - (g) Consent of Surety to final payment.
 - (h) Waiver of liens.
 - (i) Transfer of keys.
 - (j) All legal and insurance requirements.
 - (4) Record Drawings - Project record drawing, in AutoCAD 2022 and PDF formats, files shall be furnished to the University at the project completion. Two (2) CDs or thumb drives are to be submitted.
5. A/E is to design the building or structure exits shall be so arranged and maintained as to always provide free and unobstructed egress from all parts of the building or structure when it is occupied. Exit route to be 7'-6" high by 2'-4" wide as per OSHA Standard 29 CFR parts 1910.36 and 1926.34.



O. General Considerations – Prime Contractor

1. The A/E is responsible for reviewing all City of Philadelphia Agency's, Philadelphia Gas Works, Philadelphia Electric Co., Philadelphia Water Department, SEPTA, and Amtrak, requirements associated with installing, excavating, and backfilling adjacent to non-University owned underground utilities. The contract documents shall not violate existing compliant conditions. The contractor shall be responsible for all PA One-Call associated coordination.
2. In addition to the requirements presented herein, each specification shall contain the following general information:
 - a) General:
 - i) Incorporate, by reference, Divisions 00 and 01 into all required trades, i.e. Division 22, 23, 25, 26, etc.
 - ii) Define the Contractors covered by the General Requirements (i.e. Carpentry, Painting, HVAC, Plumbing, Fire Protection; Electrical, Fire Alarm, Telecommunications, Audio Visual, Insulation, Controls, and Testing, Adjusting, and Balancing, etc.).
 - iii) Define any specific technical terms relating to the trades covered by the section.
 - b) Laws, Ordinances, Regulations and Requirements:
 - i) State that all workmanship must conform to all pertinent laws, ordinances and regulations of all bodies having jurisdiction.
 - ii) Require each Contractor to pay all fees and obtain and pay for all permits and inspections required by any authority having jurisdiction in connection with his work and provide three (3) copies of all permits and inspection reports to be made part of this document to the Project Manager.
 - c) Define the contractor's method of procedure regarding the following:
 - i) Installation, connection, and interconnection of all systems in accordance with manufacturer's recommendations and best trade practices.
 - ii) Methods of protection of piping and equipment.
 - iii) Coordination between trades and responsibility for elevations, grades, etc.
 - iv) Installation of valves, dampers, panels, etc., for full accessibility, service, and maintenance.
 - d) Define the contractor's responsibility for the provision of all lintels required for the completion of his work.
 - e) Define any specific painting and/or finishing requirements for materials and equipment not supplied with a factory applied finish.
 - f) Include a description of the contractor's responsibility regarding abandonment, removal, relocation, and salvage rights.
 - g) Tests:
 - i) Define the contractors' responsibility for the execution of notification requirements, documentation of results and witnessing.
 - ii) Define, in detail, the tests required as part of the contract. Give specific details as to testing medium, duration, level, etc.
 - iii) Refer the Contractor to other specific tests requirements in this and other Divisions for systems such as Controls, Testing, Adjusting, and Balancing, Fire Protection, Electrical, Fire Alarm, Plumbing, etc.



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- h) Define the contractor's responsibility for applying, obtaining, and paying for all charges associated with the connection to non-University owned utilities. Prior to the connection to University owned utilities, the contractor shall obtain permission and coordinate such with the Department of Facilities Management or the University's Project Manager. Contractor shall contact Pennsylvania one-call and call non-participating utilities.
 - i) Operating and Maintenance Manuals:
 - i) Each contractor shall be directed to provide three (3) copies of printed instructions in separate hardback, three-ring loose-leaf binders and one (1) thumb drive. The instructions shall be prepared by section and contain detailed operating and maintenance data including wiring and piping diagrams. Each section shall be labeled and include detailed parts list data and the name, address, and phone number of the nearest supply source.
 - ii) The manuals must provide all the information required to run the building efficiently. Provide description of all equipment operation. The materials submitted must include installation manuals, repair manuals, programming manuals, troubleshooting manuals, and parts manuals.
 - iii) The manufacturer's specification sheets, if generalized in any way, will be clearly marked to show exactly which item has been supplied, and the job designation for that item (e.g. PRV-1) will be noted on manufacturer's specification sheet which includes all details for this unit including the complete model number, motor hp, voltage, etc.
 - iv) If there are differences between pieces of equipment, then include a specification sheet for each, properly marked.
 - v) Include temperature control diagrams, written sequence of operation, control program files and service instructions including any specialized tools required to perform service.
 - vi) Provide one (1) section for preventive maintenance procedures.
 - vii) Provide lubrication diagrams and procedures.
 - viii) Include Contractor's phone numbers and any other reference required to obtain warranty service.
 - j) Visits to Site:
 - i) All renovation and expansion projects require the Contractors to visit the site and inspect all existing conditions. Any discrepancies noted between the contract documents and existing conditions must be brought to the University Project Manager and Prime Professional's attention prior to the submission of bids. Change order requests will not be considered for any additional work relating to the connection of new work to existing systems or adaptability of new systems to existing structures.
 - k) Entrance of Equipment:
 - i) Each contractor will be responsible for all necessary rigging required for the completion of work under his contract.
 - l) Shutdown and Permit Request Forms:
 - i) The contractor is responsible for completing University shutdown and permit request forms located in section 01 35 00. The Contractor shall not shutdown, disconnect, weld, solder, etc. prior to University review and approval.
 - m) Servicing of Equipment and Systems:



- i) All water-filled systems shall be equipped with accessible vent valves, expansion tanks, drains and isolation valves, safeties, and gauges for the purpose of startup, operation, service, and maintenance in a cost-effective manner.
- ii) Wear and tear parts which are equipment-specific will be specified and quoted with life expectancy, lead time and price.
- iii) An extended 5-year warranty shall be included on the wear and tear parts which are equipment-specific. A list of components fitting this description shall be forwarded to the Project Manager prior to Project Closeout.
- iv) Include all specialized equipment or tools required to service or maintain the equipment.
- v) Upon final acceptance of the project by the Owner, the one (1) year guaranty period for all equipment and materials will be initiated. During this period, the contractor shall make a minimum of two (2) visits to the site (6 months after acceptance and immediately prior to the end of the guarantee period). During each visit, the contractor shall thoroughly check all equipment for proper operation. Reports shall be generated and forwarded to the Facilities Management describing the systems inspected, date of inspection and status of equipment.
- n) Supports:
 - i) Each contractor will be responsible for providing all materials, equipment supports, supplies, and labor necessary to support and brace and strengthen equipment according to industry trade standards and approved materials provided under his contract.
- o) Cutting and Patching:
 - i) Cutting and patching shall be as per the contract documents and coordinated between trades.
- p) Sleeves:
 - i) Each contractor must be required to be responsible for the furnishing and setting of all sleeves for piping and ductwork which penetrate walls, floors, and cast in place concrete construction. The specification and drawings must define and detail the installation of grouting and waterproofing of the sleeves and fireproofing, if necessary.
- q) Escutcheons:
 - i) All un-insulated piping and ductwork exposed in occupied areas must be provided with heavy, solid pattern, painted escutcheons where such materials pass through walls, floors, or ceilings. Escutcheons are not required in equipment rooms or unfinished areas.
- r) Machinery Guards:
 - i) All rotating equipment shall be provided with accessible and removable expanded sheet steel guards over belt drives, coupling and other moving elements to protect personnel from injury as required by OSHA regulations.
- s) Lubrication (per manufacturer's recommendation):
 - i) Each contractor shall be responsible for the initial lubrication of all equipment prior to equipment start-up.
 - ii) A list of all equipment requiring lubrication, including the identification of all specific points of lubrication shall be produced and forwarded to the Owner.
 - iii) Each contractor shall be required to provide written instructions on the lubricating procedure and shall furnish not less than a one-year supply of all necessary lubricants.



- t) Welding:
 - i) Each welder engaged to work on any University project shall be certified as having passed qualification tests prescribed by the National Certified Pipe Welding Bureau or other reputable laboratory or agency.
 - ii) The contractor shall request a Hot Works Permit prior to performing any welding operation. The request must be submitted by the Project Manager of Fire and Life Safety in the Department of Public Safety. Refer to Section 01 35 00.
 - iii) Specify the protection of adjacent surfaces, ventilation requirements and system fire alarm shutdown and fire watch as detailed in the standard University Scope Document. Fume controls to be used in occupied buildings.
- u) Mechanical-Electrical Coordination:
 - i) Include an article that clearly defines the extent of responsibility between the mechanical and electrical contractors regarding equipment that involves the work of both trades.
 - ii) Specific items to be addressed shall include, but in no case be limited to the furnishing and installation of:
 - (1) Motors and starters.
 - (2) Safety switches.
 - (3) Control wiring.
 - (4) Wiring diagrams.
 - (5) Power supplies.
 - (6) Pneumatic tubing and connections.
 - (7) Network wiring.
 - iii) The specific contractor shall be directed to pertinent sections of the electrical specifications which define wiring standards, conduits, motor efficiencies, controllers and automatic temperature control requirements.
- v) Shop Drawings:
 - i) Each shop drawing submitted shall be identified by the Project Name, Specification Section, and Drawing Numbers.
 - ii) Shop drawing data shall include but not be limited to:
 - (1) Manufacturer's catalog designation.
 - (2) Complete electrical data and wiring diagrams.
 - (3) Dimensions, capacities, ratings, materials, and finishes.
 - iii) Each submittal shall be required to bear the review stamp of each contractor associated with the processing of the document. The processing of shop drawings shall follow contractual relationships between the Prime Contractor and all Sub-contractors.
 - iv) Shop drawings which require coordination of two (2) or more trades shall be required to bear the stamp of the coordinating trades.
- w) Excavation and Backfill:
 - i) Define the contractor's responsibility for performing all excavation, backfilling, and pumping necessary for the completion of his work. Define shoring, excavated material storage, removal of unsuitable materials, trench depth, support of trench materials (i.e. conduits) and security requirements. As a minimum, the contract documents shall impose the following conditions:
 - (1) Each contractor shall perform all excavation, backfilling and pumping necessary for completion of work under his contract.



- (2) Removal from premises or deposit as directed by Owner all material excavated and not required or suitable for backfilling. Contractor shall provide disposal documentation that includes quantity disposed and location of disposal facility.
- (3) Carefully remove and store topsoil, shrubbery and sod until underground work is complete and trenches are backfilled and then reinstall. Replace any damaged items to the satisfaction of the Owner.
- (4) Trench depth shall allow adequate cover over piping, ducts, and conduit. Walls shall be perpendicular to the top of piping and ducts and trench bottoms shall be instrument graded in the direction of flow as required. Earth shall be scooped out under pipe hubs to provide a solid bearing for the duct banks or conduit on undisturbed earth. Cinder fill, stones or bricks beneath duct banks or conduits are **prohibited**. Where necessary provide sand, pea gravel or other underlie required by the conduit or equipment manufacturer.
- (5) Each contractor shall provide sheathing, shoring, and bracing necessary to complete his excavation and backfilling work and shall exercise every precaution necessary to prevent accident, injury, or death to any human and damage to property of others. Remove all sheathing, shoring, and bracing upon completion of work
- (6) It shall be the responsibility of each contractor to check with the various utility companies and make the necessary arrangements to avoid damage to property. Each contractor is responsible for damage during excavation to existing piping or equipment. Such damage shall be repaired promptly without cost to the Owner.
- (7) Backfill after inspection and approval. The backfill shall be made with clean earth, free from rocks, frozen particles, debris, or other foreign materials. Contractor shall provide documentation that the backfill is clean. Deposit in uniform layers not over six inches (6") thick with each layer mechanically tamped before the next layer is applied. When approved backfill material is not available from the site, each contractor, at their own expense, shall provide additional select backfill to complete the installation.
- (8) All trenches that pass under wall foundations shall be backfilled with lean concrete, full height, directly under wall footing, and at a 1:1 slope away from wall or column footing. Trenches that are parallel with and deeper than wall foundations shall be backfilled with lean concrete on a 1:1 slope away from the bottom of the wall or column footing.
- (9) Each contractor shall perform all cutting and patching to sidewalks, curbs, bituminous paving, walls, etc. required by performance of excavation and backfilling. Install and maintain temporary paving as required. Make repairs to sidewalks in complete blocks, partial patching will not be acceptable.
- (10) Where rock is encountered during installation of underground systems, carry trenches to a point six inches (6") below invert of conduit and provide a six-inch (6") layer of crushed stone or gravel as a cushion.
- (11) All excavation work shall include all pumping equipment, materials, and labor necessary to keep all excavations free of water. Provide well points as required with disposition of water.
- (12) Each contractor shall provide suitable indemnity for all accidents to humans, animals, environment, or equipment caused by his excavating and backfilling



work. He shall provide suitable guards, barricades, red lanterns, flares and take the necessary precaution for an approved and safe installation. All trenches shall be backfilled at the end of each working day. Where a trench must be left open, provide coverings of adequate size and strength over entire open area.

3. The contractor is to construct the building or structure and install infrastructure to ensure all exits shall be arranged and maintained so as to always provide free and unobstructed egress from all parts of the building or structure when it is occupied. Exit route to be 7'-6" high by 2'-4" wide as per OSHA Standard 29 CFR parts 1910.36 and 1926.34.

P. Design Build Projects

1. Prime Contractor is responsible for contracting Prime Professional and sub-consultant services for project construction and permits. Construction documents shall be in accordance with project RFP, this Guide, and local, state, and national regulations.
2. Prime Contractor is required to have their contracted Prime Professional review and sign-off on all payment applications and change orders for the project.

Q. Pre-Purchased Equipment

1. The University often pre-purchases equipment due to project scheduling. Prime Professional is to incorporate the following information into the specifications for reference by the Prime Contractor.
 - a) Pre-Purchased Specification:
 - i) General: The purpose of this specification is to pre-purchase equipment. The successful bidder shall submit shop drawings, for review. Shipping and handling costs to the site (FOB, Philadelphia, PA) shall be listed separately as an addition to the cost of the equipment. The rigging of the equipment and accessories to their final location, installations, connections, and power and controls, will be provided by the installing Contractor.
 - ii) Acceptance or Rejection of Proposals: The University, in its sole discretion, may waive any informality in any proposal, may accept any proposal or may reject any or all proposals. The University shall announce the successful manufacturer within seven (7) days after opening of proposals, but such announcement shall not be construed as a rejection of any other proposal. The accepted manufacturer shall promptly execute the Contract and all related documents, which shall be prepared by the University. Upon failure of the accepted manufacturer to execute such documents within four (4) business days after they have been presented for execution, such manufacturer shall be disqualified.
 - iii) Assignment of Contract and Payment:
 - (1) The University reserves the right to assign this Contract to the installing contractor for coordination and administration. In no event shall the responsibility of the manufacturer toward the University, as specified, be abrogated.
 - (2) The manufacturer shall agree to terms and conditions in the University, purchase order agreement and conditions specified herein. The manufacturer



shall invoice for payment at time of shipping and the University shall issue payment up to a predetermined percentage of invoiced amounts. The remaining percentage of the invoice shall be retained until acceptance by the University.

- iv) Codes, Rules, Permits and Fees: Nothing contained in this specification shall be so construed as to conflict with the standards of the National Fire Protection Association, or any local, municipal, State or Federal regulation governing the installation of the equipment specified herein, and the requirements of same. All such laws, ordinances, and regulations, which apply to this work, are hereby incorporated into and made a part of this Specification. Where applicable, materials and equipment shall bear stamps or seals of UL, IEEE, NEMA, ANSI, ASME, and other industry regulating groups. In case of difference between governing codes, specifications, laws, ordinances, industry and utility regulations, or contract documents, the most stringent shall govern. The manufacturer shall promptly notify the University, in writing, of such differences.
- v) Cooperation: The manufacturer shall submit, as required, all setting plans, templates, shop drawings, electrical wiring diagrams, etc., to insure proper space and functional relationship to other equipment and services.
- vi) Materials and Equipment:
 - (1) All materials and equipment shall be new, shall bear the manufacturer's name and shall conform to the grade, quality and standards specified herein. Type, capacity, and application shall be suitable and capable of satisfactory operation for the purpose intended.
 - (2) All materials and equipment should be adequately covered and protected against dirt, water, chemical or mechanical damage.
 - (3) No change in character or make of the material specified herein will be permitted at any time after the proposals are received. Manufacturers wishing for changes must make a written application to the University at least four (4) days prior to the time of closing of bids, and if such changes are approved by the University, each manufacturer who is involved will be notified.
- vii) Shop Drawings:
 - (1) Manufacturer shall furnish to the University one (1) PDF copy of such shop, erection, field and setting drawings or diagrams, dimensioned and in correct scale, to make clear the work intended or to show its relation to adjacent work or the work of other trades within ten (10) working days from award of Purchase Order Agreement. The Manufacturer shall make any changes to such drawings or diagrams as are required and shall resubmit one (1) PDF copy of the revised drawings for final review.
 - (2) Review of shop drawings by the University shall not imply verification of dimensions, or of information that pertains solely to the fabrication process or to techniques of construction, and shall not constitute a guarantee, final acceptance, or authorization of extra work, and shall not relieve manufacturer of responsibility to comply with contract documents.
- viii) Operating Instructions: Manufacturer shall include with the equipment one (1) PDF copy of assembly and/or installation instructions, parts lists, and periodic maintenance instructions, for all equipment being purchased. These materials shall accompany the equipment and be clearly identified.



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- ix) **Guarantee:** Manufacturer shall guarantee all labor and materials for a period of one year for operation, which shall include agreement to repair, replace in location, and make good at his expense, all defects which may appear in his work or materials during that time which, in the judgment of the University, arise from defective workmanship or imperfect or inferior materials. The guarantee period shall start after the installation of the equipment is complete and accepted by the University.
 - b) **Pre-Purchased Equipment:**
 - i) Technical data for the pre-purchased equipment and services are included herein for the benefit of the Contractor.
 - ii) The University, at the time of bidding and upon written request, will furnish complete pre-purchased equipment, services, specifications, purchase orders, shop drawings, and installation instructions of the pre-purchased equipment to the Contractors. Any items required for the installation, which are not included as pre-purchased equipment, will be furnished, and installed by the Contractor.
 - iii) It shall be the responsibility of the Contractor to receive the pre-purchased equipment from the University and relocate or transport same to their ultimate location and provide all assembly as required. The Contractor shall examine the components of all equipment when they are received and beyond the time, they are received by him, he shall assume all responsibility and prevent any abuse and damage during the installation period.
 - iv) The equipment manufacturers are responsible for exactness of all components of the equipment delivered and in the event the Contractor discovers inadequacies or missing components he shall contact the University immediately.
 - v) All pre-purchased equipment and accessories shall be installed and tested in accordance with the manufacturer's instructions and recommendations.
 - c) **Pre-Purchased Shop Drawings:**
 - i) The Contractor shall submit shop drawings and layout drawings for all work, all pieces of equipment to be constructed or installed and all items to be furnished by suppliers or subcontractors. They shall be submitted as required for the satisfactory performance of all work, or as directed, safe at the Contractor's own risk. Shop drawings shall include material lists, schedules, and complete details. Layout drawings shall clearly indicate the location and arrangement of all pieces of equipment, machinery, apparatus, ductwork, piping connections, inserts and other items. Unless otherwise specified, or indicated on the contract drawings, drawings submitted hereunder shall be on a scale 3/8-inch to a foot, and shall be complete, giving all required information. They shall be properly checked before submission to the Design Professional and shall be submitted sufficiently in advance of construction requirements to allow ample time for checking, correction, resubmitting, and rechecking.
 - ii) It shall be the Sheet Metal Contractor's responsibility to have prepared double-line detailed shop drawings in AutoCAD 2023 and to coordinate the layout of ductwork with all trades to avoid interferences with structural components, partition studs, conduits, cable trays, sprinklers, plumbing risers, piping, light fixtures, etc. Each trade will be responsible to prepare layout drawings on AutoCAD and submit electronically along with prints to the Sheet Metal Contractor who shall review, consult with each trade for changes, and jointly coordinate necessary changes. Sheet metal ductwork, because of its bulkiness, shall take precedence. At the conclusion



of the coordination process, each trade will sign off the documents indicating that all conflicts have been resolved to their satisfaction. Subsequently during the construction phase, any unforeseen changes to the work will be the responsibility of the respective trade to accommodate all others. At the completion of construction, each trade will incorporate all field changes on the AutoCAD data base and submit AutoCAD drawing(s) (with x-refs) and Adobe PDF electronic files on a CD or thumb drive along with three (3) sets of plotted prints for record purposes as part of project close-out documentation.

R. Space Management

1. It is the intent of all projects to have permanent building numbers and/or room numbers assigned during the Design Development Phase. It is the responsibility of the A/E to initiate and complete this process, with support and approval from the University's Space Management Department.
2. When a new building is added to the University's space inventory, A/E to notify the University's Space Management Department, who will assign a new building number under these general guidelines:
 - a) University City campus: Numbers below 100.
 - b) Leased buildings in University City: Numbers are in the 170+ range.
 - c) Center City campus: Numbers in the 200 series.
3. For renovation projects the University Project Manager must obtain the latest floor plans with room numbers from the University's Space Management system of record (FM: Systems).
4. When classifying and labeling rooms on drawings, A/E is to follow the Facilities Inventory and Classification Manual (FICM), 2006 edition, for room classification type. Space Management to provide clarification as needed.
5. Drawings provided to contractors or vendors are prepared by Drexel University for our own use and are provided to A/E as a courtesy. Drexel University makes no representation or warranty regarding the accuracy, completeness, or permanence of the drawing, nor for their suitability for any purpose.



II. DIVISION 01 – GENERAL REQUIREMENTS

01 24 13 Value Engineering

1. All Value Engineering (VE) exercises for a project are to include the University Project Manager, University Facilities, Prime Contractor, and A/E. All VE substitutions will be discussed at the meeting(s) and the A/E shall confirm all VE items are in fact equivalent and in accordance with this Guide and update drawings and specifications as required and redistribute to the Project Team.
2. Prime Contractor to provide a VE log with detailed items(s) description(s) and cost savings.
3. When hydronic piping material is value engineered all associated system valves are to remain as per this Guide. For example, solder copper piping is revised to Pro-Press piping; valves do not become Pro-Press also.

01 35 00 Special Procedures

1. The General Contractor or Lead Sub-Contractor (i.e. Mechanical Contractor) is required to complete Construction forms and submit to Project Manager for the University prior to performing any utility/system shutdown and/or hot work. Refer to the Drexel University Planning, Design & Construction website (<http://www.drexel.edu/facilities/design/forms/>) for the forms.

01 45 33 Code-Required Special Inspections and Procedures

1. All Prime Contractor is to confirm with the City of Philadelphia regarding the requirement for special inspections, i.e. third-party steel inspection.

01 56 26 Temporary Fencing: Construction Fence Screen Mesh Fabric

1. Required: When construction fencing is required, Contractor to provide screen mesh fabric to screen construction area in its entirety.
2. Fabric: 100% Polyethylene, Open Mesh.
3. Opacity: 80% - 90%.
4. Weight: Approx. 5 oz. per square yd.
5. Life: 3-5-year life.
6. Hems: Three-ply reinforced hems, with grommets at 2' intervals, on all sides.
7. Color: Navy Blue or Black. Submit sample to PD&C Project Manager for approval.
8. Coverage: Mesh must cover the entire fence, from top rail to bottom rail, and side to side.



9. Maintenance: Contractor required to maintain fabric with no gaps, holes, or tares for duration of project.

01 58 00 Project Identification: Construction Project Sign

1. Required: When construction fencing is required, Contractor to provide construction project sign as described below.
2. Quantity: One required for each project.
3. Design by: Architect or Landscape Architect.
4. Size: 6' high x 8' long.
5. Material: Fence screen mesh.
 - a. Fabric: 100% Polyethylene, Open Mesh.
 - b. Opacity: 80% - 90%.
 - c. Weight: Approx. 5 oz. per square yd.
 - d. Life: 3-5-year life.
 - e. Hems: Three-ply reinforced hems, with grommets at 2' intervals, on all sides.
6. Graphics to include:
 - a. Name of project.
 - b. Rendering of project, if available.
 - c. Names of design team firms.
7. Review: To be reviewed by PD&C Project Manager.
8. Maintenance: Contractor required to maintain fabric with no gaps, holes, or tares for duration of project.

01 79 00 Demonstration and Training

1. The contractor is required to fully instruct the representatives of the University in all details of operation of the equipment/system installed under their contract. A minimum of two (2) training sessions on spate days are required for all equipment due to shift work at the University, see below. One (1) training session is adequate for BAS training.
 - a) Tuesday at 3:15 pm.
 - b) Wednesday at 7:15 am.
2. The contractor is responsible for coordinating training dates with the University Project Manager and Manufacturers Representative(s) for days and times listed above.
3. All training sessions are to include hardcopies of equipment, O&M manuals and single line diagram(s) representing the system.



4. All training sessions are to be video recorded and saved on a DVD and flash drive.

01 91 00 Commissioning

1. Commissioning is to follow the City of Philadelphia Department of L&I Commercial Energy Code Compliance and Energy Code Checklists requirements.
2. A/E is responsible for incorporating all necessary commissioning documentation into the construction documents. A/E will either use commissioning documentation created by the Commissioning Authority (CxA), if contracted, or the commissioning sections in this Guide.
3. The CxA is responsible for creating/reviewing all commissioning documentation, i.e. specifications, checklists, etc.
4. The Commissioning process is a systematic procedure for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and design criteria. It shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.
 - a) Commissioning Scoping Meeting:
 - i) The scoping meeting brings together all members of the design, construction, and operations team that will be involved in the commissioning process. Each building system to be commissioned is addressed, including commissioning requirements, and completion and start-up schedules. During the scoping meeting, all parties agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.
 - b) Final Commissioning Plan:
 - i) The commissioning agent finalizes the draft Commissioning Plan using the information gathered from the scoping meeting. The initial commissioning schedule is also developed along with a detailed timeline. The timeline is fine-tuned as construction progresses.
 - c) Design Intent Documentation:
 - i) The design requirements, relative to the building systems selected for commissioning, must be explicitly documented to establish a baseline of performance expectations to which the actual installed performance is compared. The commissioning provider, with the assistance of the Owner and Design Team, prepares a Design Intent Summary that documents the design intent for those building systems selected for commissioning. The Design Intent Summary reflects the underlying assumptions and requirements that become represented in the construction documents.
 - d) Submittals:
 - i) The general contractor will provide the commissioning agent with a set of equipment and system submittals. This equipment data includes installation and start-up procedures, O&M data, performance data and temperature control drawings. The subcontractors, general contractor or A/E notify the commissioning agent of any new design intent or operating parameter changes, added control strategies and sequences of operation, or other change orders that may affect commissioned systems.



- e) Site Observation:
 - i) The Commissioning Agent makes periodic site visits to witness equipment and system installations. Each site visit will have a specific agenda and will be coordinated with the General Contractor Site Supervisor. The Commissioning Agent attends selected planning and job-site meetings to remain informed on construction progress and to update parties involved in commissioning. The General Contractor provides the Commissioning Agent with information regarding substitutions or change orders that may affect commissioned equipment or the commissioning schedule.
- f) Pre-functional Checklists and Startup Procedures:
 - i) A Pre-Functional Inspection Checklist are developed and completed for all equipment being commissioned. The checklist captures equipment nameplate and characteristics data and confirms the as-built status of the equipment or system. The checklists ensure that the systems are complete and operational and document the installation of components and completion of systems.
 - ii) The checklists are prepared by the Commissioning Agent from manufacturer's data, drawings, and specifications to include the required installation, checkout, and startup procedures. The installing Subcontractors will review the checklists and perform the checklists items, while the Commissioning Agent witnesses and completes the checklists before scheduling the functional performance testing.
- g) Development of Functional Test and Verification Procedures:
 - i) Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. The systems are run through all the sequences of operation and the response of components is verified. Testing proceeds from components to subsystems to systems, and finally to interlocks and connections between systems.
 - ii) The Commissioning Agent prepares functional performance test plans so that the complete sequence of operations is included. The Commissioning Agent obtains all documentation, including an updated points list, control sequences, and setpoints. If necessary, the commissioning agent may request clarifications from contractors and the design team regarding sequences and operation. Prior to execution, the Commissioning Agent provides a copy of the primary equipment tests to the installing Subcontractor and General Contractor who can review the tests for feasibility, safety, warranty, and equipment protection.
- h) Execution of Functional Testing Procedures:
 - i) The Commissioning Agent schedules functional tests through the General Contractor and Subcontractors. Under the supervision of the Commissioning Agent, the installing Subcontractor performs the hardware and/or software manipulations required for the testing. The Commissioning Agent witnesses and records the results of functional performance testing.
 - ii) Any deficiencies found from functional performance testing will be documented in a Deficiency Report. The report will include all details of the components or systems found to be non-compliant with the parameters of the functional performance test plans and design documents. The deficiency report will become part of the punch list. The report will detail the adjustments or alterations required to correct the system operation and identify the responsible party. The deficiency report will be continuously updated. The commissioning agent schedules any required retesting



through the general contractor. Decisions regarding deficiencies and corrections are made at as low a level as possible, preferably between Commissioning Agent, Sub-contractor, and General Contractor.

- i) Short-Term Diagnostic Monitoring:
 - i) Short-term diagnostic testing, using data acquisition equipment or building automation system trends to record system operation over a two-to-three-week period, may be used to investigate the dynamic interactions between components in the building system.
 - ii) The monitoring occurs after occupancy to evaluate the building systems' performance under natural occupancy and ambient load conditions. The objectives of the monitoring are to evaluate scheduling, the interaction between heating and cooling, and the effectiveness of the system in meeting the comfort requirements of the occupants.
- j) Operations and Maintenance Manuals:
 - i) The operation and maintenance manuals prepared by the Contractors for the Owner's Maintenance Personnel are reviewed for completeness. The Contractors are encouraged to submit O&M manuals at the earliest possible date. Materials may be added or requested from the Contractors to stress and enhance the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation. A database of preventative maintenance information may also be created from the materials in the O&M manuals.
- k) Training and Orientation of Owner Personnel and Occupants:
 - i) Effective Maintenance Personnel training is critical to the long-term performance of the new building. The Commissioning Agent will assist the Owner and General Contractor in organizing the training sessions by identifying the appropriate staff for each session and creating an overall training plan.
 - ii) For each training session, the Contractors provide a detailed agenda for each piece of equipment or system for which training is required. The agenda describes the training scope, duration, and methods, along with the name and qualifications of the trainers. The Commissioning Agent develops a plan for including in the training session Contractors / Trainers from different disciplines, when appropriate. The trainer documents each training session (duration, general subjects covered, and attendees). The Commissioning Agent may witness any of the training sessions.
- l) Warranty Period:
 - i) Seasonal variation in operations or control strategies may require additional testing during peak cooling and heating seasons to verify system performance. During the warranty period, seasonal testing and other deferred testing is completed as required to fully test all sequences of operation. The Commissioning Agent coordinates this activity. Tests are executed and deficiencies corrected by the appropriate Subcontractors, witnessed by the Commissioning Agent. Any final adjustments to the O&M manuals and as-builts due to the testing are made.
 - ii) The Commissioning Agent will request input from the Owner's Facilities Staff and Occupants about the performance of the building systems at month ten (10) of the one (1) year Contractor warranty. The Commissioning Agent also supports the General Contractor's troubleshooting process during the warranty period. The General Contractor's warranty team will first try and resolve the issues before requesting assistance from the Commissioning Agent.



- m) Commissioning Report:
 - i) A final Commissioning Report will be compiled which summarizes all of the tasks, findings, and documentation of the commissioning process. The report will address the actual performance of the building systems in reference to the design documents. All test reports by various Subcontractors, manufacturers and controlling authorities will be incorporated into the final report. The commissioning report includes:
 - (1) An evaluation of the operating condition of the systems at the time of functional test completion.
 - (2) Deficiencies that were discovered and the measures taken to correct them.
 - (3) Functional test procedures and results.
 - (4) Reports that document all commissioning field activities as they progressed.
 - (5) A description and estimated schedule of required deferred testing.



III. DIVISION 02 – EXISTING CONDITIONS

02 24 00 Environmental Assessment

The University Environmental Health and Radiation Safety (EH&RS) will provide Environmental Impact Evaluation (EIE) and Asbestos Inspection Report (AIR) reports prior to the beginning of construction. All asbestos materials, excluding roofing will be removed by EH&RS. All lead and asbestos in roofing will be the responsibility of the General Contractor. All hazardous material work will be performed by Certified Professional(s) as outlined in the Hazardous Materials sections below.

Hazardous Materials: It is expected that hazardous materials, including lead based painted substrates and asbestos containing building materials will be encountered in the work.

1. Lead Based Painted Substrates:

- a) Management of impacts to lead-based painted surfaces will be the responsibility of the Bidder by following the lead contamination mitigation & decontamination – Scope of Work, as outlined below:
 - i) The Bidder must exhibit expertise in the proper control of lead dust for all project work activities involving the impact of lead contaminated materials and/or debris by submitting dust control plans to [EH&RS Department](#) for review prior to the initiation of project activities. Dust control methods shall include but not limited to the use of containments, HEPA vacuum tool attachments, air filtration devices, sealed dust tight controls for trash chutes and collection dumpsters, and housekeeping.
 - ii) Decontamination:
 - (1) All non-porous surfaces shall be decontaminated by HEPA vacuuming and tri-sodium phosphate (TSP) wiping/mopping including, but not limited to ceilings, walls, windows, floors, doors, light bulbs and fixtures, furniture, unit vents, and miscellaneous items.
 - (2) All porous surfaces, including but not limited to furniture and carpet shall be moved back or relocated from the work area to avoid contamination.
 - (3) Safety Data Sheets (SDS) shall be provided to the [EH&RS Department](#) prior to the initiation of project activities.
 - iii) Disposal Requirements:
 - (1) Strict control of the construction debris must be maintained during all activities of this project.
 - (2) Lead contaminated debris can be disposed in the following three manners:
 - (a) Perform characterization test on the debris using the Environmental Protection Agency’s Toxicity Characteristic Leaching Procedure. If the test results are below the EPA limit, then the material can be disposed of as construction debris at a C&D facility.
 - (b) Dispose directly as hazardous in accordance with 40 CFR (Code of Federal Regulation) Parts 260 to 265 and PA 25 Article VII Hazardous Waste Management,
or
 - (c) For materials with a highly innate lead content that can be removed and disposed of in entirety, such fan units, and skylights; materials must be recycled.



*Note if Option 1 is chosen as the method of disposal, TCLP results are required to be provided to the [EH&RS](#) Department for review prior to the actual disposal of any materials.

- iv) Project Oversight:
 - (1) [EH&RS](#) will oversee the project until completion. The oversight will include but is not limited to environmental air and wipe sampling, ensuring compliance of proper dust control, cleaning effectiveness and disposal methods.
 - (2) Any cleanup required resulting from the spread of lead contamination will be charged to the Bidder.

- 2. Asbestos Containing Building Materials:
 - a) No touching, clamping, connecting, drilling, coring, or unauthorized abatement of any asbestos containing building material may occur.
 - b) All asbestos abatement work activities, [except for](#) caulking materials and roof components, must be conducted by a licensed asbestos abatement contractor/vendor contracted, coordinated, and scheduled through [EH&RS](#). Caulking materials and roof components must be removed by the University standard operating procedure (SOP) following OSHA Class II Training Requirements.
 - c) If any asbestos containing building materials are [accidentally](#) impacted and/or disturbed, the contractor must call the 24-hour emergency hotline at 215-895-2222 to initiate the proper emergency response from University personnel.



IV. DIVISION 05 – METALS

05 12 00 Structural Steel Framing

1. All structural platforms, grating, and dunnage are to be in accordance with OSHA regulations. Refer to section 07 71 00 for further documentation.

05 51 33 Metal Ladders

1. All ladders (metal, fiberglass, wood, etc.) are to be ANSI rated; Grade 1, Type IAA, 375 pounds special duty.
2. Alternating tread stairs are **prohibited**.

05 52 13 Pipe and Tube Railings

1. To limit the number of penetrations through an existing or new roof, Architect to consider using a non-penetrating guardrail system with architectural appeal. The guardrail shall meet or exceed the following criteria:
 - a) OSHA Regulations for Fall Protection.
 - b) Sightlines.
 - c) Self-supporting.
 - d) Manufacturer's installation requirements.
2. Basis of Design: BlueWater Manufacturing, SafetyRail 2000 Architectural Series, Incline Stanchion model. Architect to present substituted manufacturer(s) to University Facilities and Environmental Health and Radiation Safety Departments for Approval.



V. DIVISION 07 – THERMAL AND MOISTURE PROTECTION

1. General requirements – Codes and Standards:
 - a) Factory Mutual (FM) Global – All roofing and exterior envelope projects shall be submitted to FM Global Plan Review concurrent with the design development phase submission. The design professional shall incorporate FM review comments within the project documents prior to bid.
 - b) National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual.
 - c) Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - d) American Air Barrier Association (AABA).
 - e) Sealant Waterproofing and Restoration Institute (SWRI).
 - f) Occupational Safety and Health Administration (OSHA).
 - g) American National Standards Institute/American Society of Safety Engineers (ANSI/ASSE) Z359.2- 2007 – Fall Protection.

07 05 53 Fire and Smoke Assembly Identification

1. A/E is to define stencil height and colors for identification of fire and smoke rated walls.
2. Contractor is to provide stencil identification on all fire and smoke rated walls. Stencils are to be located above the ceiling line or as high as possible. If the wall is fully exposed and in a public area or a feature wall, consult with Project Manager for stencil location.

07 13 00 Sheet Waterproofing

1. Horizontal Application – Acceptable manufacturers: CETCO (CoreFlex preferred, Ultraseal acceptable) or Grace, Preprufe 300R, Preprufe 160R (blindside applications).
2. Vertical Application – Acceptable manufacturers: CETCO Envirosheet, Grace Bituthene, Carlisle CCW MiraDRI 860/861.
 - a) The University prefers the use of molded-sheet drainage panels/boards tied to a foundation perimeter pipe to collect and redirect all subsurface water to the below grade storm water management systems.
 - b) It is recommended that where vertical below grade waterproofing is required that proper drainage of subsurface water, such as a foundation drainage pipe be provided. Foundation drainage piping should be at a minimum dead level, 1/8-inch positive fall preferred.
3. Elevator Pits, Manholes, Etc.:
 - a) The University prefers the use of under slab/positive side waterproofing in lieu of negative side crystalline waterproofing application.
 - b) The University prefers a waterproof admixture within the design mix for below grade concrete structures.
 - c) Detailing of below grade waterproofing systems and vapor retarder systems should be clearly coordinated with appropriate manufacturers and detailed.



07 26 00 Vapor Retarders

1. A/E is to coordinate vapor barrier design when chilled beams are designed as the primary HVAC system. Refer to Section 23 82 14, Chilled Beams, for chilled beam design requirements.

07 27 00 Air Barriers

1. Fluid Applied Membrane Air Barriers:
 - a) Acceptable Manufacturers: Carlisle Barriseal or Barritech, Grace Perm-A-Barrier, Henry Air-Bloc.
2. Sheet Membrane Air Barriers:
 - a) Acceptable Manufacturers: Carlisle CCW-705, Grace Perm-A-Barrier, Henry Blueskin.
3. Accessory Materials:
 - a) The integrity of air barrier system relies on continuity. The Architect to design and detail the transition of the air barrier system to all fenestrations within the building enclosure. Compatibility of transition membranes, fenestrations, and visible perimeter joint sealants should be verified within the design and documentation phases.

07 52 16 Styrene-Butadiene-Styrene Modified Bituminous Membrane Roofing

1. Basis of design for all new and completely renovated roofs are to be Simplast two-ply Modified Bitumen roofing system. A/E is to coordinate with roofing manufacturer to select appropriate components.
2. Color: To be coordinated with Project Manager.
3. Insulation: Minimum R-20. A/E to verify thickness and type with the 2018 International Energy Conservation Code.
4. Warranty: Minimum of 10 years.

07 71 00 Roof Specialties

1. A/E is to design roof protection in the form of parapets, railings, or tie-off points. All protection will be in accordance with OSHA Regulations. A/E to coordinate with University Project Manager and Environmental Health and Radiation Safety Department.
2. Skylight construction to be able to withstand 200 lbs. of downward force or have a 42-inch parapet. If the construction does not have any of these features, then the skylight will need to have a railing or skylight screen that can withstand 200 lbs. of downward force.



07 72 13 **Manufactured Curbs**

1. All equipment roof curbs are to be as per equipment manufacturer or The Pate Company.
2. General Contractor is to verify that all equipment roof curbs are installed level, in line and at the correct height prior to mounting equipment.
3. All pipe penetration roof curbs are to be per The Pate Company with a gradated step assembly boot.
4. A/E to account for maintenance, snow removal, clearance for roofing, etc. when designing the height of roof curbs.

07 84 00 **Firestopping**

1. Install firestop systems where required by applicable code at openings through one side of a fire resistance rated wall, roof/ceiling, or floor/ceiling assembly, made to accommodate electrical, mechanical, plumbing, environmental, and communication systems.
2. Each system shall be designed and installed in accordance with the latest edition of the applicable Standards, including, but not limited to:
 - a) NFPA Standards.
 - b) Underwriters Laboratory, Inc. (UL):
 - i) ANSI/UL1479, “Fire Tests of Through Penetration Firestops”.
 - ii) ANSI/UL2079, Tests for Fire Resistance of Building Joint Systems”.
 - c) American Society for Testing and Materials (ASTM):
 - i) ASTM E-814, “Fire Tests of Through Penetration Fire Stops”.
 - ii) ASTM E-1966, “Test Method for Fire Resistive Joint Systems”.
 - iii) ASTM E-119, “Fire Tests of Building Construction and Materials”.
3. Performance criteria:
 - a) Systems shall be capable of preventing passage of smoke, flame, and hot gases sufficient to ignite cotton waste, when tested in accordance with ASTM E119.
 - b) Where systems are exposed to view, traffic, moisture, and physical damage, provide products that do not re-emulsify, dissolve, leach, breakdown or otherwise deteriorate when exposed to such conditions.
 - i) At piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
 - ii) At floor penetrations with annular spaces exceeding 4 inches wide and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads, by installing floor plates or by other means.
 - iii) At penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation. Provide products appropriately tested for the thickness and type of insulation utilized.
 - c) Materials shall be compatible with one another and with other items with which they may come in contact and shall not cause corrosion of penetrating items.



- d) Materials shall be free of solvents, asbestos, or PCB's, and non-toxic to human beings at all stages of application and during fire conditions.
 - e) Materials shall remain sufficiently flexible after installation to accommodate expected vibration and movement between penetrating items and rated building components or assemblies, or between adjacent building components or assemblies at joint systems. Materials shall not shrink noticeably after installation.
 - f) Provide fire-resistive joint sealants designed to accommodate a specific range of movement and tested for this purpose in accordance with cyclic movement test criteria as specified in Standards, ASTM E-1399, ASTM E-1966 or ANSI/ UL 2079.
 - g) Provide fire-resistive joint systems subjected to an air leakage test conducted in accordance with Standard, ANSI/ UL2079 with published L-Ratings for ambient and elevated temperatures as evidence of the ability of the fire-resistive joint system to restrict the movement of smoke.
 - h) Caulk, foam, mortar, and putty materials shall be auto bonding to permit changes to penetrating items.
 - i) Through penetration firestop systems provided shall be listed in the UL Fire Resistance Directory, or other approved testing agency, and shall be appropriate for intended use.
4. Contractor is responsible for firestopping all opening in the construction area.
5. Approved manufacturers are Hilti, Inc., 3M Fire Protection Products, Tremco, or approved equal.



VI. DIVISION 08 – OPENINGS

08 71 00 Door Hardware

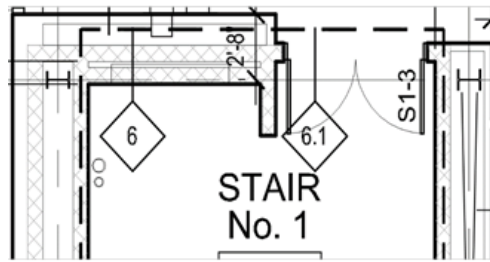
Incorporate, by reference, Divisions 8 into Division 26 and 28.

1. General:

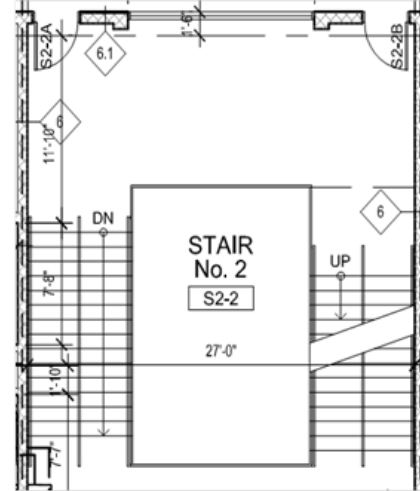
- a) The purpose of this section is to support the University Facilities design Guide for door hardware and keying and were originated for new building and renovation projects to provide a required level of quality and performance. University Facilities maintains the following hardware and is currently stocking replacement parts. The products listed in this section are limited and shall be specified **NO SUBSTITUTIONS** on new construction and renovation projects. If acceptable alternates are allowed, they will be specifically listed within the applicable section.
- b) It is the intent of this specification to provide guidelines for the Architect's specification section 08 71 00, for product groups and the hardware schedule. It is the responsibility of the Architect and their specification writer to coordinate all specified hardware to meet applicable building codes, life safety codes, third party certifications and ADA requirements.
- c) A/E and Contractor will contact the University's Door Hardware Consultant for the formulation of project hardware specifications, review of substitution request and submittal review. ASSA ABLOY will provide hardware specification services to A/E firms on behalf of the University when A/E firm is contracted for University non-housing projects. ASSA ABLOY contacts are provided below in section 1.e.
- d) Openings, with historic relevance, may require doors, frames, and hardware to be refurbished. Contractor and Supplier will be responsible to field verify existing conditions and refurbish or replace material in a style and quality that matches as closely. Renovation projects may involve other considerations and should be reviewed with University Facilities, and their consultants and the Project Manager.
- e) Contact information:
 - i) David Priest, University Specialist
 - (1) ASSA Abloy Door Security Solutions Tri-State.
 - (2) Phone number: 570-991-5203.
 - (3) Email: dpriest@dsstristate.net.
 - ii) [Patrick Doyle](#), Architectural Manager
 - (1) ASSA Abloy Door Security Solutions Tri-State.
 - (2) Phone number: [717-801-7017](tel:717-801-7017).
 - (3) Email: pdoyle@dsstristate.net.

2. Design Criteria:

- a) Whenever possible, design openings for either a 110° or 180° swing. If the available wall space is not wide enough to allow for 180° of swing (i.e.-stairwell), widen the opening to allow the doors to swing at approximately 90° - 110° to the wall. Design adjacent walls as necessary to ensure the degree of swing allows for use of floor or wall stops. See illustration examples below:



*Courtesy of James M. Karmolinski, AIA of
Kelly/Maiello Inc. Architects & Planners*



- b) Whenever possible, design banks of single doors with rim exit devices rather than pairs. In banks of doors, schedule one pair for moving larger items, and the balance as single doors. If large items must be moved through a paired opening, specify surface vertical rod exit devices with two rod guides per rod, equally spaced. Do not specify Conventional or Key Removable Mullions on paired openings.
 - c) All Mechanical Room, Electrical Room, Tele/Data Closets and Janitor Closets require the following door hardware: Door closer, latch guard and Storage room function lock.
 - d) Laboratory doors and new Tele/Data closets from common spaces require a card reader for access. Refer to section 28 10 00 for card reader specifications.
 - e) A/E to coordinate room numbering with Space Management as per section 10 14 19.
 - f) All exterior doors are to have rodent and pest type door sweeps and seals. Contractor to ensure no visible light is coming in around exterior door.
 - g) All exterior doors with card readers are to be on emergency power.
3. Technical Standards:
- a) Specify degree of opening and ensure coordination for every door, called out by individual door in submittals, and confirmed in the field regardless of the door-opening layout illustrated on the plans. It is not acceptable to install hardware based upon floor plan illustrations of door swing but shall be coordinated in the submittal phase and be optimum for the prevailing conditions at the opening. Any degree of opening that is in question shall generate an RFI submission and be resolved prior to any hardware being installed.
 - b) Finish hardware shall be installed in accordance with the manufacturer's recommended methods for installation and pertinent codes and regulations.
 - c) Specify that a Pre-Submittal Conference be conducted to coordinate compliance with requirements in Division 01 Section "Project Meetings" with attendance by representatives of Supplier(s), Installer(s), Contractor(s), University Project Manager and University Facilities to review proper methods and the procedures for receiving, handling, and installing door hardware. Requirements are:
 - i) Prior to installation of door hardware, arrange for manufacturers' representatives to hold a project specific training meeting to instruct the installing contractors' personnel on the proper installation and adjustment of their respective products. Product training to be attended by installers of door hardware (including electromechanical



- hardware) for aluminum, hollow metal, and wood doors. Training will include the use of installation manuals, hardware schedules, templates and physical product samples as required.
- ii) Inspect and discuss electrical roughing-in, power supply connections, and other preparatory work performed by other trades.
 - iii) After installation of all door hardware, arrange for manufacturers' representatives to accompany the project architect during punch list review to confirm installation accuracy and compliance with specification and manufacturer's directives. A punch list of action items will be produced by the manufacturer's representative and the architect for correction and will be confirmed on site once corrections have been made.
 - iv) A project specific training meeting to instruct the installing contractors' personnel on the proper installation and adjustment of their respective products be scheduled prior to hardware installation.
 - v) Review the required inspecting, testing, commissioning, and demonstration procedures.
 - vi) Specify that all door openings shall have a stop, and that it is the intention of the specification that an appropriate stop be provided for every opening, regardless of its presence in the hardware sets.
- d) Specify hardware sets consistent with requirements detailed herein. Require qualified supplier to develop hardware schedule.
 - e) Finish hardware shall be furnished with necessary screws, bolts, and other fasteners of proper size, type, and finish recommended by the manufacturer to securely anchor hardware in position for long life under hard use.
 - f) Fasteners shall be furnished with toggle bolts, expansion shields, sex bolts, and other anchors which are suitable for installation in materials to which finish hardware is applied, and as recommended by the hardware manufacturer.
 - g) Three (3) "push in" silencers shall be installed on strike-side of each single door frame stop; install two (2) silencers on head of double door frame stop.
 - h) Exposed fasteners shall harmonize with hardware as to material and finish.
 - i) Coordinate specification of new hardware with existing.
 - j) Specify matching finishes of new and existing hardware.
 - k) All doors are to be provided with surface mounted vertical rods with covers. Removable mullions are **prohibited**.
4. Continuous and Butt Hinges:
- a) Specify Markar FM300 x 630 heavy duty concealed leaf (edge mount) stainless steel continuous ball bearing hinges on all exterior aluminum and FRP doors and interior stairwell doors. Acceptable alternates are equivalent products by Hager and McKinney
 - b) Specify McKinney T4A3386 heavy-duty five (5) knuckle stainless steel based full mortise ball bearing hinges on all doors. Hinges to match the finish of the balance of the hardware. Acceptable alternates are equivalent products by Hager and Stanley.
 - c) Specify NRP non-rising pins for all interior and exterior steel outswing doors.
 - d) Specify stainless steel hinges and pins at exterior locations, boiler rooms, kitchens, swimming pools, and other wet atmosphere areas.
 - e) Specify that any existing special locking or security devices removed during alteration work shall be reinstalled.



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- f) Indicate all modifications of exterior doorsill substrates, if necessary to accommodate proper installation of threshold.
 - g) Specify that the hardware installers be certified installers and attend an installation seminar provided by the manufacturer's representative.
 - h) Specify that Contractor provide instruction to University personnel about adjustment and maintenance of hardware.
 - i) Specify submission of manufacturer representative's contact information, email address and telephone number for each type of hardware installed, to University field inspector, as part of closeout submittals package.
5. Locksets:
- a) Specify Corbin Russwin CL3300 Extra Heavy Duty Cylindrical Lever Locksets – No Substitutions.
 - b) Specify NZD Lever Trim.
 - c) Specify US26D/626 Finish.
 - d) All locksets shall be specified with Quick Code CT6 – Corbin Russwin format Interchangeable Core with Temporary Construction Core.
 - e) Large format.
 - f) Standard functions specified:
 - i) CL3310 Passage.
 - ii) CL3320 Privacy.
 - iii) CL3351 Entrance.
 - iv) CL3355 Classroom.
 - v) CL3357 Storeroom, including Mechanical Room, Electrical Room, Tele/Data Closets and Janitor Closets.
 - g) Security combination lockset to be Simplex L1021C-26D-41 / specify handing with Corbin Russwin keyway.
6. Cylinders and Keys:
- a) Specify Medeco X4 Patented Cores in Corbin Russwin Interchangeable Core format keyed to the existing University system.
 - b) For non-housing, academic, maintenance and business spaces, specify the 6 pin Medeco X4 32*2301 Corbin Russwin format interchangeable core, large format.
 - c) Cores shall be installed by the Contractor per the approved door hardware and keying schedule unless otherwise directed by the owner in writing.
 - d) All cores shall be factory master keyed by Medeco and combinate, unless otherwise directed in writing by University Management. University reserves the sole right to interpret, add, delete, or modify all provisions of the keying process to meet the specific needs of the University. Local or field keying by a distributor or supplier is unacceptable and will be rejected outright.
 - e) Provide temporary keyed construction cores for the contractors and owners use during construction – Corbin Russwin Quick Code CT6. Upon substantial completion, Contractor shall remove all construction cores and coordinate final keyed core installation with the University, who will accomplish all final core installations, Contractor will further coordinate with University so that security of lockable spaces within the project site security is not compromised.



- f) All codes and bittings, or any intellectual property related to the substance of said key system shall remain the property of the University.
- g) Provide six (6) master keys for each master key set. Provide three (3) change keys and two (2) blanks for each change key assigned. Provide two (2) control keys for core removal. Stamp keys with DHI standard visual key control identifier. If the University does not require three (3) change keys for some cores (numerous cores keyed alike, etc), on a project, provide the balance of the keys as blanks per Owner's request.
- h) For every project with one hundred (100) cores or more, provide two (2) extra Medeco X4 Key Blanks per core.
- i) The supplier shall be a Medeco factory authorized distributor that is approved by Medeco to purchase direct. Obtain a Blanket Letter of Authorization from Medeco authorized University personnel on University letterhead allowing said distributor to order for a specified period of time without a letter accompanying each order, as long as the products are drop shipping directly to University. Contractor shall verify presence of all ordered components in the presence of designated University personnel to ensure there are no shortages, and if so, they are properly documented and corrected. Key blanks shall only be shipped to authorized personnel at University upon written documentation and for a specified number of cores/keys/blanks for the project only.
- j) As soon as possible after final approval and ordering of the door hardware, contact the Architect, appropriate University personnel, and Medeco factory representative with a minimum two-week advance notice to schedule a keying meeting. The Medeco representative shall attend the keying meeting at the request of the University. Conduct additional keying meetings if required. Upon completion of the proposed keying schedule, forward it to the Architect and University for final confirmation prior to ordering.
- k) Medeco Representatives:
 - i) [Eric Rome](#), Director of Sales
 - (1) ASSA Abloy Door Security Solutions Tri-State.
 - (2) Phone number: [570-885-0796](tel:570-885-0796).
 - (3) Email: erome@dsstristate.net.
- l) Deliver all permanent key blanks and other security keys direct to Medeco registered University representative from manufacturer via secure courier, return receipt requested.
- m) Provide copy of all bittings, bitting list expansions, keyholders and locations on disc for direct importation into KeyWizard software. All information shall conform to KeyWizard Factory Key System Import Template, Keyholder Import Template and Location Import Template.
- n) Failure to properly comply with these requirements may be cause to require replacement of all or any part of the cylinders and keys involved as deemed necessary at no additional cost to the University. Any deviation from specified requirements shall be deemed defective material and rejected outright.
- o) If Mortise cylinder is required for special installation the University requires the following:
 - i) Corbin Russwin model 1070-112 A01-x626 – IC Mort. HSG x clover x 6 pin.
 - ii) Corbin Russwin model 3070-178-6x626 – IC rim cyl. less core, 6 pin.



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7. Exit Devices:
 - a) Specify Von Duprin 99 Series rim exit devices on all exterior single doors.
 - b) Specify Von Duprin 99 Series Surface Vertical Rod exit devices on all exterior and interior pairs of doors. Specify two (2) rod guides per rod – equally spaced.
 - c) Specify devices with cylinder dogging on all non-rated openings.
 - d) Specify 996L Trim with Corbin Russwin cylinder and cylinder collar as required.
 - e) Specify 316 Stainless Steel pulls only at doors with cylinders at main entrances. Use of 304 Stainless Steel is unacceptable.
 - f) Specify surface vertical rod exit devices, less bottom rod, on interior pairs of doors that are less than 64 inches in width. Specify two rod guides per rod - equally spaced.
 - g) Specify true architectural brass, bronze, chrome, or stainless-steel finishes. Stainless steel shall be specified unless the finish is otherwise noted.
 - h) Coordinate cylinder collars with exit device trim to ensure compatibility.

 8. Door Closers:
 - a) Specify LCN 4040XP closers (non-automated operator) – NO SUBSTITUTIONS.
 - b) Specify Norton 6000 Series closers (automated operator) – NO SUBSTITUTIONS.
 - c) Specify Top Jamb mount and Heavy Duty OH stop on all Main Entrances. Specify that all necessary support brackets and spacer blocks are included as required by opening.
 - d) Specify Heavy Duty Rigid Parallel arms whenever possible.
 - e) Do not specify stop arms of any type on closers - all interior doors shall swing 90°-100° or 180° degrees into an adjacent wall.
 - f) Closers are to be thru bolted to the doors.

 9. Stops and Holders:
 - a) Specify cast wall and floor stops for each door. All doors shall be furnished with an auxiliary stop. An overhead, wall, or floor stop shall be furnished whether scheduled or not, and as is found typically scheduled in the balance of the hardware sets. If no doorstop is scheduled (or if no specialized auxiliary door closer arm is listed), supplier shall provide an auxiliary stop, overhead, wall (or floor) stops for every door, which opens and impacts or opens into any fixed structure.
 - b) Specify Wall stops that have a metal encased rubber design with an anti-vandal feature that incorporates an imbedded steel washer in the rubber portion to prevent the bumper from being removed from the wall. All exposed fasteners shall be Security Torx type.
 - c) Specify Universal Dome floor Stop that is capable of stopping a door in both a low rise and a high-rise condition. Floor stops shall have the lip of a low-rise bumper and the dome of a high-rise bumper.
 - d) Specify magnetic holders that are capable of holding a door in a floor or wall application has a triple voltage coil that has the capability of working with 12, 24 or 120 Vac/dc and has an assortment of extensions that may be used to accommodate various applications.

 10. Door Bolts and Coordinators:
 - a) Specify BHMA grade 1 flush bolts and surface bolts as required for non-labeled openings. Specify self-latching flush bolts to comply with labeled fire door requirements. Use of automatic flush bolts is **prohibited**.
 - b) Specify a 24-inch flush bolt rod at bottom, and a 12-inch rod at top for doors up to 84 inches. Specify longer rods as necessary for taller doors.
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- c) Specify door coordinators with carry bars and closer mounting brackets where self-latching flush bolts are used.

11. Door Trim:

- a) Specify vandal resistant trim on exterior Hollow Metal doors, which have an exit device on the inside and require re-entry with a key by cylinder.
- b) Pulls should be thru bolted directly to the exit device.
- c) Specify Push plates that are 6-inch x 16 inch and beveled on four sides.
- d) Specify Pulls that are a minimum of 8 inches in length and mounted with a 4-inch x 16-inch push plate.
- e) Specify pulls that are ADA compliant.

12. Protective Trim:

- a) Specify kick plates as aluminum, on Utility area wood veneer doors. A/E to review location with the University, these should not be in public view. Kickplates to be 8 inches high, 0.050 thickness and beveled on four sides.
- b) Specify armor plates on areas that require extra protection from door damage including loading dock areas, kitchen areas or any place doors are subject to damage from carts and hand trucks. Armor plates are to be 36 inches tall or as label requirements dictate 0.050 thickness and beveled on four edges.

13. Weatherstrip:

- a) Specify 1/4 inch high, aluminum thresholds with a surface applied stop lip containing a neoprene bulb insert on all exterior openings. Threshold shall be a minimum of 6 inch in width. Set applied strip in a bed of sealant.
- b) Specify 1/4-inch-high flat thresholds on all interior stair tower doors. Thresholds to be as wide as the frame depth.
- c) Specify rigid jamb aluminum weatherstrip, with a neoprene bulb, at all exterior openings. Weatherstrip shall have the ability to be adjusted and cover gaps up to 1/8th of an inch.
- d) Specify stick-on weather-strip on all mullion faces where they come in contact with the door.
- e) Specify rigid aluminum sweeps with a brush seal and ability to cover gaps up to 1/2 of an inch.
- f) Specify 2-inch projecting aluminum rain drip caps on all exterior doors that are not under cover.
- g) Specify the finish of the weather-strip to coordinate with the door and frame color.

14. Acceptable Manufacturers:

- a) Acceptable manufacturers listed are subject to compliance with the requirements of this document and must meet the criteria of the standards listed herein. Manufacturers offering products that may be incorporated in this work shall reflect the standard of the University and are limited to the following:
 - i) Butt Hinges: McKinney, Hager, Stanley.
 - ii) Continuous Hinges: Roton, Pemko, Select.
 - iii) Cylindrical Locks: Corbin Russwin CL3300 Series – No Substitutes.
 - iv) Exit Devices: Von Duprin 99 Series – No Substitutes.
 - v) Keyed Cores: Medeco X4 in Corbin Russwin IC Format – No Substitutes.



- vi) Door Closers: LCN 4040 – No Substitutes.
- vii) Wall Stops: Rockwood, McKinney, Trimco.
- viii) Magnetic Holders: Rixson, Sargent, LCN.
- ix) Electric Strikes: HES, Folger Adam, Von Duprin.
- x) Electronic Accessories: Sargent, Securitron.
- xi) Power Supplies Securitron, Locknetics.
- xii) Pull Trim: Rockwood, McKinney, Trimco.
- xiii) Protection Plates: Rockwood, McKinney, Trimco.
- xiv) Weatherstrip: McKinney, Pemko, Reese.
- xv) Automatic Operators: Norton 6000 Series.
- xvi) Rodent & Pest Door Sweeps: Xcluder or approved equal.

15. Cabinetry Hardware:

- a) Provide cabinetry locks only when requested by the University. A/E to specify locks for cabinets to match the existing interchangeable core system. Approved manufactures and models are listed below:

Description	Manufacturer	Model / Series	Finish
Cam lock for Corbin/Ruswin IC	Olympus	CR25 series (1-1/8" cylinder)	26D
Door and drawer lock for Corbin/Ruswin IC	Olympus	CR1125 series (1-1/8" cylinder)	26D



VII. DIVISION 09 – FINISHES

1. Listed manufacturers are to be the Basis of Design and final finish selection are to be reviewed with University Project Manager, Staff and Faculty for approval.
2. All substitutions are to be presented to the University Project Manager for approval.
3. Contractor is to provide 10% attic stock per type of finish element as part of the project.

09 51 00 Acoustical Ceilings

1. University standard for general acoustical ceiling tile is:
 - a) Manufacturer: USG.
 - b) Style: Radar-ClimaPlus.
 - c) Color: White.
 - d) Size: 24-inch x 24-inch or 24-inch x 48-inch. Square edge.
 - e) Grid: Dx/DXL 15/16 inch.

09 62 00 Specialty Flooring

Flooring material for lab spaces are subject to final approval by the University during the design process. Vinyl composition tile, vinyl sheet goods, and resinous coatings are the preferred materials.

1. University standard for vinyl composition tile (VCT) is:
 - a) Manufacturer: Armstrong.
 - b) Style: Imperial texture.
 - c) Color: To Be Determined (TBD) by project.
 - d) Size: 12-inch x 12-inch.
 - e) Installation: Straight-line pattern. Do not quarter turn.
2. University standard for non-classroom vinyl sheet flooring is:
 - a) Manufacturer: Armstrong.
 - b) Style: Color Art Medintone Homogeneous Sheet.
 - c) Color: TBD by project.
 - d) Size: 6-foot rolls, welded seams.
3. University standard for resinous flooring is:
 - a) Manufacturer: Dex-o-Tex.
 - b) Style: Tek Crete SLCQ with Quick Glaze Topcoat.
 - c) Color: TBD by project.
 - d) Other: Integral base.
4. University standard for vinyl wall base is:
 - a) Manufacturer: Johnsonite.
 - b) Style: Cove base.
 - c) Color: TBD by project.



- d) Size: 4-inch high.
- 5. University standard for Classroom sheet flooring is:
 - a) Manufacturer: Mannington Commercial.
 - b) Style: Relay.
 - c) Color: TBD by project.
 - d) Size: 6-inch-wide roll goods with chemical seam sealer.

09 68 13 Tile Carpeting

- 1. University standard for carpet tile is:
 - a) Manufacturers: Interface, Shaw, Tandus or equal.
 - b) Style: TBD by project.
 - c) Color: TBD by project.

Note: A/E is to coordinate with University Project Manager for carpet tiles in classrooms. University has a separate Classroom Design Standard.
- 2. Tac-tile installation method is preferred by the University. A/E to evaluate substrate and application in schematic design phase to determine if tac-tile installation method is appropriate.

09 91 00 Painting

- 1. University standard for all paint is [Benjamin Moore](#) (no substitutions). [Vendor contact is Ricciardi Brothers at 215-462-8027. Representative contact is Linda Cipriano at linda.cipriano@benjaminmoore.com or 267-406-3494.](#)
- 2. When existing walls are to be repainted or patched and repainted, the contractor shall match the color as close as possible using the preferred University standard.
- 3. Painting of wiring is **prohibited**. Contractor shall take provisions to cover wires to maintain wire warranty. Especially critical for all data wiring!
- 4. Walls are as follows:
 - a) Common Areas, Offices, Conference Rooms: TBD by project.
 - b) Classrooms and Laboratories: [#960 Dove Wing](#).
 - c) Finish:
 - (1) Flat: All wall and ceiling types not mentioned under semi-gloss.
 - (2) Semi-gloss: Block walls and areas where GWB is to be wiped down.
 - (3) Block walls are to be painted with a filler material to fill in the pores and create a smooth finish.
 - d) [Any rooms already painted Sherwin Williams #6385 Dover White where only painting part of a room, should be a Benjamin Moore match to Sherwin Williams #6385 Dover White.](#)
- 5. Door frames are as follows:
 - a) Color: TBD by project.
 - b) Finish: Semi-gloss.



VIII. DIVISION 10 – SPECIALTIES

10 14 19 Dimensional Letter Signage

1. The University Project Manager will provide the standard details to the A/E for coordination. It is the University's option to purchase and install the signage independent of the Contractor.
2. Refer to section R – Space Management for additional information.

10 14 26 Post and Panel/Pylon Signage

1. **No smoking signs are to be manufactured by** Montgomery Signs. Contact Alan Glickman at alan@montgomerysigns.com or 610-231-4580.
2. Colors:
 - a. Background: Matthews Paint 20158 Statuary Bronze Metallic.
 - b. Lettering: Matthews Paint 02652 Garbo Silver (PMS Cool Gray 1C).
3. Size: 5-inch x 5-inch.

10 18 00 Informational Kiosks

1. A/E to specify area litter and recycling receptacle combination to be model SLTRA-180 LID, manufacturer to be Forms+Surfaces (no substitutions). Lid to be black polyethylene, body finish to be sandstone and graphic with “bottles & cans, paper, liter” written on it from left to right. Contractor to specify quantity, model, stainless steel finish, polyethylene lid color, lid graphics, liner without drain holes, and freestanding when placing the order.

10 28 00 Toilet, Bath, and Laundry Accessories

1. The following accessories are provided by University Facilities for Contractor to install. A/E is to use accessories for restroom planning and layout. All accessories are to be coordinated with ADA height requirements.
2. Hand Towel Dispenser: Kimberly-Clark, D2 hard Roll Towel Dispenser model 09073.
3. Bath Tissue Dispenser: Kimberly-Clark, D2 JRT Jr. Jumbo Bathroom Tissue Dispenser with Stub Roll model 09078.
4. Toilet Seat Cover Dispenser: Kimberly-Clark, In-Sight Toilet Seat Cover Dispenser model 09506.
5. Hand Soap Dispenser: Manual Push Style Dispenser with custom Drexel University logo, 1.25 L, metallic/black, model 4-Series, with RRD-4 refill. Website: www.dispenserhelp.com. Dispenser shall not be mounted to the mirror when multiple sinks are required.
6. ADA grab bars are to be stainless steel.



7. Toilet partition systems are to be phenolic floor mounted, basis of design to be Santana.

10 44 16 Fire Extinguishers

1. A/E and Contractor are to follow NFPA 10 requirements for portable extinguishers.
2. Contractor is to include location(s) of extinguisher(s) as part of submittal package.
3. Approved manufacturers are Kidde, Badger, and JL Industries.



IX. DIVISION 11 – EQUIPMENT

11 53 00 Laboratory Equipment

1. The approved chemical gas monitoring system is MSA TG5000 Gas Monitor.
 - a) A/E to coordinate with end users and EH&RS during design phase to determine which chemical sensors are required in the lab.
 - b) Gas monitoring equipment is to be installed in gas cylinder storage rooms or other specified areas.
 - c) The LED readout on the gas monitoring equipment is to be mounted on the wall, 60-65 inches above finish floor, in the space.
 - d) The gas monitoring equipment shall be in the space requiring testing.
 - e) A horn and strobe (Red/Amber) must be installed above the door outside of the space where the gas monitoring equipment is installed.
 - f) Warranty:
 - i. Transmitters shall be for 2 years.
 - ii. XCell Sensors shall be for 3 years, minimum.
 - g) Mounting Bracket: Stainless Steel and capable of supporting the transmitter.
 - h) The gas monitoring equipment must be connected to the building automation system as an alarm.
 - i) Gas monitoring equipment is to be on emergency power and a direct connection; plug-in style connection is **prohibited**.
 - j) The University's preferred MSA equipment vendor is Eastern Controls. Contact Joseph DeSanto, at 610-545-7122 or joseph.desanto@easterncontrols.com.

11 53 13 Laboratory Fume Hoods

1. The design and installation of Laboratory Fume Hoods and associated systems shall comply with the Laboratory Design Standard 2022, refer to Appendix A.
2. Fume hoods, snorkels, and other devices shall be provided with an LED airflow indicator. Indicator shall be located so that it is visible from the front of the fume hood and local exhaust unit. Indicator to be a Phoenix Controls Sentry Display (no substitutions).
3. Proper operation of chemical fume hoods must be demonstrated by the installing Contractor prior to project closeout. The required test is the ASHRAE 110 Test. The University requires the Contractor to subcontract the testing to ENV Services (no substitutions). The corporate office phone number is 1-800-883-3681.
4. A/E to add the following statement to the fume hood section of the specification:
 - a) Laboratory fume hoods shall achieve an average face velocity of 100 feet per minute (fpm) at a sash height of 18 inches. No one-test velocity reading within the test grid structure should vary by more than +/- 20% (i.e. 80-120 fpm based on the 100 fpm) of the average. The target rating for the tracer gas containment test cannot be above 0.10. If reading is +/- 20% or at/above 0.10 Drexel EH&RS will deem the face velocity test a failure and require a retest. Face velocity uniformity shall be achieved by installing a venture valve inside the ductwork. Refer to section 23 36 00.1 for venture valve specifications.



5. Fume hoods are to be numbered in accordance with the associated sequence, Phoenix valve, room number, i.e. FH-#-Phoenix valve tag-Room #.
6. Approved Manufacturers: BMC Manufacturing, ICI Scientific, Kewaunee Scientific Corporation – Laboratory Products Group, Labconco Corporation, and Hamilton Laboratory Solutions.



X. DIVISION 12 – FURNISHINGS

12 35 53 Laboratory Casework

1. Chemical Resistant Finish: Laboratory casework manufacturer's standard two-coat, chemical resistant, baked on finish consisting of prime coat and thermosetting topcoat, for a minimum thickness of 2 mils. Color to be white, unless directed by Project Manager.
2. Epoxy Countertops: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and with butt joints assembled with epoxy adhesive and concealed metal splines. Color to be black, unless directed by Project Manager.
3. Epoxy Sink: Molded in one (1) piece with smooth surfaces, covered corners, and bottom sloped outlet, 1/2-inch minimum thickness. Color to match epoxy countertop.
4. Phenolic Composite Shelves: Shelf configuration to be flat, 3/4-inch thick, with beveled edge and corners. Color to match laboratory casework.
5. Reagent Shelves: Shelf configuration to be flat, 3/4-inch thick, with beveled edge and corners. Color to match laboratory casework.
6. Pegboards: Material to match epoxy countertops with removable polypropylene pegs, and stainless-steel drip troughs with drain outlet and hose. Color to match epoxy countertops.
7. Faucet: Mixing faucet, deck mounted, 6-inch rigid/swing vacuum breaker gooseneck, white finish. Basis of design manufacturer to be WaterSaver, model CT414VB, or approved equal.
8. Approved Manufacturers: BMC Manufacturing, ICI Scientific, Kewaunee Scientific Corporation – Laboratory Products Group, Labconco Corporation, and Hamilton Laboratory Solutions.



XI. DIVISION 14 – CONVEYING EQUIPMENT

14 08 20 Commissioning of Elevators

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the elevator systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The elevator components that shall be included in the commissioning process include:
 - a) Hoist Motors.
 - b) Hydraulic Machines.
 - c) Elevator Pit.
 - d) Elevator Hoistway.
 - e) Controllers.
 - f) Signaling Devices.
 - g) Door Safety Devices.
 - h) Cab Interiors.
3. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power and fire alarm connections to the elevator system equipment.
 - b) Prior to completion of installation, submit “System Verification Checklists” to Engineer of Record and Owner for review.
 - c) Verify proper installation and performance of all elevator system services provided.
 - d) Complete System Verification Checklists and manufacturer’s pre-start checklists prior to scheduling acceptance and operating tests
 - e) Provide an elevator system technician to assist during functional performance testing.
 - f) Participate in the functional performance tests as required to achieve design intent.
 - g) Provide dates when governing authorities testing will be conducted.
 - h) Participate in O&M Training as required by project specifications.
 - i) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - j) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - k) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
4. Acceptance and Operating Tests:
 - a) The Owner shall witness acceptance and operating tests on the elevators. The appropriate Contractor’s and/or manufacturer’s representatives shall be on-site to perform the testing. Acceptance and operating tests shall be performed in accordance with manufacturer’s recommended procedures.



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- b) Contractors involved in the installation, fabrication, manufacturer, control, or designs of equipment shall be present at the acceptance and operating tests. A factory-authorized technician shall be on-site to conduct the testing.
5. Functional Performance Tests:
- a) Each elevator shall be tested in the presence of the Commissioning Agent (if applicable) and/or the Owner.
- b) The Functional Performance Tests do not take the place of the tests performed by the authority having jurisdiction.
- c) The Functional Performance Tests shall include the following, with the Commissioning Agent (if applicable), Owner, and authority having jurisdiction present:
- i) Elevator Hoist Motor: The elevator trade representative will demonstrate operational conformance to the project contract documents and prevailing code requirements. The operating testing includes loading the elevator to its rated capacity and operating the elevator continuously for thirty (30) minutes. The elevator will travel the full distance stopping at each level and proceeding immediately to the next level. During this test the temperature rise of the motor is recorded.
- ii) Hydraulic Machine: The elevator trade representative will demonstrate operational conformance to the project contract documents and prevailing code requirements. The elevator trade representative will field test and verify components connected to the elevator system, documenting the date, type of device, device location, response time, and sensitivity.
- iii) Controllers: The elevator trade representative will field test and verify operation of the controller to demonstrate conformance to the project contract documents and prevailing code requirements. The elevator trade representative will field test and verify the controller is receiving and displaying distance and velocity feedback from each elevator.
- iv) Signaling Devices: The elevator trade representative will demonstrate operational conformance to the project contract documents and prevailing code requirements. The elevator trade representative will field test and verify the operation of each signaling device on all floors for each elevator.
- v) Door Safety Devices: The elevator trade representative will demonstrate operational conformance to the project contract documents and prevailing code requirements. The elevator trade representative will field test and verify the operation of each door safety device on all floors for each elevator.
6. Owner Orientation and Training:
- a) The installation contractor or manufacturer's representative will provide the training. This training should include hands-on operational training. The Owner may choose to videotape this training for future use.
- b) The installation contractor shall provide the Owner with copies of all inspections and acceptance.
7. Warranty Review:
- a) The installation contractor shall provide an 11th month walk-through to observe the operation of the elevators. This will include a review meeting with the Owner's personnel to review the continuing maintenance service agreement, a discussion of warranty issues,
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maintenance practices, usage changes, and chronic problems, as well as other issues affecting the owner and the operation of the elevators.

14 20 00 Elevators

1. Elevators installed throughout campus shall comply with the following Codes:
 - a) Commonwealth of Pennsylvania Department of Labor and Industry Elevator Code, latest edition.
 - b) ASME/ANSI A17.1: Safety Code for Elevators and Escalators, 2016 Edition, as approved by the Commonwealth of Pennsylvania Department of Labor and Industry.
 - c) The Americans with Disabilities Act guidelines and regulations, ICC A117.1-2009, as approved by the Commonwealth of Pennsylvania Department of Labor and Industry.
2. Limited Use and Limited Access (LU/LA) type elevators are **prohibited**. If the Architect and/or Contractor determine that a LU/LA type of elevator is required due to existing conditions, they are to review with the University Project Manager and Facilities Department for approval.
3. The University mandates the use of non-proprietary equipment, particularly for the controllers. It is understood that non-proprietary companies have a hard time competing with the larger companies that typically provide proprietary systems.
4. Acceptable elevator companies that can be considered for new elevator installation include:
 - a) Non-Proprietary:
 - i) Code Elevator Company Inc., Steve Vogelmann, 215-443-5618.
 - ii) Elite Elevator Services, LLC, Michael Somers, 1-888-498-6180.
 - iii) Fairway Elevator Company, 215-288-6000.
 - b) Proprietary companies need to be reviewed with Drexel Facilities Management for approval.
5. The University prefers non-proprietary controllers only. Acceptable manufacturers of non-proprietary controllers include the following or University approved equal:
 - a) GAL Manufacturing Corporation – GALaxy Elevator Controls.
 - b) ECI Elevator Control Inc.
 - c) Motion Control Engineering.
6. Lighting:
 - a) The elevator car lighting shall be connected to a normal and an emergency circuit.
 - b) Elevator pits shall contain a vapor-proof fluorescent PL light.
7. Elevator Machine Room:
 - a) Appropriate ventilation shall be provided in the elevator machine room.
 - b) No water pipes shall be permitted to pass through the elevator machine room.
 - c) One ground fault circuit interrupt (GFCI) receptacle and one floor drain, or sump pump shall be installed in the elevator pit.
8. Provide elevator wall protection (blankets) for all new and refurbished elevator cabs.



9. All diagnostic tools are to be provided by the elevator manufacturer.
10. Machine room-less elevators are **prohibited**.
11. Elevator controllers are to be designed/selected with integral air conditioning unit(s). This will allow for the elevator machine room to have a general ventilation system design, as stated in item 7.a) above.



XII. DIVISION 21 – FIRE SUPPRESSION

21 00 00 Fire Suppression

1. All new buildings and renovations to existing buildings shall be fully sprinkled. The design and installation of these systems must be in accordance with current City of Philadelphia, Commonwealth of Pennsylvania, and International Fire Codes, as well as any additional requirements provided by the University’s Insurance Underwriter.
2. Each system shall be designed and installed in accordance with the latest edition of the applicable NFPA Standard, including, but not limited to:
 - a) NFPA 10 – Standard for Portable Fire Extinguishing.
 - b) NFPA 12 – Standard on Carbon Dioxide Extinguishing Systems.
 - c) NFPA 12A – Standard on Halon 1301 Fire Extinguishing Systems.
 - d) NFPA 13 – Standard for the Installation of Sprinkler Systems (for all sprinkler systems, including residential living facilities).
 - e) NFPA 14 – Standard for the Installation of Standpipes and Hose Systems.
 - f) NFPA 17 – Standard for Dry Chemical Extinguishing Systems.
 - g) NFPA 17A – Standard for Wet Chemical Extinguishing Systems.
 - h) NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection.
 - i) NFPA 70 – National Electrical Code.
 - j) NFPA 72 – National Fire Alarm and Signaling Code.
 - k) NFPA 101 – Life Safety Code.
 - l) NFPA 2001 – Standard on Clean Agent Fire Extinguishing Systems.
3. Documents submitted for Authority approval and permit applications shall be completed by a NICET Level III or Level IV certified designer in water-based extinguishing system layout or a licensed Fire Protection Engineer.
4. Fire pumps, risers, floor connections and associated alarms have been provided for most existing buildings and all floors.
5. All devices and equipment installed in the fire suppression systems shall be approved and listed by Underwriters Laboratories and/or Factory Mutual.
6. The A/E should make early contact with the University’s Fire Safety Specialist to ascertain any building-specific requirements.
7. Prior to final approvals by the University, the A/E shall submit plans and specifications to the FM Global for approval. These approvals shall then be submitted to the University.
8. All projects involving street-pressure sprinkler systems, street-pressure fire standpipe systems, or fire pumps require hydrant tests on the mains in all streets that can be used to feed the building. Historical data may or may not be available from the University or the Philadelphia Water Department.



9. All sprinkler lines shall be equipped with an inspector's test connection piped directly into a drain capable of handling discharge from a fully opened test valve.
10. The Contractor's final shop drawings and specifications shall be submitted to FM Global for approval prior to submittal to the University for Approval.
11. Final acceptance tests of the sprinkler and standpipe system in accordance with and as required by NFPA Standards must be conducted by a Contractor licensed and certified by the City of Philadelphia, Department of Licenses, and Inspection. The University's Insurance Underwriter shall be notified at least three (3) working days prior to the test to schedule their attendance at the acceptance testing. A copy of the Certificate of Compliance shall be submitted to the University Project Manager prior to Project Close-Out.
12. Contractor shall refer to Section III of the City of Philadelphia Department of Public Health Air Pollution Control Board – Air Management Regulation XV, Control of Emissions from Emergency Generators and Fire Pumps, regarding fire pump operation to determine if operation is during ozone season.
13. All equipment is to be individually scheduled.
14. Project Close-out Documents for the Fire Suppression systems include:
 - a) As-built drawings detailing all installed systems and indicating the location of all control valves.
 - b) Certification of Acceptance Tests.
 - c) Copies of any approvals obtained from the City of Philadelphia or FM Global.
 - d) Operation and Maintenance Manuals for any equipment installed.
 - e) Execution of training for University personnel on the operation of any new fire suppression equipment (e.g. pumps, compressors, etc.).
15. All new equipment is to be provided with software and hardware necessary for University Facilities to have the ability to troubleshoot and/or configure any field equipment. Equipment manufacturer is to provide software and hardware as part of closeout package.
16. The following is a list of **prohibited** installations and require University approval for their installation:
 - a) Wet fire sprinkler systems in which any component may be exposed to outdoor conditions.
 - b) Diesel-engine driven fire pumps (use electric pumps only).
 - c) Welded sprinkler piping.
17. A/E to coordinate that all materials used in this sprinkler installation should be FM Approved, if not A/E is to notify University Project Manager. FM Approved products are all marked with the "FM Diamond." This includes, but is not limited to, sprinklers, sprinkler piping/fittings, pumps, pump controllers, fire alarm systems and smoke detectors. The Approval Guide, a publication of FM Approvals, may be referenced at www.approvalguide.com. Sprinklers are to be FM Approved.



18. FM Global recommends all hydraulic calculations to be based on a water test completed within one calendar year of when the project is to begin construction.
19. Sprinkler design densities are to be:
 - a) Light Hazard – 0.10 gpm/sq.ft. over the most remote 1500 sq.ft., including 250 gpm hose allowance.
 - b) Ordinary Hazard – 0.15 gpm/sq.ft. over the most remote 2500 sq.ft., including 250 gpm hose allowance.
 - c) Equipment Type/Mechanical Rooms – 0.20 gpm/sq.ft. over the most remote 2500 sq.ft., including 250 gpm hose allowance.
20. All hydraulic calculations are to be provided with a safety factor of 10 psi.
21. Sprinkler shop drawings, hydraulic calculations, and product data shall be submitted for approval prior to beginning work. No work shall commence until approval from the Engineer, Authority having Jurisdiction and Owner's Insurance Carrier have been obtained. All sprinkler submittals shall follow NFPA-13 requirements stated in Chapter 23-Plans and calculations. Review of contractor's sprinkler submittals by the Engineer shall be in strict compliance to Chapter 23 requirements. Sprinkler contractor shall submit approved plans and calculations from the Authority having Jurisdiction and Owner's Insurance Carrier to the engineer prior to the Engineer's final submittal approval. No variations of the above requirements will be entertained.
22. Contact information for the University's Sprinkler Contractor: [Oliver Fire Protection](#) – [Pat Doyle](#), 610-496-3422 and pdoyle@OliverFPS.com.

21 05 48 Vibration and Seismic Controls for Fire-Suppression Piping and Equipment

1. A/E to determine if vibration and seismic controls are required for the project.
2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

21 05 53 Identification for Fire-Suppression Piping and Equipment

1. All fire suppression piping and equipment shall be required to be labeled to comply with OSHA and ANSI/ASME A13.1-2015 standards for the identification of systems.
2. The marking system shall identify the contents, size, direction of flow, and operating characteristics (i.e. pressure and/or temperature).
3. All valves, drains, and controls shall be labeled using plastic I.D. tags securely connected to the specific item using brass chain or "S" hooks. The contractor shall provide a list of each tagged item and its function and a valve chart in the main Sprinkler or Mechanical Room.



4. All equipment must be identified using phenolic nameplates and labeled in accordance with the nomenclature used on the drawings and compatible with the MIMS System.

21 08 00 Commissioning of Fire Suppression

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the fire suppression systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The fire suppression components that shall be included in the commissioning process include:
 - a) Sprinkler Systems.
 - b) Standpipe Systems.
 - c) Fire Pump.
 - d) Jockey Pump.
 - e) Fire Protection Vault.
3. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power and fire alarm connections to the fire suppression equipment.
 - b) Prior to completion of installation, submit "System Verification Checklists" to Engineer of Record and Owner for review.
 - c) Verify proper installation and performance of all fire suppression system services provided.
 - d) Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling acceptance and operating tests.
 - e) Provide a fire suppression system technician to assist during functional performance testing.
 - f) Participate in the functional performance tests as required to achieve design intent.
 - g) Provide dates when governing authorities testing will be conducted.
 - h) Participate in O&M Training as required by project specifications.
 - i) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - j) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - k) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
 - l) Provide written certification documenting that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the Fire Protection Trade Representative re-certifying that he has inspected the work and that it has been completed and functioning as designed. This certification must be submitted prior to the final verification.
 - m) Correct labeling equipment, valves, drains and test locations.



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- n) Prevailing code compliance certified performance of fire protection system.
 - o) Reporting characteristics and installation of fire protection system complete and fully functional per contract documents.
 - p) Fire protection contractor's material and test certificate for aboveground and below ground piping.
 - q) Provide set of record as-built drawings to the Engineer of Record for inclusion into record documents.
4. Start-Up:
- a) The installing contractor shall perform start-up of the fire pump and jockey pump. The appropriate contractors and/or manufacturer's representative shall be on-site to perform start-up. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the manufacturer's recommended procedures. The Owner will visit the site to review completeness of installation in conjunction with progress meetings prior to starting equipment.
 - b) Contractors involved in installation, fabrication, manufacturer, control, or designs of equipment shall be present at the time of start-up. A factory-authorized technician shall be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment online and expedite acceptable functional performance.
5. Functional Performance Tests:
- a) Each major system will be tested. This will be coordinated and witnessed by the Owner. Witnessing the functional performance tests will serve as a compliment to the O&M Training. No tests will be performed until the system and related subsystems have been started and documented through point-to-point checklists and other documentation.
 - b) The Functional Performance Tests shall include the following, with the Commissioning Agent (if applicable), Owner, and authority having jurisdiction present:
 - i) Sprinkler System: The fire protection trade representative shall demonstrate hydrostatic, operational, and main drain testing of the system. These tests shall meet the requirements of NFPA 13 and the AHJ. The fire protection trade representative shall hydrostatically test the system, placing the system under a working water pressure of 200 psi for a period of 2 hours or by an approved method from the AHJ. A visual loss in gauge pressure or visual leakage shall be considered a failure in testing. The leak in the system shall be repaired and the system will require testing again in the same manner. The fire protection trade representative shall coordinate the operational testing with the fire alarm contractor. The fire protection trade representative shall open the inspector's test connection, the water gong shall sound within 5 minutes and the fire alarm shall be initiated within 90 seconds. The fire alarm trade representative shall conduct a main drain test. The fire protection trade representative shall open the main drain and it shall remain open until the system stabilizes. The static and residual pressures shall be recorded.
 - ii) Standpipe System: The fire protection trade representative shall demonstrate hydrostatic and flow testing of the system. These tests shall meet the requirements of NFPA 13, 14 and the AHJ. To hydrostatically test the system the fire protection trade representative shall place the system under a working water pressure of 200 psi for a period of 2 hours or by an approved method from the AHJ. The pressure shall be monitored using a pressure gauge installed at the top of each standpipe. A visual



loss in gauge pressure or visual leakage shall be considered a failure in testing. The leak in the system shall be repaired and the system will require testing again in the same manner. The fire alarm trade representative shall coordinate the flow test with the local fire department. The flow test shall meet the requirements of NFPA 14 and the AHJ.

- iii) Fire Pump: The fire protection trade representative shall demonstrate acceptance testing of the fire pump system. The fire protection trade representative shall conduct the field acceptance test with the manufacturer's representative according to NFPA 20. The fire protection trade representative shall provide all testing equipment. The fire protection trade representative will demonstrate fire pump controller acceptance testing.
 - iv) Jockey Pump: The fire protection trade representative shall demonstrate acceptance testing of the jockey pump. The fire protection trade representative shall conduct the field acceptance test with the manufacturer's representative according to NFPA 20. The fire protection trade representative shall provide all testing equipment. The fire protection trade representative shall demonstrate jockey pump controller acceptance testing.
 - v) Fire Protection Vault: The fire protection trade representative shall demonstrate a hydrostatic and flow test of the system. These tests shall meet the requirements of NFPA 13, 14 and the AHJ.
6. Owner Orientation and Training
- a) The installing contractor shall provide the Owner comprehensive training in the understanding of the systems and operation and maintenance of each major piece of equipment.
 - b) The installation contractor or manufacturer's representative will provide the training. This training should include hands-on operational training. The Owner may choose to videotape this training for future use.
 - c) The training shall include start-up, operation in all modes possible, shutdown and any emergency procedures.
 - d) The training shall include a review of all systems using simplified system schematics including riser diagrams, valve locations, and equipment locations.
 - e) The installation contractor shall provide the Owner with copies of all inspections and acceptance.
 - f) The manufacturer's representative shall provide instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Qualified service engineers employed by the manufacturers, or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed. The start-up and shut-down modes of operation shall be demonstrated. Emergency operations shall be demonstrated.
 - g) The Contractor shall attend all sessions and shall add to each session any special information relating to the details of installation of the equipment as it might impact the operation and maintenance.
 - h) The installing contractor shall assist in the coordination of yearly testing, calibrating, and servicing as specified in the contract documents.



21 10 00 Water-Based Fire-Suppression Systems

1. Aboveground Piping:
 - a) Up to and including 2-inch: Schedule 40; Type E, Grade B or Type S, Grade B.
 - b) 2-1/2-inch and larger: Schedule 40; Type E, Grade B or Type S, Grade B.
 - i) Note – 2-1/2-inch and larger: Schedule 10; Type E, Grade B or Type S, Grade B may be used for risers only. Prior to design or use the A/E and/or Contractor is to obtain approval from University Facilities and provide documentation cost savings.
2. Aboveground Pipe Fittings:
 - a) Up to and including 2-inch: Threaded.
 - b) 2-1/2-inch and larger: Grooved.
 - c) Branch connections:
 - i) Weldolet and sockolet fittings are allowed on schedule 40 pipe.
 - ii) Merchant couplings and non-reinforced type fittings are **prohibited**.
3. Aboveground Pipe Welding:
 - a) Welding of Schedule 10 pipe is **prohibited**.
 - b) Welding of Schedule 40 pipe 2-inch and smaller is **prohibited**.
 - c) Schedule 40 pipe 2-1/2-inch and larger is to be socket or butt welded.
4. Sprinklers:
 - a) Approved manufacturers are Tyco Fire & Building Products, Viking Corporation, and Reliable Automatic Sprinkler Company.
 - b) Sprinkler Escutcheons and Guards: Type suitable for sprinkler head used and manufactured by sprinkler manufacturer.
 - c) Provide spare sprinklers for each type used in accordance with NFPA 13.
 - d) Provide one (1) special wrench for each type of sprinkler in each sprinkler cabinet for installation and replacement of sprinklers.
 - e) Sprinklers located in Tele/Data Closets are to be as high as possible and contain a safety cage.
 - f) Sprinklers located in Equipment Type/Mechanical Rooms are to have an orifice size of K-8.0.
5. All firewater services must be provided with a backflow prevention device of a type and in a location in accordance with the Philadelphia Water Department Cross Connection Control Program.
 - a) The basis of design shall be Ames Fire & Waterworks, Series 2000SS double check valve assembly principal backflow preventer (no substitutions).
 - b) The basis of design configuration shall include two full-size backflow preventers installed in parallel to permit continuous, uninterrupted water service during testing and maintenance.
 - c) Each assembly shall be provided with FM-approved epoxy-coated flanged OS&Y gate valves.
 - d) A sanitary drain shall be provided directly below the assemblies for relief valve discharge.



21 13 16 Dry-Pipe Sprinkler Systems

1. All sprinkler piping located in an unconditioned space, i.e. outdoors, attic, overhang, etc., must be a dry pipe system.

21 13 19 Preaction Sprinkler Systems

1. Preaction sprinkler systems are required in switchgear rooms.

21 20 00 Fire-Extinguishing Systems

1. A/E to design gaseous type system, i.e. FM200 or Novec, for data centers.
2. Any type of water system is **prohibited** in data centers.

21 31 13 Electric-Drive, Centrifugal Fire Pumps

1. A/E to coordinate with the University to determine if an electric-driven or diesel-driven fire pump is required for a project.
 - a) If a building is being renovated and requires a fire pump to operate the sprinkler system a diesel pump may be required if the electric service is not large enough for an electric fire pump. Drawback to a diesel fire pump is the requirement of exercising the pump once a month instead of a once-a-year acceptance test for the electric pump.
 - b) In a high-rise building, approximately 45 floors or more, with no intermediate mechanical room a diesel pump will be the better choice and be able to get you the 100 PSI pressure requirement at the top of the building.
2. Fire pumps, controllers, and automatic transfer switches are to be UL listed and Factory Mutual Approved.
3. Electric Fire Pump:
 - a) Approved manufacturers are A-C Fire Pump, Armstrong Pumps, Aurora Pentair Water, Patterson Pump Co., and Peerless Pumps.
 - b) Factory packaged unit, UL listed, and FM approved, horizontal split case, centrifugal fire pump, including pump drive, controller, and accessories, with performance requirements shown.
 - c) Base: Mount fire pump and pump drive on a common steel bent form or cast-iron base plate. Align pump and motor before and after pump base has been installed and grouted in place.
 - d) Minimum Pump Capacity: 150 percent of rated capacity, at not less than 65 percent of rated total head pressure.
 - e) Maximum Shutoff Pressure: 120 percent of rated pressure.
 - f) Casing: Cast iron, 30,000-psi minimum tensile strength, bearing housing supports, and suction and discharge flanges integrally cast with lower half pump casing. Make upper half-removable without disconnection of suction and discharge of casing flanges.



- g) Impeller: Bronze, enclosed, keyed to shaft, and held in place with threaded shaft sleeves, dynamically balanced at factory. Contractor to confirm stress cracks are not present in impeller.
 - h) Shaft: SAE 1045 steel with key locked and threaded bronze sleeves, designed to tighten upon rotation of shaft.
 - i) Gasket Seal: Between impeller hub and shaft sleeve.
 - j) Casings Rings: Renewable type, designed to seat against a shoulder in pump casing around full periphery of wearing ring. Lock wearing rings by dowelling to prevent rotation.
 - k) Bearings: For rotating parts, provide heavy-duty grease-lubricated ball bearings with water slingers. Design bearing housing to flush lubricant through bearings.
 - l) Lantern Ring: Connected to pressure side of pump.
 - m) Stuffing Boxes: With stainless steel swing bolts, nuts, and fasteners for packaging.
 - n) Driver: Vertical, open drip proof ball bearing, AC induction squirrel cage 'P' face motor, 460 Volts, 3 Phase, 60 Cycles, (solid state soft start, wye-delta, across the line, part winding, or primary resistance reduced voltage) start. Locked rotor current shall not exceed values specified in NFPA 20.
 - o) Provide flexible coupling and coupling guard.
 - p) Piping from the packing gland on each sleeve bearing to the drain be in sprinkler rated PVC.
4. Fire Pump Controller and Automatic Transfer Switch:
- a) Approved manufacturers are Joslyn Clark Corp. and Metron Inc.
 - b) House fire pump controller and automatic transfer switch in a NEMA 3R enclosure in separate barriered compartments. Complete package shall be UL listed and FM approved for fire pump service. Provide enclosure with floor mounting feet.
 - c) Fire Pump Controller:
 - i) UL listed, FM approved combined manual/automatic type suitable for (closed circuit, open circuit, transition wye-delta, or solid state soft) starting, meeting requirements of NFPA 20 and NFPA 70. House in a NEMA (2 (drip proof), 3R (rain tight), 4 (watertight) or 12 (dust tight)) enclosure. Factory assemble, wire and test. Mark "Fire Pump Controller".
 - ii) Isolating Switch and Circuit Breaker: Motor rated and capable of interrupting motor locked rotor current. Mechanically interlock isolating switch and circuit breaker assembly with a single externally operated handle. Mechanically interlock operating assembly with enclosure door.
****(ii) OR (iii)****
 - iii) Circuit Breaker: Motor rated and capable of interrupting motor locked rotor current. Provide an externally operated handle. Mechanically interlock operating assembly with enclosure door.
 - iv) Circuit breaker shall accommodate a short circuit rating of not less than 100,000 amperes RMS at 480 volts. Trip functions shall be self-contained within circuit breaker case and not require additional current transformers or voltage sources to accomplish trip function. Breaker trip curve adjustments shall be capable of being field tested to verify actual pick-up, locked rotor, and instantaneous trip points after field installation, without disturbing line or load wiring.
 - v) Equip controller with pilot lights indicating "Transfer Switch Normal", "Transfer Switch Emergency", and "Emergency Isolating Switch Off" conditions. Provide test



- and transfer bypass switches, alarm bell, and "Alarm Silence" push button mounted on front of enclosure.
- vi) Provide front mounted "Power On" pilot light, "Start" and "Stop" pushbuttons, and "Emergency Run" mechanism. "Power On" pilot light shall indicate loss of control transformer power as well as line power. Remote alarm at central fire alarm panel specified under Division 28.
****(vi) for fire alarm panel in constantly attended location OR (vii) when other remote annunciation is required****
 - vii) Provide front mounted "Power On" pilot light, "Start" and "Stop" pushbuttons, and "Emergency Run" mechanism. "Power On" pilot light shall indicate loss of control transformer power as well as line power. Provide and wire power failure, pump running, phase reversal and phase failure alarm contacts to terminals rated 0.25 amps at 24 Vdc for remote alarm. Remote alarm panel where shown.
 - viii) Combination Pressure Indicator/Pressure Switch: Mount on front of controller enclosure. Unit shall be adjustable for combined pressure settings, with a minimum differential of 6 psi (41.4 kPa).
 - ix) Fit controller with a minimum run timer and timer pilot light.
 - x) Provide separate voltage surge protective devices connected between cabinet grounding lug and ground, and between each line terminal of isolating switches and ground. These devices shall be rated to suppress voltage surges above rated line voltage.
 - xi) Provide equipment status and general alarm contacts for remote monitoring by Building Management System.
 - xii) Cable and conduit shall enter panel from side or bottom.
- d) Automatic Transfer Switch:
- i) Provide built-in emergency power transfer switch equipment, factory assembled, wired, and tested unit, furnished with main fire pump controller, meeting requirements of NFPA 20 current edition, Section 10-8 and NFPA 70. Mark unit, "Automatic Transfer Switch".
 - ii) Include a motor rated disconnect/isolating switch capable of interrupting motor locked rotor current.
 - iii) Transfer switch sensing circuitry shall be capable of sensing both normal source and emergency source. Set normal source pick-up at 95 percent and drop out at 85 percent nominal voltage. Set emergency source to pick-up at 90 percent of nominal voltage and 95 percent of nominal frequency. Transfer signal shall be delayed for one second to override momentary normal power outages, delaying transfer and motor start signals.
 - iv) Manufacture switch for fire pump controllers to accommodate a short circuit current of 100,000 amperes RMS minimum.
 - v) Provide both normally open and normally closed auxiliary contacts for remote annunciation of transfer switch position. Switch shall be electrically operated/mechanically held, and capable of being operated by a manual transfer at switch under load.
 - vi) Cable and conduit shall enter panel from side or bottom.



5. Jockey Pump:
 - a) UL listed and FM approved horizontal centrifugal jockey pump with electric pump drive, controller and pressure switch with performance requirements shown.
 - b) Construction: Bronze fitted; with mechanical seal and relief valve; close coupled; driven by a 460 volt, 3 phase, 60 cycle, open drip proof motor.
 - c) Control Panel: Wall mounted NEMA (2 (drip proof), 3R (rain tight), 4 (watertight) or 12 (dust tight)) enclosure, containing a fused disconnect switch, magnetic A-T-L starter, H-O-A selector switch, overload relays and circuitry to provide automatic start and stop from panel mounted pressure switch. Provide dual element time-delay fuses sized for motor requirements.
 - d) Cable and conduit shall enter panel from side or bottom.

6. Accessories:
 - a) Automatic Air Release Valve: Comply with NFPA 20 for installation in fire pump casing.
 - b) Circulation Relief Valve: Comply with UL 1478, brass construction, spring loaded; for installation in pump discharge piping.
 - c) Suction and discharge pressure gauges, 3-1/2-inch dials reading in psi with range equal to twice-rated discharge pressure of pump.
 - d) Eccentric tapered reducer at suction inlet of pump.
 - e) Concentric tapered increaser on discharge outlet of pump.
 - f) Flow Measuring Device: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity. Pressure rated to (175 or 250) psig.
 - g) Hose valve manifold with hose valves, caps, and chains.
 - h) Ball drip.
 - i) Pressure Relief Valve and Closed Type Discharge Cone: Comply with UL 1478, bronze or cast-iron construction, spring loaded; for installation in fire suppression piping. Use only when sum of the pump shut-off head and static pressure of water supply exceeds design pressure rating of piping system.

21 31 16 Diesel-Drive, Centrifugal Fire Pumps

1. A/E to coordinate with the University to determine if an electric-driven or diesel-driven fire pump is required for a project.
 - a) If a building is being renovated and requires a fire pump to operate the sprinkler system a diesel pump may be required if the electric service is not large enough for an electric fire pump. Drawback to a diesel fire pump is the requirement of exercising the pump once a month instead of a once-a-year acceptance test for the electric pump.
 - b) In a high-rise building, approximately 45 floors or more, with no intermediate mechanical room a diesel pump will be the better choice and be able to get you the 100 PSI pressure requirement at the top of the building.

2. Fire Pump:
 - a) Approved manufacturers are A-C Fire Pump, Armstrong Pumps, Aurora Pentair Water, Patterson Pump Co., and Peerless Pumps.



- b) Factory packaged unit, UL listed, and FM approved horizontal split case, centrifugal fire pump, including pump drive, controller, and accessories, with performance requirements shown. Calculate suction pressure on water availability table shown.
 - c) Base: Mount fire pump and pump drive on a common steel bent form or cast-iron base plate. Align pump and motor before and after pump base has been installed and grouted in place.
 - d) Minimum Pump Capacity: 150 percent of rated capacity at not less than 65 percent of rated pressure.
 - e) Maximum Shutoff Pressure: 140 percent of rated pressure.
 - f) Casing: Cast iron, 30,000 psi minimum tensile strength, bearing housing supports, and suction and discharge flanges integrally cast with lower half pump casing. Make the upper half removable without disconnection of suction and discharge of casing flanges.
 - g) Impeller: Bronze, enclosed type, keyed to shaft and held in place with threaded shaft sleeves, dynamically balanced at the factory.
 - h) Shaft: SAE 1045 steel with key locked and threaded bronze sleeves, designed to tighten upon rotation of shaft.
 - i) Gasket Seal: Between impeller hub and shaft sleeve.
 - j) Casing Rings: Renewable, designed to seal against a shoulder in pump casing around full periphery of wearing ring. Lock wearing rings by doweling to prevent rotation.
 - k) Bearings: For rotating parts, provide heavy duty grease-lubricated ball bearings equipped with water slingers. Design bearing housing to flush lubricant thorough the bearings.
 - l) Lantern Ring: Connect to pressure side of pump.
 - m) Stuffing Boxes: Equip with split packing glands.
 - n) Flexible coupling and coupling guard.
 - o) Sequence start timer.
3. Fire Pump Driver:
- a) Approved manufacturers are Eaton Corp., Firetrol (Emerson Electric), Joslyn Clark Corp., Master Control Systems, Inc., and Metron, Inc.
 - b) Diesel Engine: UL listed, and FM approved, compression ignited, with combined manual and automatic starters in accordance with NFPA 20 and specifically listed for fire pump service. Meet latest EPA emissions requirements. Connect engine to a horizontal shaft pump with flexible coupling. Provide engine with:
 - i) Governor to maintain rated pump rpm within range of 10 percent between shutoff and maximum load conditions of pump.
 - ii) Over speed governor to shut down engine at 20 percent above rated engine rpm. Device shall have manual reset only.
 - iii) Tachometer to indicate rpm.
 - iv) Oil pressure gauge to indicate lubricating oil pressure and pressure switch for external annunciation of critically low oil pressure.
 - v) Temperature gauge to indicate engine cooling water temperature and high temperature switch for connection to external annunciator(s).
 - vi) Main battery contactors for manual start of diesel in case of control failure. Provide dual battery sets for diesel start.
 - vii) Water heater to maintain diesel engine jacket temperature at 120 degrees F.
 - c) Electric Starter: Power from two storage battery units; recharge by alternator furnished with engine and battery charger furnished with fire pump controller. Charger shall



- automatically charge at maximum rate whenever required by state of charge of battery.
Furnish battery racks and cables.
- d) Cooling System: Closed circuit. Include circulating pump, heat exchanger and engine jacket temperature regulator. Coolant system shall include two indicating manual control valves, flushing type strainer, pressure regulator, automatic solenoid valve, bypass, and waste outlet connection.
 - e) Exhaust Muffler: Steel residential type with flexible exhaust connector.
4. Controller, Engineer-Driven Fire Pump:
- a) Approved manufacturers are Clarke Fire Protection Products, Inc., Cummins Fire Power, Detroit Diesel, and Caterpillar.
 - b) UL listed and FM approved combined manual/automatic unit housed in NEMA (2 (drip proof), 3R (rain tight), 4 (watertight) or 12 (dust tight)) enclosure. Factory assembled, wired, tested, and marked "Fire Pump Controller". Design controller so that engine will not start upon power failure.
 - c) Running Period Timer: To prevent frequent automatic starting of fire pump engine.
 - d) Dual battery charger with weekly test start feature.
 - e) Incorporate the following alarm functions into controller:
 - i) Engine Trouble:
 - (1) Engine over speed.
 - (2) Low oil pressure.
 - (3) High water temperature.
 - (4) Engine failed to start.
 - (5) Battery/charger failure.
 - ii) Main switch mis-set.
 - iii) Engine running.
 - f) Provide equipment supervisory contacts per NFPA 20 and NFPA 72 for remote monitoring by the building fire alarm system.
5. Packaged Day Tank:
- a) Basis of Design Manufacturer to be SIMPLEX Inc. or approved equal.
 - b) Manufacturer's Designation: SSTL.
 - c) Description: Fuel system in compliance with NFPA 20, and FM and all authorities having jurisdiction. Assembly shall include factory tested fuel oil tank and solenoid control valve, with factory installed wiring and piping, overflow basin.
 - d) Finish: Shop coat outside of tank, pumps, and piping with a rust inhibitive primer and one finish coat of gray enamel. Clearly identify material being stored with stencil and laminated NFPA sign on tank.
 - e) Components:
 - i) Minimum 275-gallon fuel tank meeting UL2080 or UL2085 construction with float control switches, solenoid and high-level automatic shut off and overflow basin alarm.
 - ii) Duplex Fuel Oil Pumps and Controller with automatic alternator, minimum 25 gpm at 1750 rpm, 50 psig. TEFC motor, 120VAC, 60 Hz.
 - iii) Fuel Piping: As per A/E specification.
 - iv) Level Switch: Locate at midpoint of tank to open solenoid valve allowing fuel flow into tank.



- v) Second Level Switch: Locate below overflow connection. This switch shall close solenoid valve acting as high level shut off for tank.
 - vi) Third Level Switch: Locate at 1/3 level of tank. This switch shall trigger 'Low Fuel Level Alarm'. Alarm shall be annunciated locally and have contacts for FMS system.
 - vii) Overflow Alarm: Locate in Rupture/Overflow basin. Alarm shall locally annunciate whenever basin contains fuel from either overflow or rupture. Provide contacts for FMS system.
 - viii) Fuel gauge.
 - ix) Press-to-test button to test components of assembly.
 - x) Removable cover for access to top components.
 - xi) Tank Drain: Threaded plug.
 - xii) Space saver overflow basin to hold 50 percent of tank volume of oil, trim design with float switch. Switch shall activate fuel overflow alarm.
 - xiii) Field Connections:
 - (1) Engine Return Piping: 1 inch.
 - (2) Vent Piping: 1.5 inch.
 - (3) Overflow Piping: 2 inch.
 - (4) Engine Suction Piping: 1 inch.
 - (5) Pump Intake for Main Tank: 1 inch.
 - (6) Terminal Compartment for Electrical Connections.
 - xiv) Accessories:
 - (1) Low, high and overflow fuel level alarm indicators, factory installed with auxiliary contacts to be wired back to Facility Management System.
 - (2) Power available light factory installed.
 - (3) Fuel strainer, field installed.
 - xv) Other modifications and accessories as required for Project.
6. Diesel Fuel Storage Tank:
- a) Fuel system in compliance with NFPA 20 and approved by FM and all authorities having jurisdiction.
 - b) Tank: UL listed, minimum 560-gallon, welded steel storage tank.
 - c) System shall include, but not be limited to: Tank vents, flame arrestors, fill piping with removable screen, strainers, valves, liquid level indicator and fittings.
 - d) Fuel Piping: As per A/E specification.
 - e) Finish: Shop coat outside of tank with a rust inhibitive primer and one finish coat of gray enamel. Clearly identify material being stored with stencil and laminated NFPA sign on tank.
7. Jockey Pump:
- a) UL listed and FM approved horizontal centrifugal jockey pump with electric pump drive, controller and pressure switch with performance requirements shown.
 - b) Construction: Bronze fitted; with mechanical seal and relief valve; close coupled; driven by a 460 volt, 3 phase, 60 cycle, open drip proof motor.
 - c) Control Panel: Wall mounted NEMA (2 (drip proof), 3R (rain tight), 4 (watertight) or 12 (dust tight)) enclosure, containing a fused disconnect switch, magnetic A-T-L starter, H-O-A selector switch, overload relays and circuitry to provide automatic start and stop from



panel mounted pressure switch. Provide dual element time-delay fuses sized for motor requirements.

8. Accessories:

- a) Automatic Air Release Valve: Comply with NFPA 20 for installation in fire pump casing.
- b) Casing Relief Valve: Comply with UL 1478, brass construction, spring loaded; for installation in pump discharge piping.
- c) Suction and discharge pressure gauges, 3-1/2-inch dials reading in psi with range equal to twice the rated pump discharge pressure.
- d) Eccentric tapered reducer at pump suction inlet.
- e) Concentric tapered increaser on pump discharge outlet.
- f) Flow Measuring Device: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity. Pressure rated to 175 or 250 psig.
- g) Hose valve manifold with hose valves, caps, and chains.
- h) Ball drip.
- i) Main Relief Valve: Comply with UL 1478, bronze or cast-iron construction, spring loaded; for installation in fire suppression piping.
- j) Closed waste cone.



XIII. DIVISION 22 – PLUMBING

22 05 00 Common Work Results for Plumbing

1. The entire plumbing and drainage system must comply with the City of Philadelphia Plumbing Code, latest edition, and this Guide.
2. Each system shall be designed and installed in accordance with the latest edition of the applicable Standards, including, but not limited to:
 - a) NFPA Standards.
 - b) Americans with Disabilities Act Accessibility Guidelines (ADAAG).
 - c) Underwriters Laboratory, Inc. (UL).
 - d) Factory Mutual System (FM).
 - e) American National Standards Institute (ANSI).
 - f) American Society for Testing and Materials (ASTM).
 - g) American Welding Society (AWS).
 - h) American Water Works Association (AWWA).
 - i) Manufacturers Standardization Society of Valve and Fitting Industry (MSS).
 - j) American Society of Mechanical Engineers (ASME).
3. ADA-compliant gender-inclusive restrooms are to be provided in each new University building or major renovation.
4. All equipment is to be individually scheduled.
5. All new equipment is to be provided with software and hardware necessary for University Facilities to have the ability to troubleshoot and/or configure any field equipment. Equipment manufacturer is to provide software and hardware as part of closeout package.
6. All central domestic hot water systems which serve fixture(s) located more than 50 feet from the hot water source shall be provided with a properly sized and valved hot water return system. Temperatures should be maintained at 110°F at the faucet.
7. All hot water heating sources shall generate a minimum of 130°F supply water.
8. A temperature-controlled mixing valve shall be installed in hot water systems requiring supply water temperature below 160°F.
9. All domestic water systems must be cleaned and disinfected in accordance with AWWA Standards per City of Philadelphia approval. Bacteriological test shall be performed by a state-certified laboratory and certified analysis and delivered to owner.
10. Heating sources for domestic hot water heaters will depend on location and application but, generally, gas-fired devices are preferred.
11. All piping and drain lines are to be installed to avoid tripping hazards in public or work areas.



12. New toilet rooms shall be provided with one 4-inch floor drain approximately centered in the room to facilitate cleaning. Trap primers shall be installed in accordance with Section P-1204.3 of the City of Philadelphia Plumbing Code. Non-electronic trap primers are preferred. Approved manufacturers are Jay R. Smith and Precision Plumbing Product Company.
13. Each restroom is to have isolation valves located outside of the room for piping mains.

22 05 13 Common Motor Requirements for Plumbing Equipment

1. All motors shall conform to the latest IEEE or NEMA standards relating to characteristics, dimensions, tolerances, temperature rise, insulation, and ratings for noise and vibration.
2. Use NEMA Class B insulation with motor frame amply sized to provide a 1.15 service factor and an ambient of 40°C maximum.
3. To maintain the University’s Green Initiative, and to optimize motor system efficiency, reduce electrical power consumption and costs, and improve system reliability, NEMA Premium® labeled electric motors shall be specified for all motors. Each motor shall achieve the NEMA Premium™ efficiency levels contained in NEMA Standards Publication MG 1-2011 as follows:

Nominal Efficiencies For "NEMA Premium™" Induction Motors Rated 600 Volts Or Less (Random Wound)						
Motor HP	Open Drip-Proof			Totally Enclosed Fan-Cooled		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
1	82.5	85.5	77.0*	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0



4. Provide shaft grounding kit for field installation:
 - a) All motors controlled by Variable Frequency Drives shall be equipped with AEGIS Shaft Grounding Ring kit to be installed by motor or equipment manufacturer or installed in the field by contractor.
5. Motors: Wire shaft ground kit on motors for use with variable frequency drives:
 - a) Ensure AEGIS Shaft Grounding Kit is installed on motor in accordance with manufacturer's recommendation.
 - b) AEGIS Shaft Grounding Ring (SGR) is bolted directly to the motor end bracket or installed with conductive epoxy to ensure ground connection from the AEGIS SGR to motor frame.

22 05 19 Meter and Gages for Plumbing Piping

1. All devices, piping, valving, relays, end switches, control components, power wiring, control wiring and interlock wiring shall be provided as required to accomplish the sequence of operation for the various pieces of equipment to provide a fully operational system.
2. Pressure and Temperature Ratings:
 - a) Each meter and gauge shall be rated and suitable for the piping system that it is being installed in.
 - b) Minimum upstream and downstream straight pipe diameters for meters shall be provided per manufacturer's published recommendations.
3. Pressure Gauges – Provide and install all gauges in such a manner as to be easily read from normal observation positions. Gauges shall be as follows:
 - a) Dial Size: 4-1/2 inch.
 - b) Accuracy: 1/2% of Full Scale, Grade 2A, ASME B40.100.
 - c) Case: Black Phenoilc, Solid Front.
 - d) Ring: Threaded Reinforced Black Polypropylene.
 - e) Window: Glass.
 - f) Pointer: Micrometer Adjustable.
 - g) Movement: Rotary, 400 SS, Teflon-Coated Pinion Gear & Segment.
 - h) Bourdon Tube & Socket: Type 316L Stainless Steel.
 - i) Optional Features: PLUS! Performance.
 - j) Manufacturer: Ashcroft.
 - k) Model: 45-1279-SS-(Connection Size & Type)-XLL-(Pressure Range).
 - l) *Alternate Manufacturer: Treice.
 - m) *Alternate Model: 450SS-45-(Connection Size)-(Connection Location)-A-(Pressure Range Code)-SS(code for fluid selection for snubber screw).
 - n) *Each gauge must be supplied with a Treice Model 870-13 or 870-16 impulse dampener.

NOTE: All pressure gauges utilized for steam service must be equipped with a coil syphon constructed of 316 stainless steel or seamless Schedule 80 carbon steel.



- o) Select range in such a manner that the operating pressures is at the mid-point of the scale. Pressure ranges shall be as follows:
 - i) Fluids, Suction Side of Pump,
Open Systems: 30" to 0 lbs. to 150 lbs.
 - ii) Fluids, Suction and Discharge
Side of Pump, Closed Systems: 0 lbs. to 100 lbs.
4. Thermometers – Provide and install all thermometers in such a manner as to be easily read from normal observation positions. Thermometer shall be as follows:
 - a) Dial Size: 5 inch.
 - b) Accuracy: 1% of Full Scale, Grade A, ASME B40.3.
 - c) Stem & Case: 304 Stainless Steel Hermetically Sealed.
 - d) Stem Diameter: 0.250 inch.
 - e) Window: Polycarbonate.
 - f) Connection: 1/2-inch NPT Union.
 - g) Location: Everyangle[®].
 - h) Manufacturer: Ashcroft.
 - i) Model: 50-EL-42-E-(Stem Length Code)-(Range Code).
 - j) Alternate Manufacturer: Treice.
 - k) Alternate Model: B856-(Stem Length Code)-(Range Code)-SWV.

NOTE: All thermometers installed in piping or pipelines shall be supplied with threaded, stepped shank, 316 stainless steel thermowells of suitable dimensions for the thermometer being supplied.

- l) Select range in such manner that the operating temperature is at the mid-point of the scale. Thermometer ranges shall be as follows:
 - i) Cold water: 40°F to 100°F.
 - ii) Hot water: 50°F to 300°F.

22 05 29 Hangers and Supports for Plumbing Piping and Equipment

1. The following hanger types shall be specified for the support of piping with buildings:
 - a) All pipe hangers shall be sized to fit over insulated piping. Provide the following insulation protection devices:
 - i) Up to and including 6" - Insulation shield equal to Anvil Fig. 167.
 - ii) 6" and above - Pipe insulation protection saddle equal to Anvil Fig. 160.
 - iii) Alternate: Insulated piping above 2" - Rigid hydrous calcium silicate insulation having a compressive strength of 200 PSI may be used at hanger locations on piping above 2". Insulation shields equal to Anvil Fig. 167 must be used in conjunction with the insulation.
 - b) All hangers and supports directly in contact with the piping must be of compatible materials.
 - c) Horizontal piping up to and including 6" nominal pipe diameter:
 - i) Ceiling Hung - Adjustable clevis hangers equal to Anvil Fig. 260.
 - ii) Floor, wall, or rack supported - offset pipe clamp equal to Anvil Fig. 103.



- d) Horizontal piping 8" through 12":
 - i) Ceiling Hung - Adjustable steel yoke pipe roll equal to Anvil Fig. 181.
 - ii) Floor or rack supported - Adjustable pipe roll stand with steel base plate equal to Anvil Fig. 274P.
 - e) Horizontal Piping above 12":
 - i) Ceiling Hung – Adjustable steel yoke pipe roll equal to Anvil Fig. 181.
 - ii) Floor or rack supported - Adjustable pipe roll with base equal to Anvil Fig. 274P.
 - f) Spring hangers shall be used within mechanical rooms to support piping connected to rotating equipment as follows:
 - i) Up to and including 6" nominal pipe size: Ceiling mounted, pre-engineered spring pipe hanger equal to Anvil Fig. B-268 Type A.
 - ii) Above 6" manual pipe size: Piping cushion for pipe rolls equal to Anvil Fig. 178.
2. Hanger Spacing: Piping shall be supported at distances not exceeding the spacing specified in Table 305.4 of the 2018 International Mechanical Code.
 3. All hub or joint pipe shall be supported within the above recommendations for steel and at each joint.
 4. Polyvinyl chloride pipe (PVC) shall be supported at intervals recommended by the manufacturer for a 120°F fluid temperature.
 5. All piping which must pass to within six (6) feet, measured horizontally, from all switchboards, panels, metering assemblies, buss ducts, etc., shall be provided with watertight sheet-metal enclosures to completely protect such equipment in the event of leakage. Provide a drain tapping at the low point of the enclosure and pipe such to the nearest drain.

22 05 48 Vibration and Seismic Controls for Plumbing Piping and Equipment

1. A/E to determine if vibration and seismic controls are required for the project.
2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

22 05 53 Identification for Plumbing Piping and Equipment

1. All domestic water piping and equipment shall be required to be labeled to comply with OSHA and ANSI/ASME A13.1-2015 standards for the identification of systems.
2. The marking system shall identify the contents, size, direction of flow, and operating characteristics (i.e. pressure and/or temperature).
3. All valves and controls shall be labeled using plastic I.D. tags securely connected to the specific item using brass chain or "S" hooks. The contractor shall provide a list of each tagged item and its function and a valve chart in the main Mechanical Room.



4. All equipment must be identified using phenolic nameplates and labeled in accordance with the nomenclature used on the drawings and compatible with the MIMS System.

22 07 19 Plumbing Piping Insulation

1. All domestic cold and hot water and hot water return piping must be insulated with 1 lb. density fiberglass insulation having an outer jacket of Kraft paper bonded to aluminum foil reinforced with fiberglass yarn. The longitudinal seams of the jacket shall overlap and be sealed using the factory applied pressure sensitive adhesive. Staples are **prohibited**. Insulation thickness shall not be less than those recommended in 2018 IECC for the intended service or that required to prevent the formation of condensation or that required to assure a maximum surface temperature of 80°F, whichever is the most stringent. The insulation shall have a maximum thermal conductivity of 0.23 BTU-IN./HR.- FT.²-°F at a mean temperature of 75°F.
2. All domestic cold and hot water and hot water return pipe risers exposed to view in occupied spaces are to be insulated and have a PVC cover. The minimum thickness of the cover will be 30 mil.
3. All non-service/maintenance related fittings (i.e. elbows, tees, etc.) shall be insulated with pre-molded, light impact, UV resistant PVC covers. The minimum thickness of the cover will be 30 mil. Fiberglass insulation thickness shall be equal to the required thickness of the adjoining piping. Foam filled fittings and covers are **prohibited**.
4. Fittings requiring service/maintenance access (i.e. flanges, unions, shut-off valves, check valves, balancing valves, PRV's, etc.) shall be insulated with removable, reusable covers which use straps and buckles to secure the cover in place. The drawings shall detail the interface between the removable cover and the adjacent piping insulation to assure a tight interface, which prevents heat loss and the formation of condensation. Covers shall consist of inner and outer walls of 304 SS 0.11" thick mesh, nylon coated 304SS 0.15" threaded seams, 304SS 1/8" thick x 1-1/2" buckles, PTFE/Teflon belting and 304SS I.D. tags.
5. All pre-fabricated underground piping systems shall be designed to meet the above insulation thickness requirements. All piping within manholes and removable covers for valves etc. shall meet the above insulation thickness requirements and shall be considered an exterior application and therefore be covered with the aluminum jacket.
6. All insulation provided shall conform to all pertinent codes including ASTM E-84, UL 73 and NFPA 255, and shall not exceed a flame spread of 25, fuel contributed 50 and smoke developed 50.
7. Rigid hydrous calcium silicate insulation having a compressive strength of 200 PSI may be used at hanger locations on piping above 2". Insulation shields equal to Anvil Fig. 167 must be used in conjunction with the insulation.



8. Refer to Pipe Insulation Schedule below for minimum insulation size based on pipe size:

Piping System Types	Fluid Temp. Range (deg. F)	Insulation Thickness (Inches) for Pipe Sizes				
		Less than 1	1 to less than 1.5	1.5 to less than 4	4 to less than 8	8 and larger
PLUMBING SYSTEMS						
Domestic, Softened, Lab & Lab Special Cold Water:	Any	1.0	1.0	1.0	1.0	1.0
Domestic, Softened, Lab & Lab Special Hot Water and Recirculating:	Above 140	1.5	1.5	2.0	2.0	2.0
	105-140	1.0	1.0	1.5	1.5	2.0
	104 & Below	1.0	1.0	1.5	1.5	2.0
Horizontal Rainwater Conductors	Any	1.0	1.0	1.0	1.0	1.0
Above Grade Horizontal Sanitary Piping from Mech. Equipment Area Floor Drains	Any	1.0	1.0	1.0	1.0	1.0

22 08 00 Commissioning of Plumbing

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the plumbing systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power to appropriate plumbing equipment.
 - b) Prior to completion of installation, submit “System Verification Checklists” to Engineer of Record and Owner for review.
 - c) Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating in accordance with the Contract Documents.
 - d) Certify that plumbing instrumentation and control systems have been completed and calibrated, that they are operating in accordance with the Contract Documents, and that pretest set points have been recorded.
 - e) Certify that the testing and adjusting procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.



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- f) Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling acceptance and operating tests.
 - g) Provide a plumbing system technician to assist during functional performance testing.
 - h) Participate in the functional performance tests as required to achieve design intent.
 - i) Where necessary, provide dates when governing authorities testing will be conducted
 - j) Participate in O&M Training as required by project specifications.
 - k) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - l) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - m) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
 - n) Provide written certification documenting that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. This certification must be submitted prior to the final verification.
 - o) Provide set of record as-built drawings to the Engineer of Record for inclusion into record documents.
3. Start-Up:
- a) The installing contractor shall perform start-up of the appropriate plumbing systems. The appropriate contractors and/or manufacturer's representative shall be on-site to perform start-up. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the manufacturer's recommended procedures. The Owner will visit the site to review completeness of installation in conjunction with progress meetings prior to starting equipment.
 - b) Contractors involved in installation, fabrication, manufacturer, control, or designs of equipment shall be present at the time of start-up. A factory-authorized technician shall be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment online and expedite acceptable functional performance.
4. Functional Performance Tests:
- a) Scope of plumbing testing shall include entire plumbing installation, from central equipment for hot water generation through distribution systems to each fixture and appliance. Testing shall include measuring capacities and pressures of operational and control functions.
 - b) Each major system will be tested. This will be coordinated and witnessed by the Owner. Witnessing the functional performance tests will serve as a compliment to the O&M Training. No tests will be performed until the system and related subsystems have been started and documented through point-to-point checklists and other documentation.
 - c) The Functional Performance Tests shall include the following, with the Commissioning Agent (if applicable) and Owner:
 - i) Water Heating Systems.
 - ii) Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment.
 - iii) Energy Supply System (heating hot water).
 - iv) Plumbing Distribution Systems.



5. Owner Orientation and Training:
 - a) The installing contractor shall provide the Owner comprehensive training in the understanding of the systems and operation and maintenance of each major piece of equipment.
 - b) The installation contractor or manufacturer's representative will provide the training. This training should include hands-on operational training. The Owner may choose to videotape this training for future use.
 - c) The training shall include start-up, operation in all modes possible, shutdown and any emergency procedures.
 - d) The training shall include a review of all systems using simplified system schematics including riser diagrams, valve locations, and equipment locations.
 - e) The installation contractor shall provide the Owner with copies of all inspections and acceptance.
 - f) The manufacturer's representative shall provide instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Qualified service engineers employed by the manufacturers, or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed. The start-up and shutdown modes of operation shall be demonstrated. Emergency operations shall be demonstrated.
 - g) The Contractor shall attend all sessions and shall add to each session any special information relating to the details of installation of the equipment as it might impact the operation and maintenance.
 - h) The installation contractor shall assist in the coordination of yearly testing, calibrating, and servicing as specified in the contract documents.

22 11 16 Domestic Water Piping

1. Domestic hot and cold piping above the ground shall be Type "L" copper conforming to ASTM B-88. Fittings shall be wrought type joined with 95-5 "LEAD FREE" solder.
2. Domestic water piping below the ground shall be Type "K" copper conforming to ASTM B-88. Fittings shall be heavy cast brass.
3. All domestic hot water, domestic cold water, and rainwater conductors shall be insulated to prevent heat loss or the formation of condensation. All central chilled domestic water system piping shall be insulated. Minimum insulation thickness shall be in accordance with the 2018 IECC as required to prevent condensation.



22 11 19 Domestic Water Piping Specialties

1. Valves – Hydronic Systems:
 - a) Cold Water and Hot Water (40°F through 210°F) Service:
 - i) Up to and including 2-inch NPS:
 - (1) Shutoff Service Only:
 - (a) Solder-End Ball Valve.
 - (b) Rating: 600 PSI CWP, 150 PSI SWP.
 - (c) Body: Three-Piece, Bronze.
 - (d) Ball & Stem: C27451 Lead Free* Brass, Chrome Plated DZR
 - (e) Seat: RPTFE.
 - (f) Stem Packing: MPTFE.
 - (g) Latch-Lock Lever & Nut: Stainless Steel.
 - (h) Brand: Apollo Valves.
 - (i) Model: 82FL14X01.
 - ii) 2 1/2-inch NPS and larger:
 - (1) Shutoff Service:
 - (a) High Performance Butterfly Valve.
 - (b) Rating: ANSI Class 150.
 - (c) Body: Carbon Steel, Lug Style.
 - (d) Stem: P-17-4 PH Stainless Steel.
 - (e) Disc: Stainless Steel.
 - (f) Seat: RTFM.
 - (g) Brand: Apollo Valves.
 - (h) Model: 2-15-L-xx-C-S.
 2. All plumbing equipment (heat exchangers, water heaters, etc.) isolation valves are to be upstream of valve assembly sets on supply and downstream of valve assembly sets on return. Valve assembly sets consists of unions, strainers, thermostats, P/T wells, etc.
 3. All domestic water systems shall be provided with shock absorbers located and installed per manufacturer's recommendation and good engineering practices. Shock absorbers shall be equal to Jay R. Smith Series 5000. Air columns with or without charging valves are **prohibited**. Provide valves to replace absorbers without causing system shutdown.
 4. Provide wall hydrants with built-in vacuum breaker on the exterior of all buildings. A minimum of one (1) hydrant shall be installed on each building face and the maximum distance between hydrants shall not exceed 100 feet. The wall hydrants shall be non-freeze type housed in a lockable wall box, Zurn Model Z1305-VB, or approved equal.
 5. All piping serving ADA sinks/lavatories are to be fitted with antimicrobial molded undersink safety covers. The covers shall be Trubro, model Lav Guard 2, or approved equal.
 6. All domestic water services must be provided with a backflow prevention device of a type and in a location in accordance with the Philadelphia Water Department Cross Connection Control Manual, 7th Edition, 2017:



- a) The basis of design shall be Apollo Valves, Model [AGD4AX](#) reduced pressure principal backflow preventer, where “X” will depend on the size of the pipe (no substitutions).
 - b) The basis of design configuration shall include two full-size backflow preventers installed in parallel to permit continuous, uninterrupted water service during testing and maintenance.
 - c) Each assembly shall be provided with FM-approved epoxy-coated flanged OS&Y gate valves.
 - d) A sanitary drain shall be provided directly below the assemblies for relief valve discharge.
 - e) [Provide airgap drain accessory.](#)
7. Provide roof hydrants with built-in vacuum breaker on the roof of all buildings. A minimum of one (1) hydrant shall be installed on the roof. The roof hydrant shall be non-freeze, automatic draining type, Zurn Model Z1388, or approved equal.

22 13 16 Sanitary Waste and Vent Piping

1. All soil and waste piping belowground shall be service weight cast iron conforming to ASTM A-74. Joints shall be lead and oakum type.
2. All soil and waste piping aboveground shall be service weight cast iron conforming to ASTM A-888. Joints shall be no-hub type.
3. Individual lavatory, urinal and indirect waste piping may be Type DWV copper between the fixture and horizontal branch main when such piping is located above grade. Shower piping should be not less than 2-inches from drain to riser.
4. All systems shall be provided with cleanouts where the sanitary or waste main change direction and in all straight mains on a maximum spacing of 50 ft. Provide access covers in finished areas.
5. Prime Contractor shall confirm floors are properly slopped towards floor and area drains in Mechanical Rooms, Restrooms, Areaways, etc.
6. A/E is to design the sanitary system with wall or floor cleanouts in restroom areas.
7. Laboratory sanitary waste piping:
 - a) No-Hub-Plain End – Above Grade:
 - i) The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion blue-line flame-retardant polypropylene pipe and fittings. The pipe shall be supplied in factory grooved 10 ft. length. Fittings are to meet or exceed Schedule 40 dimensions. Each Orion coupling shall have 300 series stainless steel outer band and 5/16” bolts, nuts and washers plated to meet a 100-hour salt spray test per ASTM B1117. The polypropylene material shall conform to ASTM D4101.
 - ii) Joints: NO-Hub with couplings.
 - iii) Piping: Orion Brownline DP with no hub couplings.



- iv) Socket fusion:
 - (1) The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion's Blueline flame retardant pipe and fittings. Pipe and fittings shall be joined using the Orion socket fusion system conforming to ASTM D2657. The pipe shall be supplied to 10 ft. lengths. The fittings shall meet or exceed schedule 40 dimensions. The polypropylene material shall conform to ASTM D4101.
 - (2) Joints: Socket fusion system.

22 15 19 General Services Packaged Air Compressors and Receivers

1. Climate Control Oil Lubricated: This compressor selection is to be used for ATC or control air, low-pressure applications where air quality is not a concern.
 2. Oil Lubricated Reciprocating or Rotary Screw: This compressor selection is to be used for ATC, control air, or general-purpose air where air quality is not a concern.
 3. Provide air dryers, air filters and coalescing filters as required per project. Refer to Item 8 in this section for installation type and description.
 4. A/E to contact The Sherman Engineering Company when designing the system. Representative is Jordan Myers at 215-340-5300.
 5. Approved manufacturers are Gardner Denver, Ingersoll Rand, and Quincy.
 6. Compressor type with features and preliminary sizing chart:
 - a) Oil-Lubricated Reciprocating Compressor:
 - Size Range: 0.5 – 5HP.
 - Capacity: 2.2-20.2 SCFM.
 - i) Air cooled.
 - ii) Oil-lubricated.
 - iii) 80% duty cycle.
 - iv) Available in Simplex or Multiplex arrangement.
 - v) High Temperature Switch.
 - vi) Vibration Isolating Resilient Mounts.
 - vii) Vinyl Lined, ASME coded receiver tank.
 - (1) Electric Auto Tank Drain.
 - viii) After cooler with separator.
 - ix) 5 μ M Inlet filter.
 - x) Corrosion resistant piping.
 - xi) Control Panel Options:
 - (1) Power disconnect required.
 - (2) Auto Lead/Lag*.
 - (3) Sequencing*.
- *Function available only for multiplex units.



- xii) Tank Size Requirements: Tables below identify system sizes available by horsepower and appropriate tank size for the corresponding horsepower:

Oil Lube Reciprocating Compressor Systems (HP)						
Simplex	0.5	0.75	1	2	3	5
Duplex	1	1.5	2	4	6	10

Tank Sizes for Oil Lube Reciprocating Compressor Systems (Gal)						
Simplex	30	30	30	30	30	30
Duplex	30	30	30	30	30	60

- xiii) Pressure Options: Table below identifies the pressure options available for each technology and the maximum line pressure for the corresponding pressure options.

	Pressure Options
	70-90 Lead / 60-80 Lag
Line Pressure	60 psi steady

- xiv) Table below identifies the system capacity based on type and horsepower at a steady line pressure of 60psig.

	HP	SCFM @ 80psi
Simplex	0.5	2.2
	0.75	3.9
	1	4.6
	2	8
	3	12.5
	5	20.2
Duplex	1	4.4
	1.5	7.8
	2	9.2
	4	16
	6	25
	10	40.4

- b) Oil-Lubricated Rotary Screw L-Series Compressor:
Pressure and Horsepower variance to be determined upon inquiry.
- i) Air cooled.
 - ii) Oil-less.
 - iii) 100% duty cycle.
 - iv) Available in Simplex or Multiplex arrangement.
 - v) High Temperature Switch.



- vi) Vibration Isolating Resilient Mounts.
- vii) Vinyl Lined, ASME coded receiver tank:
 - (1) Electric Auto Tank Drain.
- viii) After cooler with separator.
- ix) 8,000 hr lubricant.
- x) Inlet filter per ISO 5011.
- xi) Corrosion resistant piping.
- xii) Emergency Stop capability.
- xiii) Variable Frequency Drive (ABB Powerflex) with 80% turndown for units larger than 20HP.
- xiv) <75 dba noise level.
- xv) Control Panel Options:
 - (1) Power disconnect required.
 - (2) Auto Lead/Lag*.
 - (3) Sequencing*.
 - (4) Auto Restart capability.
 - (5) Fault History.
 - (6) Maintenance Alarms.
 - (7) Overpressure switch.
 - (8) Microprocessor Controller.
 - (9) Trend data logging on units >40HP.

*Function available only for multiplex units.

- xvi) Tank Size Requirements: Tables below identify system sizes available by horsepower and appropriate tank size for the corresponding horsepower:

Oil Lube L-Series Compressor Systems (HP)					
Simplex	5	7.5	10	15	20
Duplex	10	15	20	30	40

Tank Sizes for Oil Lube Air Cooled Rotary Screw Compressor Systems (Gal)					
Simplex	80	80	80	80	120
Duplex	80	80	120	240	240

- xvii) Pressure Options: Table below identifies the pressure options available for each technology and the maximum line pressure for the corresponding pressure options.

	Pressure Options
	75-(110,130,190)
Line Pressure	90, 110, 170



xviii) Table below identifies the system capacity based on type and horsepower at line pressures of 90, 110, or 170psig.

	HP	SCFM @110psi	SCFM @ 130psig	SCFM @ 190psig
Simplex	5	19.3	18.1	12.9
	7.5	28.2	24.8	18.3
	10	43.5	38.3	26.4
	15	63.1	57.2	44.1
	20	88.8	82.9	63.1
Duplex	10	38.6	36.2	25.8
	15	56.4	49.6	36.6
	20	87	76.6	52.8
	30	126.2	114.4	88.2
	40	177.6	165.8	126.2

c) Oil-Lubricated Rotary Screw LRS-Series Compressor:

Pressure and Horsepower variance to be determined upon inquiry.

- i) Air cooled.
- ii) Oil-less.
- iii) 100% duty cycle.
- iv) Available in Simplex or Multiplex arrangement.
- v) High Temperature Switch.
- vi) Vibration Isolating Resilient Mounts.
- vii) Vinyl Lined, ASME coded receiver tank:
 - (1) Electric Auto Tank Drain.
- viii) After cooler with separator.
- ix) 8,000 hr lubricant.
- x) Inlet filter per ISO 5011.
- xi) Corrosion resistant piping.
- xii) Emergency Stop capability.
- xiii) Variable Frequency Drive (ABB Powerflex).
- xiv) <75 dba noise level.
- xv) Control Panel Options:
 - (1) Power disconnect required.
 - (2) Auto Lead/Lag*.
 - (3) Sequencing*.
 - (4) Auto Restart capability.
 - (5) Fault History.
 - (6) Maintenance Alarms.
 - (7) Overpressure switch.
 - (8) Microprocessor Controller.
 - (9) Trend data logging on units >40HP.

*Function available only for multiplex units.



xvi) Tank Size Requirements: Tables below identify system sizes available by horsepower and appropriate tank size for the corresponding horsepower:

Oil Lube LRS-Series Compressor Systems (HP)							
Simplex	10	15	20	25	30	40	50
Duplex	20	30	40	50	60	80	100

Tank Sizes for Oil Lube Air Cooled Rotary Screw Compressor Systems (Gal)							
Simplex	60	120	120	120	240	240	240
Duplex	120	240	240	240	400	400	400

xvii) Pressure Options: Table below identifies the pressure options available for each technology and the maximum line pressure for the corresponding pressure options.

	Pressure Options
	75-(110,130,145,190)
Line Pressure	90, 110, 125, 170

xviii) Table below identifies the system capacity based on type and horsepower at line pressures of 90, 110, 125 or 170psig. The screw system operates on variable speed drive, which provides the capability to operate within the minimum and maximum SCFM range at a chosen pressure.

	Model No.	HP	SCFM @110psi		SCFM @ 130psig		SCFM @ 190psig	
			Min	Max	Min	Max	Min	Max
Simplex	L07RS	10	16.8	44.7	16.1	39	14.5	29.2
	L11RS	15	22.1	63.8	21.5	58.8	20.1	44.7
	L15RS	20	32.7	92	31.3	85.3	29.3	59.1
	L18RS	25	47	107.8	45.9	95.7	43	77.8
	L22RS	30	36.6	125.2	33.7	116.3	31.6	94
	L29RS	40	39	190.9	37.5	171.5	32.4	134.9
	L37RS	50	47	238	45	221	86	182
Duplex	L07RS-D	20	33.6	89.4	32.2	78	29	58.4
	L11RS-D	30	44.2	127.6	43	117.6	40.2	89.4
	L15RS-D	40	65.4	184	62.6	170.6	58.6	118.2
	L18RS-D	50	94	215.6	91.8	191.4	86	155.6
	L22RS-D	60	73.2	250.4	67.4	232.6	63.2	188
	L29RS-D	80	78	381.8	75	343	64.8	269.8
	L37RS-D	100	94	476	90	442	172	364



7. Refrigerated Air Dryers:

- a) Refrigerate air dryers* will be used on systems where the pressure dew point requirements are between 35-40°F.
 - i) Non-cycling refrigerated dryer.
 - ii) Integrated Grade B separator/filter with 3 μM particulate filtration with integral auto drain.
 - iii) Precooler/reheater heat exchanger.
 - iv) Hot gas bypass.
 - v) Integrated Grade E HE oil removal filter with integral drain**.

*Refrigerated air dryer sizing to be determined when paired with a compressor.

**Models 25 CFM and up when paired with an oil-lubricated compressor.

8. Air Filters:

- a) Requirements for sizing of air filters*:
 - i) Pressure differential slide or gauge.
 - ii) Internal or external auto drain on coalescing filters.
 - iii) Liquid level indicator in coalescing filters.
 - iv) Filter Element Grades:

GRADE*	INSTALLATION	DESCRIPTION
A	Water Separator Filter	After an air compressors' (or a standalone) aftercooler. Design: One-stage filtration with two stainless steel orifice tubes. Labyrinth style air flow path removes liquid water by forcing abrupt directional changes. Performance*: Handles bulk liquid inlet loads to 30,000 ppm w/w and provides 10-micron solid particulate separation. Efficient to flows as low as 5% of rated flow.
B	Separator/Filter	After an air compressors' (or a standalone) aftercooler or as a prefilter to a refrigerated dryer. Design: Two-stage filtration with first stage of two stainless steel orifice tubes, which remove bulk liquids and solid particulates to 10-micron. Second stage has in-depth coalescing fiber media, which captures solid particulates to 3-micron. Performance*: Handles bulk liquid inlet loads to 25,000 ppm w/w and provides 3-micron solid particulate filtration.



GRADE*	INSTALLATION	DESCRIPTION
C	General Purpose Filter	1-micron particulate prefilter for refrigerated dryers and high efficiency oil removal filters. Design: Two-stage filtration with a first stage of multiple layers of fiber media, which pre-filter the air. Second stage has in-depth coalescing fiber media, which coalesces oil aerosols and removes finer particulates to 1-micron. Performance*: Handles bulk liquid inlet loads to 2,000 ppm w/w, provides 1-micron solid particulate filtration and oil removal to 1 ppm.
D	Dry Particulate Filter	Dry, solid particulate after filter for heatless desiccant dryers. Design: Two-stage filtration with life-prolonging outside/ in air flow with first stage of alternate layers of fiber media and a media screen capturing large particulates. Second stage captures finer particulates. Not designed for any liquid loading. Performance*: Provides 1-micron solid particulate filtration of desiccant dust.
E	HE Oil Removal Filter	Prefilter to desiccant and membrane dryers, after filter to refrigerated dryers and standalone oil removal at the point-of-use of compressed air. Design: Two-stage filtration with a first stage of multiple layers of fiber media which prefilter the air. Second stage has in-depth coalescing fiber media, which coalesces oil aerosols. Includes an outer coated, closed cell foam sleeve. Performance*: Handles bulk liquid water inlet loads to 1,000 ppm w/w and provides 0.008 ppm oil aerosol removal and 0.01-micron solid particulate separation.
F	Max Efficiency Oil Removal Filter	Prefilter to desiccant and membrane dryers with a Grade C prefilter, oil-free air applications. Design: Two-stage filtration with a first stage of a coated, closed-cell foam sleeve which acts as a prefilter and flow disperser. Second stage has in-depth coalescing fiber media, which coalesces fine oil aerosols. Includes an outer coated, closed cell foam sleeve. Performance*: Handles bulk liquid water inlet loads to 100 ppm w/w and provides 0.0008 ppm oil aerosol removal and 0.01-micron solid particulate separation.



GRADE*	INSTALLATION	DESCRIPTION
G	Oil Vapor Removal Filter	After filter to high efficiency liquid oil removal filters for true oil-free applications. Design: Two-stage filtration with a generously sized first stage of a stabilized bed of carbon particles, which remove the majority of the oil vapor. Second stage has multiple layers of fiber media with bonded microfine carbon particles, which remove the remaining oil vapors. Includes an outer-coated, closed cell foam sleeve, which prevents fiber migration. Performance**: No liquid should be present at filter inlet. Provides 0.003 ppm w/w oil (as a vapor) removal and 0.01-micron solid particulate separation.

*Filter sizing and selection to be determined when paired with a compressed air system.
 **Filter efficiencies have been established in accordance with CAGI standard ADF400 and are based on 100°F (38°C) inlet temperature ** Filter efficiency has been established in accordance with CAGI standard ADF500 and is based on 100°F (38°C) inlet temperature (Note: This element needs to be changed every 1,000 hours of compressor run time).

22 33 00 Electric Domestic Water Heaters

1. Electric type water heaters are to be used when natural gas is not available or as a point of use, i.e. kitchenette. Approved manufacturers are Bradford White Corporation, AO Smith Corporation, and Rheem Manufacturing Company.
2. Storage tank construction to be glass lined steel tank, electric storage type, less than 120-gallon capacity.
3. Heater components to be included but not limited to the following:
 - a) Extruded magnesium anode.
 - b) ASME rated, bronze temperature and pressure relief valve.
 - c) Drain valve.
 - d) Inlet and outlet piping connections.
 - e) High-density glass fiber insulation meeting criteria for heat loss efficiency.
 - f) Steel jacket with baked enamel finish.
 - g) Fused on alkaline borosilicate composition glass lining.
 - h) Temperature Control Limit Switch with manual reset if temperature reaches 190°F.
 - i) Hinged compartment housing.
 - j) Control circuit transformer.
 - k) Transformer fusing.
 - l) Magnetic contactors.
 - m) Immersion style operating thermostat.
 - n) Element fusing.
 - o) Medium watt density, commercial grade, incoloy sheathed flange mounted elements with pre-wired terminal leads.



22 34 00 Fuel-Fired Domestic Water Heaters

1. A/E is responsible for identifying and documenting what natural gas pressure and pipe main is locally available at the building with PGW. This information shall be used for determining overall equipment load and pipe sizing. No equipment is to be selected below 4.5 in. w.g., which is PGW's minimum guaranteed system supply.
2. Storage water heaters and instantaneous water heaters if all the following are not exceeded:
 - a) A heat input of 200,000 BTUs/hr.
 - b) A water temperature of 210°F.
 - c) A nominal water-containing capacity of 120 gallons.
 - d) Approved manufacturers are Bradford White Corporation, A.O. Smith Corporation, and Rheem Manufacturing Company.
3. Storage water heaters and instantaneous water heaters that exceed the design criteria listed Paragraph 2 above.
 - a) Approved manufacturers are Bradford White Corporation, Lochinvar LLC, A.O. Smith Corporation, Rheem Manufacturing Company, and RBI.
4. All heaters, and installation thereof, falling under Paragraph 2, shall be equipped with ANSI/ASME CSD-1 controls and comply with the Pennsylvania Department of Labor & Industry Boiler and Unfired Pressure Vessel Regulations, Title 34, Part I, Chapter 3a.
5. Storage tank construction to be gas fired, glass lined steel tank, storage type, less than 120-gallon capacity.
6. Heater components to be included but not limited to the following:
 - a) Gas fired burner:
 - i) Automatic gas pilot assembly, pilot valve and gas pilot pressure reducing valve.
 - ii) Manual gas cock.
 - iii) Hydraulic motorized gas valve.
 - iv) Gas pressure reducing valve.
 - v) Flame safeguard.
 - b) Fused on alkaline borosilicate composition glass lining.
 - c) ASME rated steel tank on channel steel skid.
 - d) High-density glass fiber insulation meeting criteria for heat loss efficiency.
 - e) Steel jacket with baked enamel finish.
 - f) Extruded magnesium anodes.
 - g) Flame inspection port.
 - h) Handhold cleanouts.
 - i) Inlet and outlet piping connections.
 - j) Drain valve.
 - k) ASME rated, bronze temperature and pressure relief valve.
 - l) Hinged control compartment housing.
 - m) High temperature limit control with manual reset.
 - n) Upper and lower thermostats.
 - o) Combination temperature and pressure gauge.



- p) Low water cutoff.
 - q) Draft regulator.
7. Contractor is responsible for requiring a variance from the Commonwealth of Pennsylvania along with any other requirements for Unfired Pressure vessels installations. Unfired pressure vessels will not satisfy the code clearance requirements (minimum of 18 inches in front, at rear and on both sides, and 30 inch in front of manhole cover. FM Global will inspect the vessel installation upon completion.

22 42 00 Commercial Plumbing Fixtures

1. Water closets and urinals are to be wall mounted, siphon jet design using flush valves. Flush valves and fixtures shall be water-conserving type.
 - a) Bases of Design:
 - i) Water Closet Fixture: American Standard or Kohler.
 - ii) Water Closet Flush Valve: Sloan, Optima G2 Plus Series model 8111 (no substitutions).
 - iii) Urinal Fixture: American Standard or Kohler.
 - iv) Urinal Flush Valve: Sloan, Optima G2 Plus Series models 8186 or 8186-0.5 (no substitutions).
2. Lavatories shall be counter mounted. With solid surface counter.
 - a) Bases of Design:
 - i) Wall Mounted: American Standard or Kohler.
 - ii) Counter Mounted: American Standard or Kohler.
3. University does have existing floor mounted water closets in various facilities. Replacement water closets are to be American Standard or Kohler and style is to match existing.
4. Where hands-free lavatory faucets are specified, Sloan Optima EAF-150-ISM (no substitutions). At least one lavatory in all public restrooms shall be equipped with a manual faucet by Delta.
5. Dormitory lavatory fixtures shall be single lever Delta or approved equal and equipped with vandal proof aerator limiting water flow to 0.5 gallons per minute. Aerator shall be Neoperl® PCA® Spray Faucet Attachment – 0.5 gpm max (Part number B9.65F3.1).
6. Showerheads shall be water conserving type (1.5 gpm), similar to Zurn, Water Saver, Model Z7000-S9.
7. All faucets for [non-laboratories](#) and miscellaneous locations shall be manufactured by Delta.
8. [Refer to Section 12 35 53 for laboratory faucet specifications.](#)
9. Accessible piping within base cabinets shall be chrome-plated and equipped with metal stop valves having waste cups.



10. Approved manufacturer for plumbing fixture carriers is Jay R. Smith and Zurn.
11. Janitor Closet fixtures and accessories:
 - a) Basis of Design:
 - i) Basin: Size 36-inch x 24 inch or 24-inch x 24-inch, 10 inches high, molded stone, 3-inch stainless steel drain with dome strainer and lint basket. Fiat model MSB-3624 or MSB-2424.
 - ii) Faucet: Rough chrome plated cast brass, ceramic cartridges, integral stops and check valves, brass vacuum breaker, adjustable wall brace and pail hook, 4 arm handles with indicators, and 3/4-inch hose thread spout. Speakman SC-5811-RCP.
 - iii) Hose and Hose Bracket: Heavy duty 30 inch long, flexible cloth reinforced rubber hose with chrome plated threaded connector at one end. Stainless steel hose bracket with rubber hose grip. Fiat 832-AA.
 - iv) Mop Hanger: Size 24-inch x 3 inch and stainless steel with three rubber grips. Fiat 889-CC.
 - v) Bumper guard: Molded vinyl length to match receptor dimensions. Provide along all open sides of receptor. Fiat E-77-AA.
 - vi) Wall guard: Heavy 16-gauge type 430 stainless steel with No. 4 finish, two or three panel arrangements to protect adjacent wall surface from water damage. Fiat MSG series.

22 45 00 Emergency Plumbing Fixtures

1. The design and installation of Emergency Plumbing Fixtures and associated systems shall comply with the Laboratory Design Standard 2020. A copy of this Standard & Design Guide is included in Appendix A.
2. All emergency eye wash and safety shower fixtures shall be provided with a thermostatic mixing valve. Mixing valves shall be from the same manufacturer to ensure proper sizing.
3. Eyewash: Deck mounted auto-flow with 90-degree swivel type. Approved manufacturer and model is Guardian model G1805 (no substitutions).
4. Safety Showers:
 - a) Horizontally mounted: All stainless steel with pull handle. Approved manufacturer and model is Guardian model G1691 (no substitutions).
 - b) Free standing: All stainless steel with pull handle. Approved manufacturer and model is Guardian model G1696 (no substitutions).
 - c) Modesty Curtain: White polyester curtain with ring hangers and tie-back. Approved manufacturer and model is Guardian model AP250-065 (no substitutions).
5. All tempered water piping connected to an emergency plumbing fixture is to be sized and installed as per manufacturer's requirements.
6. Plumbing Contractor shall test and certify all emergency plumbing fixtures and provide associated documentation.



22 47 00 Drinking Fountains and Water Coolers

1. Water coolers to be wall mounted ADA type.
 - a) Single cooler shall be Elkay, model EZS8L.
 - b) Bi-level dual cooler shall be Elkay, model EZSTL8LC.
 - c) Bottle filling station with single cooler shall be Elkay, model EZS8WSLP EZH2O.
2. In-Wall bottle filling station shall be Elkay, model LZWSM8K.

22 61 00 Compressed-Air Systems for Laboratory and Healthcare Facilities

1. Oil-Less Rotary Scroll: This compressor selection is to be used in laboratory grade systems with low flow/intermittent use where air quality is vital to the process/experiment.
2. Oil-Less Rotary Screw Water Sealed: This compressor selection is to be used in laboratory grade systems with high flow where air quality is vital to the process/experiment.
3. Provide air dryers, air filters and coalescing filters as required per project. Refer to Item 15 in this section for installation type and description.
4. All new and renovated laboratory compressed air systems shall be designed, installed, tested/certified in strict accordance with the City of Philadelphia approved International Building Codes. Coordinate project specification with University Facilities and Environmental Health and Radiation Safety Departments regarding project requirements.
5. All piping shall be labeled in accordance with OSHA and ASME A13.1.
6. Tubing: Seamless, Type K (ASTM B819) hard drawn copper tubing, factory oxygen cleaned, nitrogenized, capped, and bagged. Where material compatibility issues are between the piping and gas, suitable materials must be utilized.
7. Joints: Brazed with alloy classification BCuP5 (15 percent silver, 5 percent phosphorous, 80 percent copper), with continuous nitrogen gas purge in accordance with ASTM B32, ANSI/AWS A5.8 and Federal Specification QQ-B-654A Grade III.
8. Fittings: Wrought copper, solder cup ends in accordance with ANSI B16.22.
9. System shall be tested and certified in accordance with International, National, and local code requirements.
10. A/E to contact The Sherman Engineering Company when designing the system. Representative is Jordan Myers at 215-340-5300.
11. Approved manufacturers are Gardner Denver, Ingersoll Rand, and Quincy.
12. Compressor type with features and preliminary sizing chart:
 - a) Oil-Free Rotary Screw Compressor:
Size Range: 20 – 50HP.



Capacity: 11.1 – 427.4 SCFM.

- i) Air cooled.
- ii) Oil-less.
- iii) 100% duty cycle.
- iv) Available in Simplex or Multiplex arrangement.
- v) High Temperature Switch.
- vi) Vibration Isolating Resilient Mounts.
- vii) Vinyl Lined, ASME coded receiver tank:
 - (1) Electric Auto Tank Drain.
- viii) After cooler with separator.
- ix) 3 µM Inlet filter.
- x) Corrosion resistant piping.
- xi) Emergency Stop capability.
- xii) Variable Frequency Drive (ABB Powerflex) with 80% turndown for units larger than 20HP.
- xiii) <75 dba noise level.
- xiv) Control Panel Options:
 - (1) Power disconnect required.
 - (2) PLC/HMI controller.
 - (3) Modbus Capable.
 - (4) Auto Lead/Lag*.
 - (5) Sequencing*.
 - (6) Auto Restart capability.
 - (7) Fault History.
 - (8) Maintenance Alarms.
 - (9) Overpressure switch.
 - (10) Microprocessor Controller.
 - (11) Trend data logging on all units.

*Function available only for multiplex units.

- v) Tank Size Requirements: Charts below identify system sizes available by horsepower and appropriate tank size for the corresponding horsepower:

Oil Less Screw Compressor Systems			
Simplex	20	30	50
Duplex	40	60	100
Triplex	60	90	

Tank Sizes for Oil Less Compressor Systems			
Simplex	120	240	240
Duplex	240	400	400
Triplex	400	400	



- vi) Pressure Options: Chart below identifies the pressure options available for each technology and the maximum line pressure for the corresponding pressure options.

	Pressure Options
	75-145psi adjustable
Max Line Pressure	60-135psi

- vii) Chart below identifies the system capacity based on type and horsepower at line pressures of 115 or 145psig.

	HP	SCFM @115psi		SCFM @ 145psig	
		Min	Max	Min	Max
Simplex	20	11.1	77.9	15.4	64.5
	30	24	117.9	27.2	103.6
	50	42	213.7	38.4	186.6
Duplex	40	22.2	155.8	30.8	129
	60	48	235.8	54.4	207.2
	100	84	427.4	76.8	373.2
Triplex	60	33.3	233.7	46.2	193.5
	90	72	353.7	81.6	310.8

13. Compressor type with features and preliminary sizing chart:

- a) Oil-Free Rotary Scroll Compressor:
 Size Range: 3 – 10HP.
 Capacity: 7.6 - 93 SCFM.
 Working Line Pressure: 115 / 155psig.
 Maximum Line Pressure: 100 / 125psig.
- i) Air cooled.
 - ii) Oil-less.
 - iii) 100% duty cycle.
 - iv) Available in Simplex or Multiplex arrangement.
 - v) High Temperature Switch.
 - vi) Vibration Isolating Resilient Mounts.
 - vii) Vinyl Lined, ASME coded receiver tank:
 - (1) Electric Auto Tank Drain.
 - viii) After cooler with separator.
 - ix) 5 µM Inlet filter.
 - x) Corrosion resistant piping.
 - xi) <72 dba noise level*.



- xii) Control Panel Options:
 - (1) Power disconnect required.
 - (2) Fusible disconnects.
 - (3) PLC/HMI controller.
 - (4) Modbus Capable.
 - (5) Auto Lead/Lag**.
 - (6) Sequencing**.
 - (7) Auto Restart capability.

*Enclosed scroll system provides lower noise level.

**Function available only for multiplex units.

- viii) Tank Size Requirements: Charts below identify system sizes available by horsepower and appropriate tank size for the corresponding horsepower:

Oil Less Scroll Compressor Systems (HP)				
Simplex	3	5	7.5	10
Duplex	6	10	15	20
Triplex	9	15	21.5	30
Quadraplex	12	20	30	40

Tank Sizes for Oil Less Compressor Systems (Gal)				
Simplex	30	30	80	80
Duplex	30	80	80	120
Triplex	80	80	120	240
Quadraplex	80	120	240	240

- ix) Pressure Options: Chart below identifies the pressure options available for each technology and the maximum line pressure for the corresponding pressure options.

	Pressure Options	
Max Line Pressure	116psi	140psi
	100	125

- x) Chart below identifies the system capacity based on type and horsepower at line pressures of 116 or 140psig.

	HP	SCFM @116psi	SCFM @ 140psig
Simplex	3	9.2	7.6
	5	13.9	12.5
	7.5	22.1	16
	10	31	25.3
Duplex	6	18.4	15.2
	10	27.8	25
	15	44.2	32
	20	62	50.6



	HP	SCFM @ 116psi	SCFM @ 140psig
Triplex	9	27.6	22.8
	15	41.7	37.5
	21.5	66.3	48
	30	93	75.9

14. Desiccant Air Dryers:

- a) Desiccant air dryers* will be used on laboratory air systems that require low pressure dew points as low as -100°F. Heatless desiccant dryers use approximately 15% of the dryers rated capacity as purge air to keep the desiccant beds dry.
 - i) Four optional dew point choices in fixed cycle operating modes (-100°F, -40°F, -4°F, and 38°F).
 - ii) Dew point demand driven controlled purge air.
 - iii) Integrated Grade E pre-filter and Grade D post-filter**.
 - iv) Left and right tower pressure gauges with purge gauge.
 - v) Moisture Indicator.
 - vi) Purge control valve.

*Desiccant air dryer sizing to be determined when paired with a compressor.

**See compressed air filter section for specification.

15. Air Filters:

- a) Requirements for sizing of air filters*:
 - i) Pressure differential slide or gauge.
 - ii) Internal or external auto drain on coalescing filters.
 - iii) Liquid level indicator in coalescing filters.
 - iv) Filter Element Grades:

GRADE*	INSTALLATION	DESCRIPTION
A	Water Separator Filter	After an air compressors' (or a standalone) aftercooler. Design: One-stage filtration with two stainless steel orifice tubes. Labyrinth style air flow path removes liquid water by forcing abrupt directional changes. Performance*: Handles bulk liquid inlet loads to 30,000 ppm w/w and provides 10-micron solid particulate separation. Efficient to flows as low as 5% of rated flow.
B	Separator/Filter	After an air compressors' (or a standalone) aftercooler or as a prefilter to a refrigerated dryer. Design: Two-stage filtration with first stage of two stainless steel orifice tubes, which remove bulk liquids and solid particulates to 10-micron. Second stage has in-depth coalescing fiber media, which captures solid particulates to 3-micron. Performance*: Handles bulk liquid inlet loads to 25,000 ppm w/w and provides 3-micron solid particulate filtration.



GRADE*	INSTALLATION	DESCRIPTION
C	General Purpose Filter	1-micron particulate prefilter for refrigerated dryers and high efficiency oil removal filters. Design: Two-stage filtration with a first stage of multiple layers of fiber media, which pre-filter the air. Second stage has in-depth coalescing fiber media, which coalesces oil aerosols and removes finer particulates to 1 micron. Performance*: Handles bulk liquid inlet loads to 2,000 ppm w/w, provides 1-micron solid particulate filtration and oil removal to 1 ppm.
D	Dry Particulate Filter	Dry, solid particulate after filter for heatless desiccant dryers. Design: Two-stage filtration with life-prolonging outside/ in air flow with first stage of alternate layers of fiber media and a media screen capturing large particulates. Second stage captures finer particulates. Not designed for any liquid loading. Performance*: Provides 1-micron solid particulate filtration of desiccant dust.
E	HE Oil Removal Filter	Prefilter to desiccant and membrane dryers, after filter to refrigerated dryers and standalone oil removal at the point-of-use of compressed air. Design: Two-stage filtration with a first stage of multiple layers of fiber media which prefilter the air. Second stage has in-depth coalescing fiber media, which coalesces oil aerosols. Includes an outer coated, closed cell foam sleeve. Performance*: Handles bulk liquid water inlet loads to 1,000 ppm w/w and provides 0.008 ppm oil aerosol removal and 0.01-micron solid particulate separation.
F	Max Efficiency Oil Removal Filter	Prefilter to desiccant and membrane dryers with a Grade C prefilter, oil-free air applications. Design: Two-stage filtration with a first stage of a coated, closed-cell foam sleeve which acts as a prefilter and flow disperser. Second stage has in-depth coalescing fiber media, which coalesces fine oil aerosols. Includes an outer coated, closed cell foam sleeve. Performance*: Handles bulk liquid water inlet loads to 100 ppm w/w and provides 0.0008 ppm oil aerosol removal and 0.01-micron solid particulate separation.



GRADE*	INSTALLATION	DESCRIPTION
G	Oil Vapor Removal Filter	After filter to high efficiency liquid oil removal filters for true oil-free applications. Design: Two-stage filtration with a generously sized first stage of a stabilized bed of carbon particles, which remove the majority of the oil vapor. Second stage has multiple layers of fiber media with bonded microfine carbon particles, which remove the remaining oil vapors. Includes an outer-coated, closed cell foam sleeve, which prevents fiber migration. Performance**: No liquid should be present at filter inlet. Provides 0.003 ppm w/w oil (as a vapor) removal and 0.01-micron solid particulate separation.

*Filter sizing and selection to be determined when paired with a compressed air system.
 **Filter efficiencies have been established in accordance with CAGI standard ADF400 and are based on 100°F (38°C) inlet temperature ** Filter efficiency has been established in accordance with CAGI standard ADF500 and is based on 100°F (38°C) inlet temperature (Note: This element needs to be changed every 1,000 hours of compressor run time).

22 62 00 Vacuum Systems for Laboratory and Healthcare Facilities

1. All new and renovated laboratory vacuum systems shall be designed, installed, tested/certified in strict accordance with the City of Philadelphia approved International Building Codes. Coordinate project specification with University Facilities and Environmental Health and Radiation Safety Departments regarding project requirements.
2. All piping shall be labeled in accordance with OSHA and ASME A13.1.
3. Piping: Seamless, Type L (ASTM B88) hard drawn copper tubing. Where material compatibility issues are between the piping and gas, suitable materials must be utilized.
4. Joints: Solder with grade HB lead-free solder in accordance with ASTM B32, ANSI/AWS A5.8 and Federal Specification QQ-B-654A Grade III.
5. Fittings: Wrought copper, solder cup ends in accordance with ANSI B16.22.
6. System shall be tested and certified in accordance with International, National, and local code requirements.
7. Approved vacuum pump manufacturers are Gardner Denver Nash, Kinney Vacuum Pumps, and SIHI Pumps Americas.
8. A/E to contact The Sherman Engineering Company when designing the system. Representative is Mark Franklin at 215-340-5300.



9. Bench top dry scroll vacuum systems offers improved performance, exceptional pumping capability, quiet operation, and extended service intervals. All bench top vacuum units will be point of use pumps with a 115V input supply.
 - a) Bench top units are capable of supplying 3.6 – 13.0 CFM with ultimate vacuum levels below 10 – 2 mbar.
 - b) Low noise power level must be less than or equal to 53 dBA.
 - c) Dry scroll pump must be hermetically sealed to ensure the vacuum environment is not contaminated.
 - d) Pump must operate between a temperature range of 41 – 104°F.
 - e) All point-of-use bench top vacuum pumps will be sized individually with the help of a qualified engineer. All other vacuum is assumed provided by a house vacuum system.

10. All house systems specified in this section assume a once through seal water flow. If there is concern for amount of water drained, please consult the factory to review the partially, or fully, recirculated seal water arrangement options available. Please consult Sherman Engineering to confirm seal water flow rate.

11. Tank mounted liquid ring vacuum systems: This vacuum system is to be used in laboratory facilities requiring a pump that offers less than or equal to 56 scfm at 20 inHg per pump. Systems can come in simplex or multiplex arrangements and will include the following scope of supply:
 - a) One (1) Nash Vectra SX Model monoblock style vacuum pump in standard construction, including a ductile iron head, 316 SS rotor, 304 SS body, cast iron port plate, and SS encapsulated steel shaft. The pump is outfitted with John Crane type mechanical seal including a carbon rotating element, ceramic stationary element, Viton elastomers and 316 SS components.
 - b) One (1) EISA compliant TEFC motor, NEMA C-face, 230/460V, 3Ph, 60Hz, 1.15 service factor.
 - c) One (1) horizontal vacuum receiver tank with deck to support vacuum system, ASME coded, painted steel construction with epoxy lined interior.
 - i) All 1.5 HP systems will be assembled on a 60-gallon horizontal receiver tank.
 - ii) 3HP – 10 HP systems will be assembled on a 120-gallon horizontal receiver tank.
 - d) One (1) carbon steel discharge water trap silencer.
 - e) One (1) inlet pipeline to include:
 - i) Inlet check valve.
 - ii) Inlet isolation valve.
 - iii) Vacuum relief valve.
 - iv) Vacuum gauge.
 - f) One (1) seal water supply line to include:
 - i) Flow control valve.
 - ii) Solenoid valve.
 - iii) Strainer.
 - iv) Seal line isolation valve.
 - g) One (1) Electrical control panel furnished mounted and wired with circuit breaker disconnects, across the line starters, H-O-A selector switches, running lights, vacuum switches, timed alternation, minimum run timers in a NEMA enclosure.
 - h) One (1) lot of piping to create a complete functional package.



12. Base mounted liquid ring vacuum systems: This vacuum system is to be used in laboratory facilities requiring a pump that offers greater than 56 scfm at 20 inHg per pump. Systems can come in simplex or multiplex arrangements and will include the following scope of supply:
 - a) One (1) Nash Vectra GL Model single stage liquid ring vacuum pump in ductile iron construction. Including a ductile iron head, rotor, body, cone, and a steel shaft. The pump is outfitted with John Crane type single mechanical seals, including a carbon rotating element, ceramic stationary element, Viton elastomers and 316 stainless steel components.
 - b) One (1) EISA compliant TEFC motor, NEMA C-face, 230/460volt, 3 phase, 60 Hz, 1.15 service factor.
 - i) Pump/Motor Couplings.
 - ii) Coupling Guard.
 - c) One (1) Steel baseplate to support vacuum system.
 - d) One (1) Carbon Steel discharge water trap silencer.
 - e) One (1) inlet pipeline to include:
 - i) Inlet check valve.
 - ii) Inlet isolation valve.
 - iii) Vacuum relief valve.
 - iv) Vacuum gauge.
 - f) One seal water supply line to include:
 - i) Flow control valve.
 - ii) Solenoid Valve.
 - iii) Strainer.
 - g) One (1) Electrical control panel furnished mounted and wired with circuit breaker disconnects, across the line starters, H-O-A selector switches, running lights, vacuum switches, timed alternation, minimum run timers in a NEMA enclosure.
 - h) Lot of piping to create a complete functioning package.
13. All systems are to be provided with vibration isolation mounts.
14. All systems to be provided with inlet, discharge and seal water flex connections shipped loose for field installation.

22 63 00 Gas Systems for Laboratory and Healthcare Facilities

1. All new and renovated laboratory gas systems shall be designed, installed, tested/certified in strict accordance with the City of Philadelphia approved International Building Codes. Coordinate project specification with University Facilities and Environmental Health and Radiation Safety Departments regarding project requirements.
2. All piping shall be labeled in accordance with OSHA and ASME A13.1.
3. Tubing (non-Hydrogen and non-Helium): Seamless, Type K (ASTM B819) hard drawn copper tubing, factory oxygen cleaned, nitrogenized, capped, and bagged. Where material compatibility issues are between the piping and gas, suitable materials must be utilized.



4. Joints (non-Hydrogen and non-Helium): Brazed with alloy classification BCuP5 (15 percent silver, 5 percent phosphorous, 80 percent copper), with continuous nitrogen gas purge in accordance with ASTM B32, ANSI/AWS A5.8 and Federal Specification QQ-B-654A Grade III.
5. Fittings (non-Hydrogen and non-Helium): Wrought copper, solder cup ends, factory oxygen cleaned, nitrogenized, capped, and bagged, in accordance with ANSI B16.22.
6. Tubing (Hydrogen and Helium): Seamless stainless-steel tubing, factory oxygen cleaned, nitrogenized, capped, and bagged. Where material compatibility issues are between the piping and gas, suitable materials must be utilized.
7. Fittings (Hydrogen and Helium): Swaglock type, factory oxygen cleaned, nitrogenized, capped, and bagged, in accordance with ANSI B31.12.
8. All gas systems shall be tested and certified in accordance with International, National, local code, and PGW requirements.
9. Gas Cylinder Manifold: Automatic switchover system to provide a continuous supply of gas from the bank of cylinders. Standard gas delivered. Standard features shall be single body switchover regulator, 3-foot flexible hoses for each cylinder, integral check valves, inlet pressure gauges, 1/4" outlet compression fitting and steel back plate to mount regulator. The system shall be BeaconMedaes AFAM3000 Series or [Swagelok Changeover \(SCO\)](#).

22 67 00 Processed Water Systems for Laboratory and Healthcare Facilities

1. A/E is to verify all model numbers with EVOQUA on a per project basis.
2. DI water piping shall be polyvinylidene fluoride (PVDF). Pipe will be manufactured to schedule 80 iron pipe dimensions, from virgin, unpigmented PVDF resin, meeting ASTM D3222, using no plasticizers or pigments. Pipe shall be furnished in 10-inch lengths, grooved, and capped. Pipe shall meet all dimensional tolerances of ASTM D2447. Basis of Design for pipe shall be manufactured by Orion. Ball valves and fittings shall be compatible with pipe material.
3. Distilled water tubing shall be polyethylene tubing – ASTM F1281 or ASTM F1282. Fittings and joints-brass compression type. Pipe shall be made of unpigmented pressure rated pipe and fittings tested per ASTM E-84, the flame spread index maximum 110, and smoke developed is maximum 515. Pipe shall be rated for food grade applications. Ball valves and fittings shall be compatible with pipe material.
4. DI Water Equipment:
 - a) Overview: The DI water equipment shall be purchased from EVOQUA Water Technologies (no substitutions). Contact Ernest Keeper at 215-638-7700, ext. 133. The “Central” Reagent Grade Water System shall consist of (4) individual components:
 - i) Pretreatment Skid.
 - ii) Reverse Osmosis.



- iii) Storage Tank.
- iv) Distribution Skid.
- b) Building Sizing:
 - i) Number of floors with number of point of use (POU) per floor.
 - ii) Flow rate shall be 0.5 GPM per POU.
 - iii) Total loop Peak flow in GPM.
 - iv) Loop flow required per pipe riser and branch piping on each floor.
 - v) Reverse Osmosis make up flow.
 - vi) Domestic feed flow required – GPM @ 60 psi or greater for RO and backwashing requirements.
 - vii) Water Quality: ASTM type III water quality standard of greater than 4 Megohm.
 - viii) Loop piping must be designed in one continuous recirculation loop, with individual isolation valves, check valves, flow meters and balancing valves for each floor and isolation valves (1/2”) for each point of use.
- c) Pretreatment Skid #1:
 - i) The Pretreatment skid shall be stainless steel with side rail supports and brackets.
 - ii) All equipment shall be pre-plumbed, in schedule 80 PVC, and pre-wired. Plumbing Contractor shall be required to bring domestic hot and cold water (3/4”) directly to the “labeled” inlets on the blend valve (Domestic feed valve).
 - iii) Skid shall be pre-wired with (1) dedicated electrical outlets for the softener. Skid Media shall be loose shipped and filled on site by vendor. Media handling and loading must be per manufacture specifications. Skid connections: Inlet – 3/4 inch Hot and Cold domestic water requirements:
 - (1) Outlet – 1” PVC flange connection.
 - (2) Drain – 0.5” PVC flange connection.
 - (3) Electricity – 115V.
 - iv) Pretreatment Skid Components:
 - (1) Thermostatic control blend valve: Evoqua model W2T151176 sized to minimize pressure loss. Valve should include temperature gauge and integral stops. Temperature setting will be 77°F, for consistent and reliable product flow. Inlet size should be 0.75-inch, and outlet should be 1-inch with a flow rating up to 10 gpm to handle pretreatment backwash flow. Valve should include mounting bracket.
 - (2) Duplex pre filter: Evoqua model W2T144434 (2) 20” Polypro pro housing with (2) 5-micron filter cartridge, Evoqua model W2T159701.
 - (3) Activated Carbon exchange tank: Evoqua model W5TDICAR0360FSQ with 3.5cf of acid washed virgin carbon each. Corrosive resistant FRP pressure vessel with ABS liner.
 - (4) Water Softener: Evoqua model W3T85693 with 2 cf. of strong acid cation resin. Corrosive resistant FRP pressure vessel with blown molded plastic liner wrapped with high-strength epoxy resin and fiberglass. Control head should have a 7-day timer with a 5-cycle motorized piston control for regeneration. The unit shall regenerate as required to eliminate entrapped particulates and recharge the cation resin with sodium. Unit shall have pre and post pressure indication and sample ports. Unit requires 115V power via a standard receptacle located behind the unit location. The unit shall come with a brine tank and shall be located off skid, as close as possible.



5. Reverse Osmosis Unit Skid #2:
- a) Evoqua model W3T332589 (M41RGPV002D). The M41-HP-GP Series RO, 2.8 GPM Reverse Osmosis System, which includes (2) Patented Full Fit Thin Film Membrane elements (TFCs) to ensure better sanitizations, monitor and controller, alarm panel, reject recovery system that will provide 75% recovery of feed water, auto-flush (sends unacceptable permeate water to drain), and vertical multistage centrifugal pump. Instrumentation including: feed and product conductivity, temperature, pressure, and system flow rates, RO system controlled by a ROC-150 Micro Controller housed in an industrial enclosure, isolation valves for cleaning membranes. Electricity – 480V-3PH.
 - b) The reverse osmosis system will be suitable for the following:
 - i) It shall reduce the dissolved mineral content by 90 - 95 percent.
 - ii) Reduce bacteria levels by <99%.
 - iii) The system shall have a multi-stage centrifugal pump. The pump and motor will be designed to reduce noise to a minimum.
 - iv) The system shall use reverse osmosis elements in a spiral-wound configuration.
 - v) The elements shall be polyamide thin film composite membrane type and will be capable of producing water for dialysis at least 90% free of dissolved solids. Performance is based on standard conditions of feed water at 77°F.
 - vi) The system controls and alarms shall be electrically interconnected with the system control panel.
 - vii) The unit shall automatically restart 5 times after a low-pressure alarm.
 - viii) Pressure gauges, flow indicators, a temperature gauge, conductivity device, % rejection.
 - ix) Sample ports will be provided so the operation of the system can be monitored.
 - x) The system controls shall include such safety devices to protect the system from no flow, high temperature and low-pressure situations.
 - xi) Ease of maintenance and accessibility to all components must be a priority of the system design.
 - xii) All piping shall be schedule 80 PVC or stainless steel, no copper or brass.
 - c) The main RO alarm panel will incorporate the following alarms:
 - i) Low feed pressure.
 - ii) High temperature.
 - iii) Low percentage rejection with a set point of <80%.
 - iv) Variable conductivity alarm set to two time's nominal conductivity.
 - v) The above must include both audio and visual alarms.
 - d) Equipment Connections:
 - i) RO inlet connection is 1" FNPT, S80PVC.
 - ii) RO outlet connection is 3/4" FNPT, S80PVC.
 - iii) RO Drain – 1/2" PVC FNPT – to be run to floor drain.
 - iv) Electricity: 480V – 3PH – 5 amps.
 - v) Powered from the system main control panel.
 - e) Post RO mixed beds:
 - i) Evoqua model W5TDIMB10120FSP.
 - ii) Two (2) fiberglass tank with 1 cf regenerated in each tank.
 - iii) Quality light between the tanks Evoqua model W2T152075.



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6. Storage Tank Skid #3:
- a) The storage tank shall have (1) 1.5-inch FNPT outlet connection, (1) 1.5-inch FNPT return connection, 0.5-inch level sensor connection, 0.75-inch vent connection and 1 inch overflow connection and a 1-inch 2 psi check shall be provided by the vendor to be installed at the vertical low point of the overflow pipe. The overflow pipe, fittings, check valve, vent filter, housing, fittings shall all be loose shipped by the vendor and installed by the plumbing contractor with vendor supervision.
 - i) 250-gallon HDPE, cylindrical, closed top, cone bottom, storage tank. The storage tank shall be constructed of virgin high density FDA approved polyethylene, 6 inch gasketed manway cover and linear polyethylene molded pedestal.
 - ii) Tank should include a 20-inch 0.2-micron hydrophobic vent filter and housing Evoqua models W2T155073 and W2T170768.
 - iii) Level control via Effector level sensor Evoqua model W2T386995.
 - iv) 1.5-inch back pressure control valve to maintain loop pressure.
 - v) 1.5-inch block and bleed valves for loop flushing.
7. Distribution:
- a) The post treatment skid shall be stainless steel with side rail supports and brackets. All equipment shall be pre-plumbed and prewired to the Main Control Panel.
 - b) Post Treatment skid piping shall be installed with 1.5-inch socket fused GF+ PP piping, there shall be (1) 1.5-inch flange for the storage tank feed connection, (1) 1.5-inch flange for the loop “building feed” connection. Plumbing contractor shall connect loop piping to the skid.
 - c) Skid Components:
 - i) Duplex distribution pumps: (2) Evoqua model W2T806483 VFD – alternating vertical, multi-stage centrifugal pumps with wetted parts constructed of 316 stainless-steel. The pumps shall 480 VAC 3-phase; each pump shall be equipped with high temperature mechanical seal assemblies with tungsten carbide seal faces mounted in stainless steel components. Continuous operation temperatures up to 250°F. Motors are totally enclosed fan cooled (TEFC), with NEMA C face design that provide a minimum service factor of 1.15. Pumps shall be plumbed in parallel and controlled by the main system control panel housing the motor starters and overloads. They shall have 3-position HOA switches and be protected by the low storage tank level alarm on the control panel. Pumps shall produce XX gpm @ 100 psi (CRNE5-9) X HP and recirculate product water to the floors and back 24 hours a day. Pumps shall alternate every 24 hours. An overload condition shall automatically switch to the alternate pump and remain until fault condition is eliminated.
 - ii) Ultraviolet Disinfection unit: Evoqua model W2T144487 Aquafine MP 2SL:
 - (1) 24 gpm ultraviolet sterilizer-containing (2) lamps will disinfect deionized water to the process loop.
 - (2) 254 nm UV will destroy microorganisms by altering genetic material and rendering them unable to reproduce.
 - (3) UV shall be constructed of 316 stainless-steel, containing baffles to induce turbulence to prevent channeling.
 - (4) Unit power shall be 115 Volt, powered and controlled by the Main Control Panel.



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- iii) The final filter housing: Evoqua model W2T169185, 10-inch multi-tube filter housing electro polished 316L stainless steel – 7 round housing accommodates (7) 10-inch 0.2-micron bacteria filters per housing, Evoqua model W2T170756. The housing should be 2-inch flange inlet and outlet, with 3/4-inch drain port and 1/4-inch air bleed. Unit shall have pre and post pressure indications, isolation true union ball valves and sample ports.
 - iv) The loop return piping shall be routed to the storage tank and connected to the provided back pressure regulating valve.
 - v) Main control panel: Shall be PLC based. HOA switches for pumps and UV, motor starters and overloads for the dual recirculation pumps. The dual recirculation pumps shall alternate every 24 hours per the PLC program and automatically switch to the standby pump if an overload condition occurs. The panel shall house a Thornton M300 multi-parameter meter, which will monitor the final outlet resistivity and temperature (SENSOR INCLUDED WITH PANEL). The panel will incorporate all alarms from the RO, storage tank high level, low level, low-low level, and low resistivity. It will alarm for pump overload conditions and final conductivity and temperature alarms. All alarms shall be audible (65-90 decibels) and visual. Panel shall incorporate full fusing for all loads and reset and silence buttons. The panel will also include a micro-view HMI for alarm set points. The Panel shall have one alarm contact for building BMS. Power requirements for the panel are 480V, 3 phase, 30 amp.
 - vi) Slip stream to DI: Distribution skid will include a slip stream flow back through the post RO DI tanks to maintain final resistivity. Flow shall be directed through a control valve, 0 – 5 gpm flow meter and check valve.



XIV. DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

1. General HVAC information:
 - a) All HVAC systems or units serving common or public spaces (corridors, lounges, lobbies, multipurpose rooms, laundry rooms, exercise rooms, etc.) shall be installed in secure locations that are inaccessible to the occupants or to the public.
 - b) The secure locations required above shall be mechanical rooms or closets designed specifically and exclusively for HVAC equipment installations. HVAC systems or units shall not be installed in custodial, telecommunications, or other closets unless the system or unit being installed serves only that closet.
 - c) All HVAC systems or units serving common or public spaces shall be controlled by one of the University standard building automation systems and space temperature shall be monitored by vandal-proof, flush-mount, stainless steel wall plate sensors. Under no circumstances shall a conventional thermostat be utilized in common or public spaces.
 - d) If a building automation system is not otherwise part of the mechanical system design, a building automation system shall be provided and installed exclusively for HVAC control in all common or public spaces. The building automation system shall meet all the requirements for building automation systems that are specified in Division 25.
 - e) All equipment installed in the University should be controlled from centrally located Building Automation Systems. Division 25 describes the specific minimum control requirements associated with the central control system. The University has multiple systems; specifications should be written to the specific system.
 - f) Temperature and relative humidity of all rooms or zones shall be monitored and controlled through the Building Automation System.
 - g) All billed electrical, water, steam and fuel services shall be metered into the Building Automation System. Prime Professional is to coordinate with University Facilities regarding specifying either direct hard-wired connections or integration to the BAS system, i.e. Modbus.
 - h) The assigning of responsibility for the cutting and patching of all work must be coordinated by the entire design team and be thoroughly and succinctly detailed in the contract documents.
 - i) Coordination of the design for the location of all floor and wall openings, lintels, equipment pads, etc. is the responsibility of the professional engaged to design the system which penetrates the floor, wall, or roof.
 - j) Exterior HVAC installations must consider the aesthetics of the building, noise pollution, accessibility, maintainability, safety regulations and health effects.
 - k) All new equipment is to be provided with software and hardware necessary for University Facilities to have the ability to troubleshoot and/or configure any field equipment. Equipment manufacturer is to provide software and hardware as part of closeout package.
 - l) The following is a list of **prohibited** installations and require University approval for their installation:
 - i) Refer to part 8 under section 25 00 00 for additional **prohibited** items.
 - ii) Plug valves (except as specified herein for natural gas service).
 - iii) Triple-duty (combination) valves used for shutoff service – only single devices are permitted.
 - iv) Press-end valves.
 - v) Groove-end valves.



- vi) Cast press fittings.
 - vii) Press fittings larger than 2-inch NPS.
 - viii) Cast iron fittings (use malleable iron or forge steel fittings).
 - ix) Standard-performance butterfly valves (use high performance valves only).
 - x) HVAC paddle-type flow switches (use differential pressure or electronic flow switches).
 - xi) Dielectric unions (use dielectric waterways).
 - xii) Gate valves (except as specified herein for steam service).
 - xiii) Balancing valves used for shutoff service.
 - xiv) Schedule 10 stainless steel pipe (use Schedule 40).
 - xv) Butt-welded seam steel pipe (use electric resistance welded or seamless pipe).
 - xvi) Bullhead piping connections.
 - xvii) Insertion flow meters (use inline meters only).
 - xviii) Paddle wheel (turbine) flow meters.
 - xix) Internally lined duct systems.
 - xx) Fiberglass duct systems.
 - xxi) Dual temperature systems.
 - xxii) Dual duct systems.
 - xxiii) High static pressure systems.
 - xxiv) Airflow measuring devices other than multi-point thermal dispersion or Pitot traverse stations are selected and installed in compliance with AMCA Standard 203.
 - xxv) Wireless control elements; i.e. valves, dampers, relays, etc.
 - xxvi) Through-wall unit systems.
 - xxvii) Induction units.
 - xxviii) Multi-zone units.
 - xxix) Unit ventilators.
 - xxx) Trane water-source heat pumps.
 - xxxi) Heat wheels utilizing silica gel.
 - xxxii) Dependence on energy recovery for required capacity. Oversizing of main cooling and heating components should be reviewed with the University Engineer.
 - xxxiii) The installation of ductwork, pumps, etc. on roofs. If required due to space constraints the design needs to be reviewed with the University Engineer.
 - xxxiv) Single-wall rooftop air handlers.
 - xxxv) Electric heat in air handlers. Only as a last resort and needs to be reviewed with the University Engineer.
 - xxxvi) Equipment exposed to weather, except exhaust fans from toilets and fume hoods and double-wall rooftop air handlers.
 - xxxvii) Underground storage tanks.
 - xxxviii) Emergency generators equal to, or larger than, 1,000 HP (air permit ramifications).
 - xxxix) Ethylene glycol is **prohibited**, except in the LeBow Engineering Center, Center for Automation, and Bossone Research.
- m) Accessibility:
- i) All devices shall be within reach for operation without dismantling equipment except access doors.



- ii) Equipment and devices located six feet or more above the floor shall be accessible through platforms protected by guardrails.
 - iii) All valves, balancing dampers, and miscellaneous materials located above ceilings must be made accessible by installing access doors. Equipment and devices above ceilings may not be located above counters, cabinets, or stationary room furnishing. Materials above accessible lay-in ceilings must be located from below the ceilings through the installation of ceiling markers applied to the underside of the ceilings. The ceiling marker shall be a red adhesive circle applied to the ceiling and shall have a diameter of 3/8-inch.
 - iv) Design should not install rotating equipment above ceiling and should provide for an equipment room, (VAV and CAV thermal units are an exception). During the Schematic Design Phase, the A/E shall indicate if an exception is required. Equipment approved for above ceiling location shall be serviceable directly from ladder or a service platform provided.
 - v) Pipe and duct spaces shall be designed to adequately house the intended quantity of materials and to allow for a minimum future expansion of 25%. The shaft space shall have minimum interior dimensions of 2'-0" square. Hinged and locked access door shall be installed and provide access to the shaft on alternate levels.
 - vi) Make provisions for chain hoist above all motors and pumps weighing over 75 lbs.
 - n) All mechanical rooms and electrical substations shall be provided with emergency lighting and electrical outlets.
 - o) All mechanical rooms shall be provided with minimum 4-inch floor drains near equipment containing water, strainers, and blowdowns. Specialized equipment may require a larger drain. Trap primers shall be installed in accordance with Section P-1204.3 of the City of Philadelphia Plumbing Code. Non-electronic trap primers are preferred. Approved manufacturers are Jay R. Smith and Precision Plumbing Product Company.
 - p) Floors in mechanical rooms shall be sloped toward floor drains providing positive unrestricted flow without puddling. Trench drains, curbs, floor penetrations, floor to wall connection details must be included to prevent flooding to floors below during routine maintenance or pipe breaks.
 - q) Consideration must be given to the proximity of outdoor air intakes to relief outlets, exhaust outlets, streets, and loading docks. Outdoor air intakes located below grade are **prohibited**. If outdoor air intake is relocated to be located below grade due to renovation, Contractor shall dig a well that is 12-inches below the louver, 6 inches wider than the louver and 24 inches from the louver face with a grate and CMU well walls.
 - r) Strainers and blowdowns shall be installed away from electrical equipment.
 - s) All equipment must be installed on raised concrete pads. Pads shall be a minimum of 4-inches high.
2. All equipment is to be individually scheduled.
 3. All new buildings and major renovations are to be designed to include baseboard heat at the exterior wall.



23 01 30.51 HVAC Air Distribution System Cleaning

1. The cleaning of air ducts shall be performed in accordance with ACR 2013, “Assessment, Cleaning, and Restoration of HVAC Systems”, published by the National Air Duct Cleaners Association.
2. Where possible, access to duct interiors to facilitate the duct cleaning should be made by dismantling the ducts or through existing openings such as supply diffusers, return grilles, duct end caps, and existing service openings.
3. Where new service openings are required to facilitate the duct cleaning, such openings shall be created in accordance with the “Guidelines for Constructing Service Openings in HVAC Systems”, published by the National Air Duct Cleaners Association.
4. A/E to coordinate extent of cleaning existing ductwork with PD&C and Facilities Management.

23 05 00 Common Work Results for HVAC

1. Each system shall be designed and installed in accordance with the latest edition of the applicable Standards, including, but not limited to:
 - a) NFPA Standards.
 - b) Americans with Disabilities Act Accessibility Guidelines (ADAAG).
 - c) ASME A17.1/CSA B44 Safety Code for Elevators and Escalators.
 - d) ANSI Z9.5 American National Standard for Laboratory Ventilation.
 - e) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - f) ASHRAE Standard 15 Safety Code for Mechanical Refrigeration.
 - g) ASHRAE Standard 55 Thermal Comfort.
 - h) ASHRAE Standard 62 Ventilation for Acceptable Indoor Air Quality.
 - i) ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.
 - j) ASHRAE Standard 110 Method of Testing Performance of Laboratory Fume Hoods.
 - k) Underwriters Laboratory, Inc. (UL).
 - l) Factory Mutual System (FM).
 - m) Air Conditioning and Refrigeration Institute (ARI).
 - n) Air Diffusion Council (ADC).
 - o) Air Movement and Control Association (AMCA).
 - p) American National Standards Institute (ANSI).
 - q) American Society for Testing and Materials (ASTM).
 - r) American Welding Society (AWS).
 - s) American Water Works Association (AWWA).
 - t) Associated Air Balance Council (AABC).
 - u) Cooling Tower Institute (CTI).
 - v) Manufacturers Standardization Society of Valve and Fitting Industry (MSS).
 - w) American Society of Mechanical Engineers (ASME).
 - x) ANSI/SMACNA HVAC Duct Construction Standards.
 - y) SMACNA Seismic Restraint Manual.



2. Provide a statement that all multiple pieces of materials and equipment, i.e., valves, motors, starters, vibration isolators, etc., shall be of one manufacturer.
3. Refer to Section 23 05 53 “Identification for HVAC Piping and Equipment”.
4. Piping General - Specify that the contractor shall:
 - a) Remove all burrs and sharp edges from piping.
 - b) Run all piping parallel with or at right angles to walls, floors, and partitions.
 - c) Pitch all piping systems to assure proper drainage and venting. Install drains with hose connections at all low points and 1/2" ball valves at all high points.
 - d) The use of pipe bushings is **prohibited**.
 - e) Piping – Steam – All Pressures – Specify the following:
 - i) All steam piping installations shall be performed according to the manufacturer’s instructions, recommended best practices, and ANSI/ASME B31.1 Code for Pressure Piping.
 - ii) Pipe reductions or enlargements in horizontal steam lines shall be performed with eccentric reducers.
 - iii) All flange gaskets for steam service shall be in accordance with ASME B16.20 for spiral wound gaskets with outer centering ring. Flange gaskets shall be Garlock FLEXSEAL® Style RW, with flexible graphite filler material, or approved equal.
 - iv) All flange bolting shall be ASTM A193 Grade B7 with ASTM A194 Grade 2H hex nuts. Bolt length shall be in accordance with ASME B16.5. Neither studs nor threaded rod shall be used.
 - v) All slip-on flanges shall be backwelded.
 - vi) All bolt threads shall be lubricated with anti-seize thread compound.
 - vii) Make up flanges prior to completing the last weld in connecting piping. Alignment of piping shall be correct without forcing, drifting, or bending
 - viii) Make up joints with spiral wound gaskets by taking up bolts until flange faces touch centering rings. Record torque required for flange closure and re-apply after piping warm-up.
 - ix) After piping has been maintained at operating temperature for 48 hours, recheck bolting to restore initial bolt tension.
 - x) Electric welding machine grounding conductors shall be connected in a manner that will prevent welding current flow through any steam equipment that contains electronics (such as a steam meter or pressure transmitter), to prevent damage to the equipment's electronics during installation.
5. Pressure vessels: All pressure vessels must conform to ASME Code, Commonwealth of Pennsylvania requirements and shall be constructed, inspected, and stamped accordingly.

23 05 13 Common Motor Requirements for HVAC Equipment

1. All motors shall conform to the latest IEEE or NEMA standards relating to characteristics, dimensions, tolerances, temperature rise, insulation, and ratings for noise and vibration.



2. Use NEMA Class B insulation with motor frame amply sized to provide a 1.15 service factor and an ambient of 40°C maximum.
3. The A/E shall be responsible for coordinating the purchase of motor starting equipment. The documents shall clearly state each trade’s responsibility.
4. To maintain the University’s Green Initiative, and to optimize motor system efficiency, reduce electrical power consumption and costs, and improve system reliability, NEMA Premium® labeled electric motors shall be specified for all motors. Each motor shall achieve the NEMA Premium™ efficiency levels contained in NEMA Standards Publication MG 1-2011 as follows:

Nominal Efficiencies For "NEMA Premium™" Induction Motors Rated 600 Volts Or Less (Random Wound)						
Motor HP	Open Drip-Proof			Totally Enclosed Fan-Cooled		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
1	82.5	85.5	77.0*	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0

5. Current density design of motors shall be limited so that overload protection provided by standard motor starters will be adequate to prevent overheating during stall or slightly prolonged acceleration.
6. Starters must be of the combination type (circuit breaker/starter) complete with integral transformers, thermal overload protections, 120-volt coils, low voltage protection, indicating pilot lights (neon or LED type), hand-off-automatic switches and all necessary auxiliary contacts.
7. All motors shall be mounted to the rotating equipment they serve.



8. Wet or outdoor applications shall be provided with TEFC motors only.
9. All motors on cooling towers, air handling units and energy recover units in excess of 2,000 CFM and circulating pumps shall be equipped with variable speed drives equipped with integral electrical bypass or full electromechanical bypasses. The manufacturer shall only be ABB, refer to Section 26 29 23 for model number and specification. A/E to design one VFD connected to one motor.
10. Provide shaft grounding kit for field installation:
 - a) All motors controlled by Variable Frequency Drives shall be equipped with AEGIS Shaft Grounding Ring and insulated bearing kits to be installed by motor or equipment manufacturer or installed in the field by contractor.
11. Motors: Wire shaft ground kit on motors for use with variable frequency drives:
 - a) Ensure AEGIS Shaft Grounding Kit is installed on motor in accordance with manufacturer's recommendation.
 - b) AEGIS Shaft Grounding Ring (SGR) is bolted directly to the motor end bracket or installed with conductive epoxy to ensure ground connection from the AEGIS SGR to motor frame.
12. EC motors are acceptable for use with direct drive type fans and equipment similar to small fan coil units, water source heat pumps, and fan powered VAVs, etc.
13. Contractor is to setup direct drive type fan VFD(s) for their maximum hertz setting. The maximum hertz setting is based on the maximum motor amperage draw per the motor nameplate. VFD technician and BAS contractors are to coordinate this programming prior to the TAB contractor starting their work. If this work is not coordinated the University will not be responsible for additional charges.

23 05 16 Expansion Fittings and Loops for HVAC Piping

1. Use expansion loops in lieu of expansion joints. Approval for the use of expansion joints must be obtained from the University's Project Manager prior to the use of such. The desired methods of expansion compensation in underground steam piping, in order of preference, are as follows:
 - a) Loops
 - i) All loops shall be constructed with long radius elbows welded into the line.
 - ii) All loops must be subjected to cold spring during installation to approximately one-half of the total compensation between hot and cold conditions.
 - b) Ball joints.
 - c) Telescoping slip joints.
2. Pipe Alignment Guides: All piping which must be provided with expansion loops shall be fitted with pipe guides in the quantity and spacing recommended by the manufacturer. Guides shall be equal to Anvil Fig. 255 for pipe sizes 6" and below and Anvil Fig. 256 for piping above 6". Guides shall be firmly attached to the building structure.



3. Anchors: Securely anchor all piping utilizing expansion loops to the building structure with steel angles, properly braced and welded to the pipe. A Structural Engineer shall review all loads imposed upon the structure by the piping system. The contractor shall be required to submit shop drawings detailing the proposed anchors for review.
4. A/E may use flexible loops in tight areas within existing buildings and upon approval by the University. Flexible loops are to meet ASCE Standards and approved Building Codes.
 - a) Basis of Design: Tri-Flex Loop by Bell & Gossett or approved equal.

23 05 19 Meters and Gages for HVAC Piping

1. All devices, piping, valving, relays, end switches, control components, power wiring, control wiring and interlock wiring shall be provided as required to accomplish the sequence of operation for the various pieces of equipment to provide a fully operational system. Refer to Division 25 for specific details and information.
2. Pressure and Temperature Ratings:
 - a) Each meter and gauge shall be rated and suitable for the piping system that it is being installed in.
 - b) Minimum upstream and downstream straight pipe diameters for meters shall be provided per manufacturer's published recommendations.
3. Pressure Gauges – Provide and install all gauges in such a manner as to be easily read from normal observation positions. Gauges shall be as follows:
 - a) Dial Size: 4-1/2-inch.
 - b) Accuracy: 1/2% of Full Scale, Grade 2A, ASME B40.100.
 - c) Case: Black Phenoilc, Solid Front.
 - d) Ring: Threaded Reinforced Black Polypropylene.
 - e) Window: Glass.
 - f) Pointer: Micrometer Adjustable.
 - g) Movement: Rotary, 400 SS, Teflon-Coated Pinion Gear & Segment.
 - h) Bourdon Tube & Socket: Type 316L Stainless Steel.
 - i) Optional Features: PLUS! Performance.
 - j) Manufacturer: Ashcroft.
 - k) Model: 45-1279-SS-(Connection Size & Type)-XLL-(Pressure Range).
 - l) *Alternate Manufacturer: Treice.
 - m) *Alternate Model: 450SS-45-(Connection Size)-(Connection Location)-A-(Pressure Range Code)-SS(code for fluid selection for snubber screw).
 - n) *Each gauge must be supplied with a Treice Model 870-13 or 870-16 impulse dampener.

NOTE: All pressure gauges utilized for steam service must be equipped with a coil syphon constructed of 316 stainless steel or seamless Schedule 80 carbon steel.



- o) Select range in such a manner that the operating pressures is at the mid-point of the scale. Pressure ranges shall be as follows:
- i) Refrigerant: 30" to 0 lbs. to 150 lbs.
 - ii) Steam, 0 to 20 lbs.: 0 lbs. to 30 lbs.
 - iii) Steam, 21 to 60 lbs.: 0 lbs. to 100 lbs.
 - iv) Steam, 61 to 150 lbs.: 0 lbs. to 200 lbs.
 - v) Steam, 151 to 250 lbs.: 0 lbs. to 300 lbs.
 - vi) Fluids, Suction Side of Pump,
Open Systems: 30" to 0 lbs. to 150 lbs.
 - vii) Fluids, Suction and Discharge
Side of Pump, Closed Systems: 0 lbs. to 100 lbs.
4. Thermometers – Provide and install all thermometers in such a manner as to be easily read from normal observation positions. Thermometer shall be as follows:
- a) Dial Size: 5-inch.
 - b) Accuracy: 1% of Full Scale, Grade A, ASME B40.3.
 - c) Stem & Case: 304 Stainless Steel, Hermetically Sealed.
 - d) Stem Diameter: 0.250 inch.
 - e) Window: Polycarbonate.
 - f) Connection: 1/2-inch NPT Union.
 - g) Location: Everyangle[®].
 - h) Manufacturer: Ashcroft.
 - i) Model: 50-EL-42-E-(Stem Length Code)-(Range Code).
 - j) Alternate Manufacturer: Treice.
 - k) Alternate Model: B856-(Stem Length Code)-(Range Code)-SWV.

NOTE: All thermometers installed in piping or pipelines shall be supplied with threaded, stepped shank, 316 stainless steel thermowells of suitable dimensions for the thermometer being supplied.

- l) Select range in such manner that the operating temperature is at the mid-point of the scale. Thermometer ranges shall be as follows:
- i) Steam, 0 to 20 psi: 50°F to 300°F.
 - ii) Steam, 21 to 150 psi: 50°F to 400°F.
 - iii) Steam, 151 to 250 psi: 50°F to 400°F.
 - iv) Condenser water: 50°F to 120°F.
 - v) Chilled water: 30°F to 100°F.
 - vi) Heating water: 50°F to 250°F.
 - vii) Closed Circuit Cooler: 60°F to 120°F.
 - viii) Ice Storage water: 0°F to 90°F.

23 05 29 Hangers and Supports for HVAC Piping and Equipment

1. The following hanger types shall be specified for the support of piping within buildings:



- a) All pipe hangers shall be sized to fit over insulated piping. Provide the following insulation protection devices:
 - i) Up to and including 6" - Insulation shield equal to Anvil Fig. 167.
 - ii) 6" and above - Pipe insulation protection saddle equal to Anvil Fig. 160.
 - iii) Alternate: Insulated piping above 2" - Rigid hydrous calcium silicate insulation having a compressive strength of 200 PSI may be used at hanger locations on piping above 2". Insulation shields equal to Anvil Fig. 167 must be used in conjunction with the insulation.
 - b) All hangers and supports directly in contact with the piping must be of compatible materials.
 - c) Horizontal piping up to and including 6" nominal pipe diameter:
 - i) Ceiling Hung - Adjustable clevis hangers equal to Anvil Fig. 260.
 - ii) Floor, wall or rack supported - offset pipe clamp equal to Anvil Fig. 103.
 - d) Horizontal piping 8" through 12":
 - i) Ceiling Hung - Adjustable steel yoke pipe roll equal to Anvil Fig. 181.
 - ii) Floor or rack supported - Adjustable pipe roll stand with steel base plate equal to Anvil Fig. 274P.
 - e) Horizontal Piping above 12":
 - i) Ceiling Hung – Adjustable steel yoke pipe roll equal to Anvil Fig. 181.
 - ii) Floor or rack supported - Adjustable pipe roll with base equal to Anvil Fig. 274P.
 - f) Spring hangers shall be used within mechanical rooms to support piping connected to rotating equipment as follows:
 - i) Up to and including 6" nominal pipe size: Ceiling mounted, pre-engineered spring pipe hanger equal to Anvil Fig. B-268 Type A.
 - ii) Above 6" manual pipe size: Piping cushion for pipe rolls equal to Anvil Fig. 178.
2. Hanger Spacing: Piping shall be supported at distances not exceeding the spacing specified in Table 305.4 of the 2018 International Mechanical Code.
 3. All hub or joint pipe shall be supported within the above recommendations for steel and at each joint.
 4. Polyvinyl chloride pipe (PVC) shall be supported at intervals recommended by the manufacturer for a 120°F fluid temperature.
 5. All piping which must pass to within six (6) feet, measured horizontally, from all switchboards, panels, metering assemblies, buss ducts, etc., shall be provided with watertight sheet-metal enclosures to completely protect such equipment in the event of leakage. Provide a drain tapping at the low point of the enclosure and pipe such to the nearest drain.

23 05 33 Heat Tracing for HVAC Piping

1. Install heat trace on all cooling tower condenser water supply and return, equalization, drain, overflow, cold water make-up, chilled water (without glycol) supply and return, hot water supply and return, steam, and steam condensate located outdoors.
2. Install prior to insulating piping systems.



3. Select cable lengths to maintain 40°F fluid in pipe for freeze protection, with an outdoor ambient at -20°F.
4. Provide the system with necessary standoff and cable tie kits.
5. Provide monitoring and alarming via BAS system to prove system is drawing current as opposed to monitoring contract in a heat trace controller.
6. Approved manufacturer is Raychem or approved equal. The following components and model numbers are for a Raychem system:
 - a) Braided Self-Regulating Cable: (watt pre linear foot)XL-(voltage)-CR.
 - i) Watt per linear foot: Available in 5, 8, or 12.
 - ii) Voltage (1 or 2): “1” represents 120V (5 and 8W/ft.). “2” represents 208/240/277V (5, 8 and 12W/ft).
 - b) Power Connection Kits: Rayclic-PC.
 - c) Splices: Rayclic-S.
 - d) Tees: Rayclic-T.
 - e) End Seal Kits: Rayclic-E.
 - f) Lighted End Seal: Rayclic-LE.
 - g) Binding Tape: GT-66.
 - h) Aluminum Tape: AT-180.
 - i) Indicating Strip Pipe Label: ETL.
 - j) Controllers:
 - i) Digitrace 910 controller with ambient sensing RTD-200 for single circuit systems.
 - ii) Digitrace 920 with ambient sensing RTD-200 for systems between 2 and 8 circuits.
 - iii) Digitrace ACS-30 with ambient sensing RTD-200 for systems above 8 circuits.
 - iv) Controller is to be sized to allow for extra control points, for 25% growth.
7. Field Quality Control:
 - a) Initial start-up and field-testing (commissioning) of the system shall be performed by a factory technician or factory representative per the owner’s requirements.
 - b) Field Tests And Inspections:
 - i) The System shall be commissioned in accordance with the Manufacturer’s Installation and Operation manual.
 - ii) Field visits to be scheduled at the following interval:
 - (1) Pre-installation training. Note: Heating cable shall be meagered and recorded after installation, but before thermal insulation by the installation contractor per Manufacturer’s Installation and Operation manual.
 - (2) Heating cable shall be meagered after installation of thermal insulation.
 - (3) Final commissioning includes controller programming (if applicable).
 - iii) The technician shall verify that the controller parameters are set to the application requirements.
 - iv) The technician shall verify that the controller alarm contacts are properly connected to the BMS (if applicable).
 - c) System Startup:
 - i) All commissioning results will be recorded and submitted.



22 05 48 Vibration and Seismic Controls for HVAC

1. A/E to determine if vibration and seismic controls are required for the project.
2. All vibration isolators and seismic restraints described in this Section shall be the product of a single manufacturer. The basis of design for this section is The VMC Group, including Vibration Mountings & Controls, Amber/Booth, or Korfund Dynamics. Products from other nationally recognized manufacturers are acceptable provided their systems strictly comply with these specifications and have the approval of the specifying engineer.
3. Vibration Isolation Types:
 - a) Type A: Spring Isolator – Free Standing A*.
 - i) Spring isolators shall be free standing and laterally stable without any housing and complete with a molded elastomeric cup or 0.25-inch elastomeric acoustical friction pad between the bottom of isolator and the support.
 - ii) All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
 - iii) Spring diameters shall be no less than 0.8 inch of the compressed height of the spring at rated load.
 - iv) Springs shall have a minimum additional travel to solid equal to 50% of the operating deflection.
 - b) Type B: Seismically and Wind Restrained Spring Isolator – M S, MSS, AMSR.
 - i) Restrained spring mountings shall have a Type A spring isolator within a rigid housing that includes vertical limit stops to prevent spring extension if weight is removed. The housing shall serve as blocking during erection. A maximum clearance of 0.25 inch shall be maintained around restraining bolts and internal elastomeric deceleration bushings. Limit stops shall be out of contact during normal operation. If housings are to be bolted or welded in position, there must be an internal isolation pad or elastomeric cup. Housing shall be designed to resist all seismic forces.
 - c) Type C: Combination Spring/Elastomer Hanger Isolator (30° Type) HRSA.
 - i) Hangers shall consist of rigid steel frames containing minimum 1-1/4-inch-thick elastomeric elements at the top and a steel spring with general characteristics as in Type A. The elastomeric element shall have resilient bushings projecting through the steel box.
 - ii) Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the rod bushing and short-circuiting the spring.
 - iii) Submittals shall include a hanger drawing showing the 30° capability.
 - iv) Hanger locations requiring pre-compression for holding piping at fixed elevation shall be pre-compressed or pre-positioning for all manufacturers.
 - d) Type D: Elastomer Double Deflection Hanger Isolator HR.
 - i) Molded (minimum 1-1/4-inch thick) elastomeric element with projecting bushing lining the rod clearance hole. Static deflection at rated load shall be a minimum of 0.35 inches.
 - ii) Steel retainer box encasing elastomeric mounting capable of supporting equipment up to two times the rated capacity of the element.



- e) Type E: Combination Spring/Elastomer Hanger Isolator HRS.
 - i) Spring and elastomeric elements in a steel retainer box with the features as described for Type C and D isolators.
 - ii) Hanger locations requiring pre-compression for holding piping at fixed elevation shall be pre-compressed or pre-positioning for all manufacturers.
 - iii) 30° angularity feature is not required.
- f) Type F: Seismically Restrained Elastomer Floor Isolator – RSM, MB.
 - i) Bridge-bearing elastomeric mountings shall have a minimum static deflection of 0.2 inch and all-directional seismic capability. The mount shall consist of a ductile iron or aluminum casting containing molded elastomeric elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock-absorbing elastomeric materials shall be compounded to bridge-bearing or Durulene specifications.
- g) Type G: Pad Type Elastomer Isolator (Standard) Maxiflex.
 - i) One layer of 0.75-inch-thick elastomeric pad consisting of 2-inch square modules for size required.
 - ii) Load distribution plates shall be used as required.
 - iii) Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short-circuiting.
- h) Type H: Pad Type Elastomer Isolator (High Density) NRC.
 - i) Laminated canvas duck and neoprene, maximum loading 1000 psi, minimum 0.5-inch thick.
 - ii) Load distribution plate shall be used as required.
 - iii) Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short-circuiting.
- i) Type I: Thrust Restraints – TRK.
 - i) A spring element similar to Type A isolator shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting movement of air handling equipment to 0.25-inch due to thrust forces. Contractor shall supply hardware.
 - ii) Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.
- j) Type J: Pipe Anchors – AG.
 - i) All-directional acoustical pipe anchor, consisting of two sizes of steel tubing or piping separated by a minimum 0.5-inch thick 60 durometer elastomer.
 - ii) Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction.
 - iii) Applied loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
- k) Type K: Pipe Guides – AG.
 - i) Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing or piping separated by a minimum 0.5-inch thickness of 60 durometer elastomer.
 - ii) The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and replaceable to allow for selection of pipe movement.
 - iii) Guides shall be capable of ± 1.625 -inch motion, or to meet location requirements.



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4. Seismic Restraint Types:
- a) Type I: Spring Isolator, Restrained – MS, MSS, AEQM, ASCM, AMRS.
 - i) Refer to vibration isolation Type B.
 - b) Type II: Seismically Restrained Elastomer Floor Isolator – MB.
 - i) Refer to vibration isolation Type F.
 - c) Type III: All-Directional Seismic Snubber – SR, ER.
 - i) All-directional seismic snubbers shall consist of interlocking steel members restrained by an elastomeric bushing. Bushing shall be replaceable and a minimum of 0.25 inch thick. Applied loading shall not exceed 1000 psi. A minimum air gap of 0.125 inches shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Elastomeric bushings shall be rotated to ensure no short circuits exist before systems are activated.
 - d) Type IV: Floor or Roof Anchorage Cast-In Plates.
 - i) Rigid attachment to structure utilizing wedge type anchor bolts, anchored plates, machine screw, bolting or welding. Power shots are unacceptable.
 - e) Type V: Seismic Cable Restraints – SB, LRC
 - i) Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges.
5. Equipment Bases:
- a) All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4 inches) for resisting wind and seismic forces in accordance with the project location. Fastening to metal deck is unacceptable.
 - b) Base Types:
 - i) Type B-1: Integral Structural Steel Base – WFB, SFB.
 - (1) Rectangular bases are preferred for all equipment.
 - (2) Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case and end suction pumps shall include supports for suction and discharge elbows.
 - (3) All perimeter members shall be structural steel beams with a minimum depth equal to 1/12 of the longest dimension between isolators.
 - (4) Base depth need not exceed 12 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
 - (5) Height saving brackets shall be employed in all mounting locations to provide a minimum base clearance of 2 inches.
 - ii) Type B-2: Concrete Inertia Base – CPF.
 - (1) Vibration isolation manufacturer shall furnish rectangular welded or bolted modular steel concrete pouring forms for floating and inertia foundations.
 - (2) Bases for split case and end suction pumps shall be large enough to provide suction and discharge elbows.
 - (3) Bases shall be a minimum of 1/12 of the longest dimension between isolators but not less than 6 inches.



- (4) The base depth need not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity.
 - (5) Forms shall include a minimum concrete reinforcing consisting of 0.375-inch bars welded in place, a maximum of 16 inch on centers running both ways in a layer 1 to 1.5 inches above the bottom.
 - (6) Forms shall be furnished with steel templates to hold the component anchor bolts sleeves and anchors while concrete is being poured.
 - (7) Height saving brackets shall be employed in all mounting locations to maintain a 2-inch minimum operational clearance below the base.
- iii) Type B-3: Seismic Isolation Curb – P6200, P6300.
- (1) Curb-mounted rooftop equipment shown on isolation schedule shall be mounted on structural seismic spring isolation curbs. The upper frame must provide continuous support for the equipment and must be captive to resiliently resist wind and seismic forces. The lower frame must accept point support for both seismic attachment and leveling. The upper frame must be designed with positive fastening provisions (welding or bolting), to anchor the rooftop unit to the curb, which will not violate the National Roofing Contractors Association (NRCA) ratings of the membrane waterproofing. Sheet metal screws are only acceptable if all provisions in Section 1.4, Article B, paragraph 7, Design Seismic Loads, are met. Contact points between the rooftop unit, the curb and the building's structure shall show load path through those locations only.
 - (2) All-directional elastomeric snubber bushings shall be minimum of 0.25 inches thick. Steel springs shall be laterally stable and rest on 0.25 inches thick elastomeric acoustical pads or cups.
 - (3) Hardware must be plated, and the springs shall be powder-coated or cadmium-plated.
 - (4) The curb's waterproofing shall be designed to meet all NRCA requirements.
 - (5) All spring locations shall have full spring view access ports with removable waterproof covers and all isolators shall be adjustable, removable, and interchangeable.
 - (6) Isolated curbs shall be supplied with a continuous air seal between the upper floating member and the stationary wood nailer.
- iv) Type B-4: Seismic Non-Isolated Curbs – P6000.
- (1) Seismic curbs shall have all provisions as Type B-3 curbs with the exception of spring isolation.
 - (2) System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel, capable of carrying the design seismic loads.
- v) Type B-5: Isolated Equipment Supports – R7200/R7300.
- (1) Continuous structural equipment supports rails that combine equipment support and isolation mounting into one unitized roof flashed assembly with all features as described for Type B-3.
 - (2) System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel, capable of carrying the design seismic loads.



- vi) Type B-6: Non-Isolated Equipment Supports – R7000.
 - (1) This shall have the same provisions as Type B-5 without spring isolation.

6. Flexible Connectors:

- a) Type FC-2: Flexible Stainless-Steel Hose – SS-FP, SS-FW, SS-PM, SS-WE.
 - i) Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3-inches and larger shall be flanged. Smaller sizes shall have male nipples.
- b) Type BC-2: Connector shall be braided bronze for Freon connections.
 - i) Minimum lengths shall be as tabulated:

Flanged		Male Nipples	
3x14	10x26	1/2x9	1-1/2x13
4x15	12x28	3/4x10	2x14
5x19	14x30	1x11	2-1/2x18
6x20	16x32	1-1/4x12	

- ii) Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

7. Equipment Installation

- a) Equipment shall be isolated and/or restrained as per Tables A-E at the end of this section.
- b) Place floor mounted equipment on 4-inch actual height concrete housekeeping pads properly sized and doweled or expansion shielded to the structural deck. Anchor isolators and/or bases to housekeeping pads. Concrete work is specified under that section of the contract documents.
- c) Additional Requirements:
 - i) The minimum operating clearance under all isolated components bases shall be 1 or 2 inches. A/E to specify based on equipment type and weight.
 - ii) All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators, and restraints.
 - iii) All components shall be installed on blocks to the operating height of the isolators. After the entire installation is complete and under full load, including water, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free to move in all directions, within the limits of the restraints.
 - iv) Ceilings containing diffusers or lighting fixtures must meet seismic requirements by using earthquake clips or other approved means of positive attachment to secure diffuser and fixtures to T-bar structure.
 - v) All floor or wall-mounted equipment and tanks shall be restrained with Type V restraints.

8. Piping and Ductwork Isolation

- a) Vibration Isolation of Piping:
 - i) The minimum operating clearance under all isolated components bases shall be 2 inches.
 - ii) HVAC Water Piping: All spring type isolation hangers shall be pre-compressed or pre-positioned if isolators are installed prior to fluid charge. If installed



- afterwards, field pre-compressed isolators can be used. All HVAC piping in the machine room shall be isolated as well as pressurized runs in other locations of the building 6 inches and larger. Type E hangers shall isolate horizontal pressurized runs in all other locations of the building. Floor supported piping shall rest on Type B isolators. Heat exchangers and expansion tanks are considered part of the piping run. The first 3 isolators from the isolated equipment shall have at least the same static deflection as specified for the mountings under the connected equipment.
- iii) Steam and Condensate Piping: All ceiling suspended piping in the mechanical equipment room shall be isolated with Type D hangers. All floor supported piping shall be supported with Type F isolators. At locations where supports are either acting as anchors or guides, Type D and F isolators shall be deleted, and anchor or guide shall be resiliently attached to the structure utilizing isolation washers and bushings to prevent metal to metal contact. Isolation washers and bushings shall be molded from Type “H” material.
 - iv) Plumbing Water Lines: Plumbing water lines in the machine room shall only be isolated if connected to isolated equipment (See Table B). Isolator type shall be as listed in item 8.a).i), above.
 - v) Riser Location: All risers shall be supported on Type J or K anchors, or guide restraints positively attached to both the riser and structure. Spiders welded to the pipe can substitute for Type K guides using J Type anchors.
 - vi) Control Air Piping: Where control air piping is connected to isolated components, all piping shall be isolated, and equipment shall be flexibly connected in horizontal and vertical plane with Type FC-2 flexible connectors.
 - vii) Gas lines shall not be isolated.
 - viii) Fire protection lines shall not be isolated.
- b) Seismic Restraint of Piping, Conduit, Bus Duct and Cable Tray:
- i) The minimum operating clearance under all isolated components bases shall be 2 inches.
 - ii) All high hazard and life safety pipe regardless of size such as fuel oil piping, fire protection mains, gas piping, medical gas piping and compressed air piping and piping with an $I_p=1.5$ shall be seismically restrained or braced. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI single arm braces may be used on non-isolated piping. There are no exclusions for size or distance in this category.
 - iii) Seismically restrain piping, with an $I_p = 1.0$, located in boiler rooms, mechanical equipment rooms and refrigeration equipment rooms that is 1-1/4-inch I.D. and larger. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI single arm braces may be used on non-isolated piping.
 - iv) Seismically restrain all other piping 2-1/2-inch diameter and larger. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type VI seismic cable restraints or single arm braces may be used on non- isolated piping.
 - v) See Table D for maximum seismic bracing distances.
 - vi) Multiple runs of pipe on the same support shall have distance determined by calculation.



- vii) Rod braces shall be used for all rod lengths as listed in Table E.
 - viii) Clevis hangers shall have braces placed inside of hanger at seismic brace locations.
 - ix) Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided, they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
 - x) For fuel oil and all gas piping, transverse restraints must be at 20 foot maximum and longitudinal restraints at 40 foot maximum spacing.
 - xi) Transverse restraint for one pipe section may also act as longitudinal restraint for a pipe section of the same or smaller size connected perpendicular to it if the restraint is installed within 24 inches of the centerline of the smaller pipe or combined stresses are within allowable limits at longer distances.
 - xii) Hold down clamps must be used to attach pipe to all trapeze members before applying restraints. Use Type V or VI restraint, if trapeze is smaller than 48 inches long.
 - xiii) Branch lines may not be used to restrain main lines or cross-mains.
 - xiv) All fire protection branch lines shall be end tied.
 - xv) Where pipe passes through a fire-rated, seismic gypsum wall, the wall can act as a lateral/transverse brace for pipe sizes up to and including 6 inches provided fire stopping material is tight to the pipe.
 - xvi) Where pipe passes through a seismic block or concrete wall, the wall can act as a lateral/transverse brace.
 - xvii) Where horizontal pipe crosses a building's drift expansion joint, allowance shall be part of the design to accommodate differential motion.
 - xviii) Vertical pipe and conduit risers between floors shall have their differential movement part of the seismic design for building drift. Risers shall be anchored as required.
 - xix) For horizontal passage of all underground utilities through building's foundation wall, all pipes shall pass freely through an oversized opening and waterproofed accordingly to accommodate maximum allowable building drift. (Seismic Restraint Type VIII)
- c) Vibration Isolation of Ductwork:
- i) The minimum operating clearance under all isolated components bases shall be 2 inches.
 - ii) All discharge runs for 50 feet from the connected equipment shall be isolated from the building structure by means of Type A or Type E isolators. Actual spring deflection shall be a minimum of 0.75 inches.
 - iii) All duct runs having air velocity of 1500 feet per minute (fpm) or more shall be isolated from the building structure by Type E combination spring elastomer hangers or Type A floor spring supports. Spring deflection shall be a minimum of 0.75 inches.
- d) Seismic Restraint of Ductwork:
- i) The minimum operating clearance under all isolated components bases shall be 2 inches.
 - ii) Restrain all ductwork with cross sectional area of 6 square feet or larger. Type V seismic cable restraints or Type VI single arm braces shall be used on this duct. Duct that serves a life safety function or carries toxic materials in an "Essential or High



- Hazard Facility” must be braced with no exceptions regardless of size or distance requirements.
- iii) Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
 - iv) See Table D for maximum seismic bracing distances.
 - v) Duct must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze. Additional reinforcing is not required if duct sections are mechanically fastened together with frame bolts and positively fastened to the duct support suspension system.
 - vi) A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
 - vii) Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.
 - viii) If ducts are supported by angles, channels or struts, ducts shall be fastened to it at seismic brace locations in lieu of duct reinforcement.
- e) Exemptions:
- i) Equipment:
 - (1) Continuous structural equipment support rails that combine equipment support and isolation mounting into one unitized roof flashed assembly with all features as described for Type B-3.
 - (2) Curb-mounted mushroom, exhaust, and vent fans with curb area less than nine square feet are excluded.
 - (3) Floor or curb-mounted equipment weighing less than 400 lbs and not resiliently mounted, where the Importance Factor, $I_p = 1.0$ and there is no possibility of consequential damage.
 - (4) Equipment weighing less than 20 lbs and distribution systems weighing less than 5 lbs/lineal foot, with an $I_p = 1.0$ and where flexible connections exist between the component and associated ductwork, piping or conduit.
 - (5) Chain supported lighting fixtures as described in Section 13.6.1 (ASCE 7-05).
 - ii) Duct (Applies to $I_p = 1.0$ only):
 - (1) Continuous structural equipment support rails that combine equipment support and isolation mounting into one unitized roof flashed assembly with all features as described for Type B-3.
 - (2) Rectangular, square, and oval air handling ducts less than six square feet in cross sectional area.
 - (3) Round air handling duct less than 28 inches in diameter.
 - (4) Duct runs supported at locations by two rods less than 12 inches in length from the structural support to the structural connection to the ductwork.
 - iii) Piping and Conduit:
 - (1) All high deformability pipe or conduit 3 inches or less in diameter suspended by individual hanger rods where $I_p = 1.0$.
 - (2) High deformability pipe or conduit in Seismic Design Category C, 2 inches or less in diameter suspended by individual hanger rods where $I_p = 1.5$.



- (3) High deformability pipe or conduit in Seismic Design Category D, E or F, 1 inch or less in diameter suspended by individual hanger rods where $I_p = 1.5$.
 - (4) All clevis supported pipe or conduit runs installed less than 12 inches from the top of the pipe to the underside of the support point and trapeze supported pipe suspended by hanger rods having a distance less than 12 inches in length from the underside of the pipe support to the support point of the structure.
 - (5) Piping systems, including their supports, designed, and constructed in accordance with ASME B31.
 - (6) Piping systems, including their supports, designed, and constructed in accordance with NFPA, provided they meet the force and displacement requirements of Section 13.3.1 and 13.3.2 (ASCE 7- 05).
- f) Exemptions Do Not Apply For:
- i) Life Safety or High Hazard Components:
 - (1) Piping systems, including their supports, designed, and constructed in accordance with NFPA, provided they meet the force and displacement requirements of Section 13.3.1 and 13.3.2 (ASCE 7- 05).
 - (2) Including gas, fire protection, medical gas, fuel oil and compressed air needed for the continued operation of the facility or whose failure could impair the facility's continued operation, Occupancy Category IV of the IBC regardless of governing code for HVAC, Plumbing, Electrical piping or equipment.
(*A partial list is illustrated.*) High Hazard is additionally classified as any system handling flammable, combustible, or toxic material. Typical systems not excluded are additionally listed below.
 - ii) Electrical:
 - (1) Includes critical, standby, or emergency power components including conduit (1-inch nominal diameter and larger) cable tray or bus duct, lighting, panels, communication lines involving 911, etc.
 - iii) Piping:
 - (1) Fuel oil, gasoline, natural gas, medical gas, steam, compressed air or any piping containing hazardous, flammable, combustible, toxic or corrosive materials. Fire protection standpipe, risers, and mains. Fire Sprinkler Branch Lines must be end tied.
 - iv) Duct:
 - (1) Smoke evacuation duct or fresh air make up connected to emergency system, emergency generator exhaust, boiler breeching or as used by the fire department on manual override.
 - v) Equipment:
 - (1) Previously excluded non-life safety duct mounted systems such as fans, variable air volume boxes, heat exchangers and humidifiers having a weight greater than 75 lbs require independent seismic bracing.

9. Field Quality Control, Inspection

- a) All Independent Special and Periodic Inspections must be performed and submitted on components. *Note: Special Inspection services are to be supplied by the owner.*



- b) Upon completion of installation of all vibration isolation devices, the manufacturer’s chosen representative shall inspect the completed project and certify in writing to the Contractor that all systems are installed properly, or list any that require correction. The contractor shall submit a report to the Architect, including the representative’s report, certifying correctness of the installation, or detailing corrective work to be done.

10. Field Quality Control, Inspection

a) Selection Guide For Vibration Isolation and Seismic Restraint

Table “A” HVAC Equipment										
EQUIPMENT (See Notes)	On Grade, Basement or Slab on Grade						Above Grade			
	Size/ Type	Mtg	Isol	Nom Defl*	Base	Restr	Isol	Nom Defl*	Base	Restr
Absorption Machine		Floor	---	---	---	IV	B	0.75	B-2	IV
Air Handling Units Indoor		Floor	B	0.75	---	IV	B	1.5	---	IV
		Ceiling	---	---	---	---	C	0.75	---	V
Air Compressor, Tank or Floor Mounted	To 10 HP	Floor	B	0.75	---	IV	B	1.50	---	IV
	>10 HP	Floor	B	0.75	B-2	IV	B	1.50	B-2	IV
Dry Coolers Outdoor Condensing Units/ Condensers		Roof	---	---	---	IV	B	2.50 Minimum	B-5	IV
Axial Fans (Inline Type)		Floor	B	0.75	---	IV	B	See Guide	---	IV
		Ceiling	---	---	---	---	C	See Guide	---	V
Base Mounted Pumps	To 15 HP	Floor	B	0.75	B-2	IV	B	0.75	B-2	IV
	>15 HP	Floor	B	0.75	B-2	IV	B	1.50	B-2	IV
Boilers		Floor	G	0.10	---	IV	B	0.75	---	IV
Cabinet Fans & Packaged AHU Indoor	To 1 HP	Floor	F***	0.20	---	IV	B	0.75	---	IV
		Ceiling	---	---	---	---	C	0.75	---	V
	>1 HP	Floor	B	0.75	---	IV	B	See Guide	---	IV
		Ceiling	---	---	---	---	C	See Guide	---	V
Centrifugal Chillers		Floor	B	0.75	---	IV	B	1.50	---	IV
Centrifugal Fans Arr. 1 & 3	Class 1	Floor	B	0.75	B-1	IV	B	See Guide	B-1	IV
	Class 2 & 3	Floor	B	0.75	B-2	IV	B	See Guide	B-2	IV
Centrif. Fans (Vent Sets) Arr. 9 & 10	Class 1	Floor	B	0.75	---	IV	B	See Guide	See Note 4	IV
	Class 2 & 3	Ceiling	---	---	---	---	C	See Guide	B-2	V
Computer Room Units		Floor	F***	0.20	*	IV	B	1.5	*	IV
Condensate Pumps		Floor	F***	0.20	If req.	IV	F***	0.20	If req.	IV
Cooling Towers		Floor	B	0.75	---	IV	B	2.50	B-1,B-5 optional	---
Curb Mtd. Equip. (Non-Isol.)		Roof	---	---	---	IV	---	---	B-6	---



Table "A" HVAC Equipment (cont.)										
	On Grade, Basement or Slab on Grade						Above Grade			
Fan Coil Units		Floor	F***	0.20	---	IV	B	0.75	---	IV
		Ceiling	---	---	---	---	E	0.75	---	V
Outdoor Reciprocating, Rotary or Screw Chillers		Floor	F***	0.20	---	IV	B	1.50	---	---
		Roof	---	---	---	IV	B	2.50	B-5	---
Rooftop AHU/AC (curb mounted)	< 10 Ton	Roof	---	---	---	IV	B	1.50	B-3 See Notes 5,6	---
	> 10 Ton	Roof	---	---	---	IV	B	2.50	B-3 See Notes 5,6	---
Rooftop AHU/AC (dunnage mounted)	< 10 Ton	Roof	---	---	---	IV	B	1.50	B-8	---
	> 10 Ton	Roof	---	---	---	IV	B	2.50	B-8	---

**See Minimum Deflection Guide for Equipment with Low RPM*

***By Unit Manufacturer.*

****Type RVD Double Deflection Neoprene Mounts May Be Substituted for Non-Seismic Installations.*

Table "B" Plumbing Equipment										
	On Grade, Basement or Slab on Grade						Above Grade			
EQUIPMENT (See Notes)	HP	Mtg	Isol	Defl	Base	Restr	Isol	Defl	Base	Restr
Air Compressors & Vacuum Pumps	Up to 10	Floor	B	0.75	---	IV	B	1.50	---	IV
	Over 10	Floor	B	0.75	B-2	IV	B	1.50	B-2	IV
Base Mounted Pumps	Up to 15	Floor	B	0.75	B-2	IV	B	0.75	B-2	IV
	Over 15	Floor	B	0.75	B-2	IV	B	1.50	B-2	IV

Table "C" Electrical Equipment										
	On Grade, Basement or Slab on Grade						Above Grade			
EQUIPMENT (See Notes)	Size	Mtg	Isol	Defl	Base	Restr	Isol	Defl	Base	Restr
Transformers (Dry Type)	All	Floor	---	---	---	IV	D	0.30	*	IV
		Ceiling	---	---	---	V	C	0.20	*	V
Generators	All	Floor	B	1.0	---	IV	B	1.50	*	IV
Generators	All	Over Occupied Space	---	---	---	---	B	2.50	*	IV
UPS Systems	M	All	---	---	---	---	B	1.50	*	IV

**Where Component cannot be point supported, Base Type B-1 shall be used.*



Minimum Deflection Guide for Equipment with Low RPM

Lowest RPM of Rotating Equipment	Minimum Actual Deflection
Less Than 400	3.5 inches
401 thru 600	2.5 inches
601 thru 900	1.5 inches
Greater than 901	0.75 inches

b) General Notes for All Tables:

- i) Abbreviations:
 - (1) Mtg = Mounting.
 - (2) ol = Vibration Isolator Type per Part 3, Vibration Isolation Types.
 - (3) Defl = Minimum Deflection of Vibration Isolator.
 - (4) Base = Base Type per Part 5, Equipment Bases.
 - (5) Restr = Seismic Restraint Type per Part 4, Seismic Restraint Types.
- ii) All deflections indicated are in inches.
- iii) For equipment with variable speed driven components having driven operating speed below 600 rpm, select isolation deflection from minimum deflection guide.
- iv) For roof applications, use base Type B-5.
- v) Units may not be capable of point support. Refer to separate air handling unit specification section. If that section does not provide base and external isolation is required, provide Type B-1 base by this section for entire unit.
- vi) Static deflection shall be determined based on the deflection guide for Table “A.”
- vii) Deflections indicated are minimums at actual load and shall be selected for manufacturer’s nominal 5-inch, 4-inch, 3-inch, 2-inch, and 1-inch deflection spring series; RPM is defined as the lowest operating speed of the equipment.
- viii) Single stroke compressors may require inertia bases with thicknesses greater than 14 inch maximum as described for base B-2. Inertia base mass shall be sufficient to maintain double amplitude for 0.125 inches.
- ix) Floor mounted fans, substitute base Type B-2 for class 2 or 3 or any fan having static pressure over 5 inches.
- x) Indoor utility sets with wheel diameters less than 24 inches need not have deflections greater than 0.75 inches.
- xi) Curb-mounted fans with curb area less than 9 square feet are excluded.
- xii) For equipment with multiple motors, Horsepower classification applies to the largest single motor.



11. Spacing Chart For Suspended Components

Table "D" Seismic Bracing (Maximum Allowable Spacing Shown- Actual Spacing to Be Determined by Calculation)			
Equipment	On Center Transverse	On Center Longitudinal	Change Of Direction
Duct All Sizes	30 Feet	60 Feet	4 Feet
Pipe Threaded, Welded, Soldered Or Grooved; Conduit and Conduit Racks			
To 16 inches	40 Feet	80 Feet	4 Feet
18 – 28 inches	30 Feet	60 Feet	4 Feet
30 – 40 inches	20 Feet	60 Feet	4 Feet
42 inches & Larger	10 Feet	30 Feet	4 Feet
Pipe - No Hub Or Bell And Spigot			
2.5 inches & Larger	10 Feet	20 Feet	4 Feet
Boiler Breeching	30 Feet	60 Feet	4 Feet
Chimneys & Stacks	30 Feet	60 Feet	4 Feet
Conduit	40 Feet	80 Feet	4 Feet
Bus Duct	20 Feet	40 Feet	4 Feet
Cable Tray	40 Feet	80 Feet	4 Feet

12. Vertical Hanger Rod Bracing Schedule

Table "E" Hanger Rod Bracing Schedule (Stiffener to be maximum 6" from end of rod)					
Rod Dia. (inches)	Clamp Size	Maximum Unbraced Rod Length (inches)	Steel Angle Size (inches)	Clamp Spacing (inches)	Min. # of Clamps per Stiffener
3/8	SRBC-1-1/4	19	1 x 1 x 0.25	16	2
1/2	SRBC-1-1/4	25	1 x 1 x 0.25	20	2
5/8	SRBC-1-1/4	31	1 x 1 x 0.25	24	2
3/4	SRBC-1-1/2	37	1.5 x 1.5 x 0.25	28	2
7/8	SRBC-1-1/2	43	1.5 x 1.5 x 0.25	33	2
1	SRBC-1-1/2	50	1.5 x 1.5 x 0.25	40	2

23 05 53 Identification for HVAC Piping and Equipment

1. All piping and duct systems shall be required to be labeled to comply with OSHA and ANSI/ASME A13.1-2015 standards for the identification of systems.
2. The marking system shall identify the contents, size, direction of flow, and operating characteristics (i.e. pressure and/or temperature).



3. All valves, controls and dampers shall be labeled using plastic I.D. tags securely connected to the specific item using brass chain or "S" hooks. The contractor shall provide a list of each tagged item and its function and a valve chart in the main Mechanical Room.
4. All equipment must be identified using phenolic nameplates and labeled in accordance with the nomenclature used on the drawings and compatible with the MIMS System.

23 05 93 Testing, Adjusting, and Balancing for HVAC

The following paragraphs describe the responsibilities of the HVAC Contractor and the TAB Contractor. The A/E shall ascertain that the contract documents accurately reflect such.

1. The HVAC Contractor shall be responsible for the proper testing, adjusting, and balancing of all heating, ventilating and air conditioning systems installed under his contract, including the configuration, installation, and commissioning of the Project-specific automatic temperature control system components and integration into the University BAS.
2. The Contractor shall furnish all labor, materials, instruments, and equipment necessary to accomplish the successful completion of all testing, adjusting and balancing work as required for the operation of all systems including the automatic temperature controls, in accordance with the intent of the Construction Documents, Addendums, Bulletins and RFIs.
3. Testing, adjusting and balancing procedures shall not proceed until systems have been completed and are in full working order. The Mechanical Contractor shall operate systems as required for completion of their work.
4. Satisfactory completion of work under this specification is prerequisite to the pre-final review of completed systems by the Design Engineer.
5. The contract documents shall be prepared to include all labor, materials, instruments, and equipment necessary to effect complete and proper testing, adjusting, and balancing of the heating, ventilating and air conditioning systems, proper operation of complete automatic temperature control system and proper operation of all systems in accordance with the letter and intent of the Construction Documents, Addendums, Bulletins and RFIs. The Mechanical Contractor shall be responsible for providing all such equipment.
6. The University shall engage, under a direct contract or via the CM, an Independent and Qualified Testing and Balancing Organization whose primary source of work is the Testing, Adjusting and Balancing and Adjusting (TAB) of heating, ventilating and air conditioning systems following procedures prescribed by a recognized agency such as the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).
7. Leakage tolerances are to meet or exceed the following allowances:
 - a) Adjust air systems to plus or minus 5 percent, maximums, and minimums, from scheduled values indicated.
 - b) Adjust air terminal units to within the following tolerances from scheduled air flows:
 - i) Variable Air Volume (VAV) Units: Plus or minus three (3) percent.
 - ii) Constant Air Volume (CAV) Units: Plus or minus three (3) percent.



- iii) Air Valve (AV) Units: Plus or minus three (3) percent.
 - c) Adjust air terminal units for minimum leakage at design close off.
 - d) Adjust air terminal devices (outlets and inlets) to plus or minus five (5) percent between rooms, except those multiple devices on the same system branch within each room may be adjusted to plus or minus ten (10) percent.
 - e) Adjust hydronic systems to plus or minus five (5) percent of design conditions indicated.
 - f) Adjust AHU's and ERU's to a maximum of one (1) percent of design conditions indicated.
 - g) Adjust airside terminal equipment not listed above to plus or minus five (5) percent of design conditions indicated.
8. TAB contractor must provide a floor plan showing diffuser and register layouts and designations used on balancing report.

23 07 13 Duct Insulation

1. The use of duct liner for acoustical purposes is only permitted with University approval prior to incorporating into a system's design. Its use will only be permitted where it is impractical or not feasible to utilize other sound attenuating devices, such as inline duct silencers or elbow silencers. Double walled ducts consisting of an outer wall of galvanized sheet metal, an inner wall of perforated galvanized sheet metal with insulation sandwiched between the layers is permitted but may prove cost prohibitive.
2. All supply, return, and relief systems in non-conditioned areas shall be externally insulated.
3. All outdoor air intake ductwork shall be externally insulated.
4. All high temperature (180°F and above) exhaust duct systems shall be insulated to reduce surface temperature to a maximum of 90°F.
5. Duct insulation shall be as required by the 2018 IECC and referenced standards or the minimum thicknesses listed herein, whichever is the most stringent.
6. Duct systems shall be insulated as follows:
 - a) All ducts within the mechanical rooms or exposed in any areas must be insulated with 2-inch-thick rigid fiberglass board having an outer fiberglass reinforced foil or Kraft paper face. Minimum density shall be 1.0 lb. The maximum permissible permeability is 0.02 perms.
 - b) All ductwork concealed within chases or located above ceilings in non-conditioned spaces (ducted return systems) shall be insulated with 2-inch-thick fiberglass duct wrap having an outer fiberglass reinforced foil face. The minimum density of the insulation shall be 1.0 lb. The maximum permissible permeability is 0.02 perms.
 - c) All high temperature exhaust duct systems shall be insulated with fiberglass insulation as follows:
 - i) Round duct insulation shall conform to the requirements specified for piping systems. Refer to Section 23 07 19 "HVAC Piping Insulation". High temperature ducts run in unconditioned areas or exterior to the building need not be insulated unless the



- formation of corrosive condensation is possible and will result in damage to the system or create a hazard to building occupants or maintenance staff.
- ii) Rectangular ductwork shall conform to the requirements for exposed or concealed duct systems as detailed above and below, and insulated to reduce surface temperature to a maximum of 90°F.
 - d) All exterior duct systems requiring insulation (supply, return, process) shall be jacketed with a laminated, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane, having a high performance acrylic adhesive capable of installation with no mechanical attachment.
 - i) Material shall be VentureClad 1577 CW or equal, with finish selected based on availability and desired final appearance of the insulated system.
 - ii) Jacketing material is to have a maximum flame spread/smoke developed index of 10/20 per UL 723, a 0.0000 water vapor permeance rating per ASTM E-96, and mold inhibitors incorporated.
 - iii) All products shall be UV stable.
 - e) All rigid duct insulation shall be secured to the duct as follows:
 - i) Apply bonding adhesive equal to Foster 85-15 adhesive to the entire duct system.
 - ii) Impale the insulation to the duct and adhesive using welded pins spaced on 12-inch centers and not less than 3-inches from each edge or corner of insulation. Provide additional pins as required to bond insulation to beaded duct.
 - iii) Duct reinforcing materials will not be permitted to be exposed without insulation. Duct support connections shall be sealed watertight where such penetrate the exterior insulation.

23 07 16 HVAC Equipment Insulation

1. All heat exchanging equipment shall be insulated to prevent the formation of condensation on exterior surfaces as well as to prevent excessive heat loss or gain. The following specific pieces of equipment shall be fully insulated with the designated material as described or referenced below:
 - a) Steam and hot water to hot water heat exchangers, air separators, full flow filters, storage tanks, and compression/expansion tanks as follows:
 - i) The interface between the tube bundle flanges and/or piping flanges to the shell flanges shall be insulated with a removable cover to aid in the maintenance of the exchanger. The removable jackets shall be the same design and material as that specified for strainers, valves and PRV's. Refer to Section 23 07 19 "HVAC Piping Insulation".
 - ii) The shell of the heat exchanger shall be insulated with flexible fiberglass board type insulation having an outer jacket of Kraft paper bonded to aluminum foil and reinforced with fiberglass yarn. All joints and seams shall be covered with a vapor sealing, 3" wide, pressure-sensitive adhesive tape.
2. Chilled Water Tube Bundles - All bundles must be factory insulated with flexible rubber insulation. The insulation shall prevent the formation of condensation in an atmosphere of 90°F and 80% RH with a chilled water temperature of 42°F. Insulation applied to all water boxes must be removable and constructed in accordance with the requirements of Section 23 07 19 "HVAC Piping Insulation".



3. All chilled water pumps and specialties (strainer, suction diffuser, balancing valve, etc.) shall be fitted with removable insulation boxes constructed with 18-gauge sheet metal enclosures, 3/4-inch-thick flexible closed cell elastomeric insulation.

23 07 19 HVAC Piping Insulation

1. All steam, condensate, chilled water, glycol and heating hot water piping must be insulated with 1 lb. density fiberglass (calcium silicate on steam and foam glass insulation on chilled water piping in manholes) insulation having an outer jacket of Kraft paper bonded to aluminum foil reinforced with fiberglass yarn. The longitudinal seams of the jacket shall overlap and be sealed using the factory applied pressure sensitive adhesive. Staples are **prohibited**. Insulation thickness shall not be less than those recommended in 2018 IECC for the intended service or that required to prevent the formation of condensation or that required to assure a maximum surface temperature of 80°F, whichever is the most stringent. The insulation shall have a maximum thermal conductivity of 0.23 BTU-IN./HR.- FT.²-°F at a mean temperature of 75°F.
2. All steam, condensate, chilled water, glycol and heating hot water pipe risers exposed to view in occupied spaces are to be insulated and have a PVC cover. The minimum thickness of the cover will be 30 mil.
3. All non-service/maintenance related fittings (i.e. elbows, tees, etc.) shall be insulated with pre-molded, light impact, UV resistant PVC covers. The minimum thickness of the cover will be 30 mil. Fiberglass insulation thickness shall be equal to the required thickness of the adjoining piping. Foam filled fittings and covers are **prohibited**.
4. Fittings requiring service/maintenance access (i.e. flanges, unions, shut-off valves, check valves, balancing valves, PRV's, etc.) shall be insulated with removable, reusable covers which use straps and buckles to secure the cover in place. The drawings shall detail the interface between the removable cover and the adjacent piping insulation to assure a tight interface, which prevents heat loss and the formation of condensation. Covers shall consist of inner and outer walls of 304 SS 0.11" thick mesh, nylon coated 304SS 0.15" threaded seams, 304SS 1/8" thick x 1-1/2" buckles, PTFE/Teflon belting and 304SS I.D. tags.
5. Refrigeration system piping (suction and liquid lines) shall be insulated with flexible closed cell elastomeric insulation with a wall thickness as per the Pipe Insulation Schedule, under item 11 of this section. The insulation shall have a maximum thermal conductivity of 0.27 BTU-IN./HR.- FT.²-°F at a mean temperature of 75°F. Insulation to conform to the 2018 IECC.
6. Insulation exposed to the outdoors shall be protected by covering such as an aluminum or stainless-steel jacket using butted joints and snug fit 15-degree beveled edge aluminum or stainless-steel collars. All joints will be coated with mastic on the inside to affect a watertight enclosure.



7. All pre-fabricated underground piping systems shall be designed to meet the above insulation thickness requirements. All piping within manholes and removable covers for valves etc. shall meet the above insulation thickness requirements and shall be considered an exterior application and therefore be covered with the aluminum jacket.
8. All insulation provided shall conform to all pertinent codes including ASTM E-84, UL 73 and NFPA 255, and shall not exceed a flame spread of 25, fuel contributed 50 and smoke developed 50.
9. Rigid hydrous calcium silicate insulation having a compressive strength of 200 PSI may be used at hanger locations on piping above 2". Insulation shields equal to Anvil Fig. 167 must be used in conjunction with the insulation.
10. Refer to Pipe Insulation Schedule below for minimum insulation size based on pipe size.

Piping System Types	Fluid Temp. Range (deg. F)	Insulation Thickness (Inches) for Pipe Sizes				
		Less than 1	1 to less than 1.5	1.5 to less than 4	4 to less than 8	8 and larger
<u>HEATING SYSTEMS</u>						
Steam Condensate,	Above 350	4.5	5.0	5.0	5.0	5.0
Pumped Condensate,	251-350	3.0	4.0	4.5	4.5	4.5
Steam, Hot Water, &	201-250	2.5	2.5	3.0	3.0	3.0
Hot Water/Glycol:	141-200	1.5	1.5	2.0	2.0	2.0
	105-140	1.5	1.5	2.0	2.0	2.0
<u>COOLING SYSTEMS</u>						
Chilled Water, Glycol,	40-60	1.5	1.5	1.5	1.5	1.5
Refrigerant or Brine:	Below 40	1.5	1.5	1.5	1.5	1.5
<u>OTHER SYSTEMS</u>						
Boiler Blowdowns and Drain:	Any	1.5	2.5	3.0	3.0	3.0
Condensate Receiver Unit Vent and other Steam Vents:	Any	1.0	1.0	1.0	1.0	1.0
Cooling Coil Condensate Drain:	Any	1.0	1.0	1.0	1.0	N/A
Condenser Water (Indoors):	Any	1.0	1.0	1.0	1.0	1.0



Piping System Types	Fluid Temp. Range (deg. F)	Insulation Thickness (Inches) for Pipe Sizes				
		Less than 1	1 to less than 1.5	1.5 to less than 4	4 to less than 8	8 and larger
<u>OTHER SYSTEMS</u>						
Make-up Cold Water:	Any	1.0	1.0	1.0	N/A	N/A
Bypass Feeder Piping:	Any	1.0	1.0	1.0	N/A	N/A
Heat Traced Lines (Above Grade):	Any	2.0	2.0	2.0	2.0	2.0

11. Refer to Section 23 07 16 "HVAC Equipment Insulation" for details relating to chilled water pump insulation boxes.

23 08 00 Commissioning of HVAC

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the HVAC systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The HVAC components that shall be included in the commissioning process include, but shall not be limited to, the following:
 - a) Air Handling Units.
 - b) Chillers.
 - c) Hydronic Pumps.
 - d) Blower Coil Units.
 - e) Fan Coil Units.
 - f) Cabinet Heaters.
 - g) Fans.
 - h) Control Systems.
 - i) HVAC System Integration.
 - j) Air Terminal Devices.
 - k) Chilled Beams.
 - l) CAVs and VAVs.
 - m) Fan Power VAVs.
3. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power, controls, and alarm connections to the HVAC equipment.
 - b) Prior to completion of installation, submit "System Verification Checklists" to Engineer of Record and Owner for review.
 - c) Verify proper installation and performance of all HVAC system components provided.



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- d) Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling acceptance and operating tests.
 - e) Provide an HVAC and BAS system technician to assist during functional performance testing.
 - f) Participate in the functional performance tests as required to achieve design intent.
 - g) Participate in O&M Training as required by project specifications.
 - h) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - i) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - j) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
 - k) Provide written certification documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the HVAC Trade Representative re-certifying that he has inspected the work and that it has been completed and functioning as designed. This certification must be submitted prior to the final verification.
 - l) Provide set of record as-built drawings to the Engineer of Record for inclusion into record documents.
4. Coordination with Controls Contractor:
- a) Close monitoring of the Control Contractor's progress will promote efficient coordination of the TAB work. The CC will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing.
5. Start-Up:
- a) The installing contractor shall perform start-up of the HVAC equipment. The appropriate contractors and/or manufacturer's representative shall be on-site to perform start-up. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the manufacturer's recommended procedures. The Owner will visit the site to review completeness of installation in conjunction with progress meetings prior to starting equipment.
 - b) Contractors involved in installation, fabrication, manufacturer, control, or designs of equipment shall be present at the time of start-up. A factory-authorized technician shall be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment online and expedite acceptable functional performance.
6. Functional Performance Tests:
- a) Each major system will be tested. A random sample of each subsystem will be tested. The Functional Performance Tests shall be performed in the presence of the Owner and shall serve as a complement to the O&M Training. No tests will be performed until the system and related subsystems have been started, the testing and balancing report has been



- submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
- b) The Functional Performance Tests shall include the following, with the Commissioning Agent (if applicable) and/or Owner present:
 - i) Air Handling Units shall be tested in designed operating modes.
 - ii) Chiller shall be tested under relevant operating conditions.
 - iii) Hydronic Pumps shall be tested under relevant operating conditions.
 - iv) Blower Coil Units shall be tested under relevant operating conditions.
 - v) Fan Coil Units shall be tested under relevant operating conditions.
 - vi) Cabinet Heaters shall be tested for conformance to project specifications.
 - vii) Fans shall be tested for conformance to project specifications.
 - viii) Control systems shall be tested for conformance to project specifications.
 - ix) HVAC systems shall be tested to assure that the building as an integrated system operates properly, and to verify that interlocks and interactions between new and existing equipment and systems function according to design intent.
 - x) Off-season mode testing shall be implemented as necessary to assure conformance with the project specifications.
 - xi) Installing contractors are expected to participate as required by the project specifications.
7. Owner Orientation and Training:
- a) The installing contractor shall provide the Owner comprehensive training in the understanding of the systems and operation and maintenance of each major piece of equipment.
 - b) The installation contractor or manufacturer's representative will provide the training. This training should include hands-on operational training. The Owner may choose to videotape this training for future use.
 - c) The training shall include start-up, operation in all modes possible, shutdown and any emergency procedures.
 - d) The training shall include a review of all systems using simplified system schematics including riser diagrams, valve locations, and equipment locations.
 - e) The installation contractor shall provide the Owner with copies of all inspections and acceptance.
 - f) The manufacturer's representative shall provide instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Qualified service engineers employed by the manufacturers, or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed. The start-up and shut-down modes of operation shall be demonstrated. Emergency operations shall be demonstrated.
 - g) The Contractor shall attend all sessions and shall add to each session any special information relating to the details of installation of the equipment as it might impact the operation and maintenance.
 - h) The installing contractor shall assist in the coordination of yearly testing, calibrating, and servicing as specified in the contract documents.



- i) The Control Trade Representative shall attend all sessions and be prepared to conduct the controls portion of the training as it relates to each equipment section.
- j) The Control Trade Representative shall conduct the training session on the controls system hardware and software.
- k) The piping, insulation and sheet metal Trade Representatives shall conduct sessions on their respective trades with emphasis on any peculiarities of the systems, pressure limitations and maintenance requirements.
- l) The TAB Trade Representative shall conduct a training session reviewing the procedures and methods used in the TAB process, shall review the TAB data, and shall demonstrate use of test equipment which may have been turned over to the Owner and shall point out the locations of all pitot traverse locations for the Owner's future use.

23 11 23 Facility Natural-Gas Piping

1. All gas systems must comply with the 2018 International Fuel Gas Code which incorporates, by reference, NFPA, ANSI, and ASME standards. In addition, all installations shall comply with the Philadelphia Gas Works Field Services Department Piping Specifications and Equipment Installations (January 2010).
2. Natural gas piping shall be schedule 40 steel conforming to ASTM A-53, Grade B, Type ERW or seamless with screwed or welded black malleable iron fittings.
3. Each branch take-off shall be provided with an approved WOG ball valve or lubricated plug valve having a semi-steel body, single gland, wrench type operation, 175 PSI.
4. Natural gas booster pump:
 - a) Basis of Design manufacturer is to be Eclipse, Inc.
 - b) At a minimum, the booster is to be hermetic type, UL listed, have NEMA Class 1, Group D explosion proof motor with thermal overload protection, have a steel casing and control panel with NEMA 4 construction.
5. Provide an emergency shut-off button both inside and outside the room/laboratory using natural gas. Shut-off buttons for the room are to be interconnected to a solenoid valve located in the piping outside the room. Shut-off buttons are to be equipped with push button covers.
6. Provide an emergency shut-off button at each entrance and exit door in the mechanical room where natural gas equipment is installed. Shut-off buttons for the room are to be interconnected to a solenoid valve located in the piping supplying the equipment.
7. A/E to add the following list of items to each relevant specification section. Contractors are required to complete all the items and have Drexel review prior to submission:
 - a) Contractor to install boiler as per the approved manufacturer's IOM.
 - b) Submit an Intent to Install Boiler form (LIBI-302-Revision).
 - c) Submit a Clearance Variance form (LIIB-303-Revision), if applicable.
 - d) Submit the following Installation Permit Applications to the City of Philadelphia Department of Public Health, Air Management Services:
 - i) Boilers, Warm Air Furnaces, and Hot Water Heaters.



- ii) Internal Combustion Engines.
8. A/E to coordinate with item 5 in section 23 52 00, Heating Boilers, for gas pressure requirements.

23 21 13 Hydronic Piping

1. Hydronic piping pertains to all chilled water, glycol hot water heating and ice storage chilled water piping systems installed throughout the University.
2. Underground piping systems shall be designed and installed in accordance with the requirements and limitations of ANSI/ASME B31.1 “Power Piping”.
3. Piping within buildings shall be designed and installed in accordance with the requirements and limitations of ANSI/ASME B31.9 “Building Services Piping”.
4. All HVAC equipment (heat exchangers, air coils, etc.) isolation valves are to be upstream of valve assembly sets on supply and downstream of valve assembly sets on return. Valve assembly sets consists of unions, strainers, thermostats, P/T wells, etc.
5. All control valves, butterfly valves, etc. are to be mounted such that actuators and handles are located on the bottom half (3 o’clock to 9 o’clock) on the piping. Actuators and handles located on the top half (9 o’clock to 3 o’clock) of the pipe are **prohibited**.
6. Aboveground Hydronic Piping:
 - a) Chilled Water and Heating Hot Water (40°F through 210°F) Service:
 - i) Up to and including 4-inch NPS: Hard-Drawn Seamless Copper Water Tubing ASTM B88 - Type L.
 - ii) 6-inch NPS and larger: Carbon Steel Pipe, ASTM A53 Grade B-Type ERW or S, Schedule 40.
 - b) Ice Storage Chilled Water (Less than 40°F) Service:
 - i) Up to and including 4-inch NPS: Hard-Drawn Seamless Copper Water Tubing ASTM B88 - Type L.
 - ii) 6-inch NPS and larger: Stainless Steel Pipe, ASTM A312, Type 316L, Schedule 40.
 - c) Tubing for Instrumentation (All Services):
 - i) Seamless Stainless Steel, ASTM A269 Type 316, 1/2-inch OD x 0.049-inch Wall Thickness.
7. Pipe Fittings – Hydronic Systems:
 - a) Chilled Water and Heating Hot Water (40°F through 210°F) Service:
 - i) Up to and including 4-inch NPS:
 - (1) Wrot Copper Solder Joint Fittings, ASME B16.22, ASTM B75, Nibco.
 - (2) Wrot Copper Press-End Fittings, ASME B16.22, ASTM B75, EPDM, Viega Smart-Connect.

NOTE: Cast press-end fittings are not permitted.



- ii) 6-inch NPS and larger:
 - (1) Carbon Steel Butt Welding Fittings, ASME B16.9, ASTM A234 WPB, Schedule STD.
 - (2) Ductile Iron Grooved-End (Victaulic) Fittings, ASTM A536.
NOTE: Grooved-end valves or other specialties are not permitted. Grooved-end fittings are permitted for glycol service, upon approval by the University.
 - b) Ice Storage Chilled Water (Less than 40°F) Service:
 - i) Up to and including 4-inch NPS:
 - (1) Wrot Copper Solder Joint Fittings, ASME B16.22, ASTM B75, Nibco.
 - (2) Wrot Copper Press-End Fittings, ASME B16.22, ASTM B75, EPDM, Viega Smart-Connect.
NOTE: Cast press-end fittings are not permitted. Press-end valves or other specialties are not permitted.
 - ii) 6-inch NPS and larger:
 - (1) Stainless-Steel Butt-Welding Fittings, ASME B16.9, ASTM A312, 316SS, Schedule 40S.
 - c) Tubing for Instrumentation (All Services):
 - i) Seamless Stainless Steel, ASTM A269 Type 316, 1/2-inch OD x 0.049-inch Wall Thickness.
 - ii) Stainless Steel Gaugeable Tube Fittings, ASTM A276 or ASTM A182, 316SS, Swagelok or Parker A-Lok.
8. Valves – Hydronic Systems [Alternate Bray information is listed after first brand in brackets. Information that is the same for both is listed once.]:
- a) Chilled Water and Heating Hot Water (40°F through 210°F) Service:
 - i) Up to and including 2-inch NPS:
 - (1) Shutoff Service Only:
 - (a) Solder-End Ball Valve.
 - (b) Rating: 600 PSI CWP, 150 PSI Steam.
 - (c) Body: Two-Piece, Bronze.
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves.
 - (h) Model: 77C-24 (Size Designation) - 27 Series.
 - (2) Shutoff Service and Gauge & Instrument Isolation:
 - (a) Threaded Ball Valve.
 - (b) Rating: 600 PSI CWP, 150 PSI Steam. [1500 PSI WOG, 150 PSI Steam].
 - (c) Body: Two-Piece, Bronze. [Two-Piece, WCB Carbon Steel].
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves. [Flow-Tek, a Bray Subsidiary].
 - (h) Model: 77C-14 (Size Designation) - 27 Series. [S90-(Size Designation)-3-R-R-L].



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- (3) Low Point Drain & High Point Manual Vent:
 - (a) Threaded Ball Valve with Hose Cap & Chain.
 - (b) Rating: 600 PSI CWP.
 - (c) Body: Two-Piece, Bronze.
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Stem Packing / Stem Bearing: MPTFE / RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves.
 - (h) Model: 70-14(Size Designation) HC-27 Series.
 - (4) Modulating (Bypass) Service:
 - (a) Threaded Globe Valve.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Bonnet: Bronze ASTM B-62 or Bronze ASTM B-16. [Carbon Steel A216 Gr. WCB].
 - (d) Disc Holder: Bronze ASTM B-62 or Bronze ASTM B-16.
 - (e) Disc: PTFE (15% Glass Filled). [Stainless Steel Gr. CF8M Type 316].
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions. [Titan Flow Control, Inc.]
 - (h) Model: Figure 7TF. [CV 51-CS].
 - (5) Check Valve:
 - (a) Threaded Swing Check Valve, Threaded Cap.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Cover: Bronze ASTM B-62/B-61.
 - (d) Disc Holder: Bronze ASTM B-62 or Bronze ASTM B-16.
 - (e) Disc: PTFE (15% Glass Filled).
 - (f) Brand: Crane Energy Flow Solutions.
 - (g) Model: Figure 141TF.
 - (6) Manual Balancing Valve:
 - (a) Threaded End Manual Balancing Valve.
 - (b) Rating: 400 PSI.
 - (c) Body, Trim, & Seat: Ametal.
 - (d) Seat & Stem Seals: EPDM.
 - (e) Brand: Victaulic Tour & Anderson.
 - (f) Model: 787H.



- ii) 2-1/2-inch NPS and larger:
 - (1) Shutoff Service:
 - (a) High Performance Butterfly Valve.
 - (b) Rating: ANSI Class 150. [ANSI Class 150, Zero Leakage].
 - (c) Body: ASTM A216 Carbon Steel, Lug Style.
 - (d) Stem: ASTM A564 Type 630 Stainless Steel.
 - (e) Disc: ASTM A351 CF8M Stainless Steel.
 - (f) Seat: Virgin TFE. [RPTFE self-adjusting for both high and low-pressure service (suitable for saturated steam at 150 PSIG)].
 - (g) Packing: TFE Vee. [Packing: PTFE plus 1 Carbon Fiber Ring to provide constant compression and seal for full rating of valve].
 - (h) Brand: Cameron WKM MB-1 Dynacentric. [Bray / McCannalok High Performance]
 - (i) Model: (Size Designation)-B5-113-02-S02-11-WG. [41-(size designation)-1101-466].

Bray Valve Note: Valve shall be suitable for double dead-end service no downstream flange at WOG pressure rating. Basis of Design: Bray/McCannalok S41-466. Performance and Testing: Seat seal rating shall be zero leakage (exceeds ANSI Class VI) to API 5D, soft seat standard. Valves are to be capable of bi-directional shut-off, zero leakage, with the down-stream flange removed. Each valve to be tested to 110% of cold working pressure rating, ANSI 150 = 315 PSIG, zero leakage allowable. Installation: Use appropriate gasket materials for flange connection. Install with retaining plate upstream, normal flow. Follow manufacturers recommended bolt chart. Valve may be installed with valve shaft horizontal (recommended) or vertical. Install in accordance with manufacturers Installation Manual.
 - (2) Modulating (Bypass) Service:
 - (a) Flanged Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 300.
 - (c) Body & Bonnet: Stainless Steel ASTM A351 – CF8M. [Carbon Steel A216 Gr. WCB].
 - (d) Disc: Stainless Steel ASTM A351 – CF8M. [Stainless Steel Gr. CF8M Type 316].
 - (e) Packing: PTFE.
 - (f) Brand: Crane Energy Flow Solutions – Aloyco. [Titan Flow Control, Inc.]
 - (g) Model: Figure 2317. [CV 51-CS].



- (3) Check Valve:
- (a) High Performance Check Valve.
 - (b) Rating: ANSI Class 150.
 - (c) Body: Wafer Style, ASTM A216 Carbon Steel.
 - (d) Seal: EPDM.
 - (e) Disc, Arm & Pin: 316 Stainless Steel.
 - (f) Brand: Crane Energy Flow Solutions – Uni Check. [Ritepro, a Subsidiary of Bray].
 - (g) Model: (Size Designation)-15-A-0-3-4-1-3-0. [Model: 210 15-(Size Designation)-SET].

Bray Valve Note: Design: The inlet is to incorporate a contoured shape and optimum diameter for a Venturi effect for high flow, capacity and low pressure drop. The disc shall have a convex profile that supports flow both upper and lower surfaces in the full open position creating a lifting force. The spring-loaded disc is to close before flow reversal to reduce water hammer. Basis of Design: Check valves on pump protection parallel pumps to a common header to employ an external lever and compression spring; Ritepro SA40. Check valves in line used for non-return to use an internal spring; Ritepro 210. Testing: Valves to be 100% hydro tested and marked in accordance with ASME B16.34 or API 598, zero permissible leakage. Installation: All valves to be installed per the manufacturer's instructions for installation, orientation and check action.

- (4) Manual Balancing Valve:
- (a) Manual Balancing Valve.
 - (b) Rating: 300 PSI, ANSI Class 150 Flanged End.
 - (c) Body & Seat: ASTM A536 Grade 40-60-18 Ductile Iron.
 - (d) Seat & Stem Seals: EPDM.
 - (e) Brand: Victaulic Tour & Anderson.
 - (f) Model: 788 Grooved End, 789 Flanged End.

NOTE: Grooved-end fittings are not permitted for glycol service, regardless of sealing materials used.

- b) Ice Storage Chilled Water (Less than 40°F) Service:
- i) Up to and including 2-inch NPS:
 - (1) Shutoff Service Only:
 - (a) Solder-End Ball Valve.
 - (b) Rating: 600 PSI CWP, 150 PSI Steam.
 - (c) Body: Two-Piece, Bronze.
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves.
 - (h) Model: 77C-24 (Size Designation) - 27 Series.



- (2) Shutoff Service and Gauge & Instrument Isolation:
 - (a) Threaded Ball Valve.
 - (b) Rating: 600 PSI CWP, 150 PSI Steam. [1500 PSI CWP, 150 PSI Steam].
 - (c) Body: Two-Piece, Bronze. [Two-Piece, WCB Carbon Steel].
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves. [Flow-Tek, a Bray Subsidiary].
 - (h) Model: 77C-14 (Size Designation) - 27 Series. [S90-(Size Designation)-3-R-R-L].
- (3) Low Point Drain & High Point Manual Vent:
 - (a) Threaded Ball Valve with Hose Cap & Chain.
 - (b) Rating: 600 PSI CWP.
 - (c) Body: Two-Piece, Bronze.
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Stem Packing / Stem Bearing: MPTFE / RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves.
 - (h) Model: 7010 (Size Designation) HC-27 Series.
- (4) Modulating (Bypass) Service:
 - (a) Threaded Globe Valve
 - (b) Rating: ANSI Class 150
 - (c) Body & Bonnet: Bronze ASTM B-62 or Bronze ASTM B-16. [Carbon Steel A216 Gr. WCB].
 - (d) Disc Holder: Bronze ASTM B-62 or Bronze ASTM B-16. [Stainless Steel Gr. CF8M Type 316].
 - (e) Disc: PTFE (15% Glass Filled).
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions. [Titan Flow Control, Inc.]
 - (h) Model: Figure 7TF. [CV 51-CS].
- (5) Check Valve:
 - (a) Threaded Swing Check Valve, Threaded Cap.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Cover: Bronze ASTM B-62/B-61.
 - (d) Disc Holder: Bronze ASTM B-62 or Bronze ASTM B-16.
 - (e) Disc: PTFE (15% Glass Filled).
 - (f) Brand: Crane Energy Flow Solutions.
 - (g) Model: Figure 141TF.
- (6) Manual Balancing Valve:
 - (a) Threaded End Manual Balancing Valve.
 - (b) Rating: 400 PSI.
 - (c) Body, Trim, & Seat: Ametal.
 - (d) Seat & Stem Seals: EPDM.
 - (e) Brand: Victaulic Tour & Anderson.
 - (f) Model: 787H.



- ii) 2-1/2-inch NPS and larger:
 - (1) Shutoff Service:
 - (a) High Performance Butterfly Valve.
 - (b) Rating: ANSI Class 150. [ANSI Class 150, Zero Leakage].
 - (c) Body: ASTM A351 CF8M Stainless Steel, Lug Style.
 - (d) Stem: ASTM A564 Type 630 Stainless Steel.
 - (e) Disc: ASTM A351 CF8M Stainless Steel.
 - (f) Seat: TFE. [RPTFE self-adjusting for both high and low-pressure service (suitable for saturated steam at 150 PSIG)].
 - (g) Packing: TFE Vee.
 - (h) Brand: Cameron WKM MB-1 Dynacentric. [Bray/McCannalok High Performance].
 - (i) Model: (Size Designation)-B5-123-02-S02-11-WG. [41-(Size Designation)-1101-066].
Bray Valve Notes: Valve shall be suitable for double dead-end service no downstream flange at WOG pressure rating. Basis of Design: Bray/McCannalok S41-466. Performance and Testing: Seat seal rating shall be zero leakage (exceeds ANSI Class VI) to API 5D, soft seat standard. Valves are to be capable of bi-directional shut-off, zero leakage, with the down-stream flange removed. Each valve to be tested to 110% of cold working pressure rating, ANSI 150 = 315 PSIG, zero leakage allowable. Installation: Use appropriate gasket materials for flange connection. Install with retaining plate upstream, normal flow. Follow manufacturers recommended bolt chart. Valve may be installed with valve shaft horizontal (recommended) or vertical. Install in accordance with manufacturers Installation Manual.
 - (2) Modulating (Bypass) Service:
 - (a) Flanged Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Bonnet: Stainless Steel ASTM A351 - CF8M. [Carbon Steel A216 Gr. WCB].
 - (d) Disc: Stainless Steel ASTM A351- CF8M. [Stainless Steel Gr. CF8M Type 316].
 - (e) Packing: PTFE.
 - (f) Brand: Crane Energy Flow Solutions – Aloyco. [Titan Flow Control, Inc.]
 - (g) Model: Figure 317. [CV 51-CS].



- (3) Check Valve:
- (a) High Performance Check Valve.
 - (b) Rating: ANSI Class 150.
 - (c) Body: Wafer Style, ASTM A351- CF8M Stainless Steel.
 - (d) Seal: EPDM.
 - (e) Disc, Arm & Pin: 316 Stainless Steel.
 - (f) Brand: Crane Energy Flow Solutions – Uni Check. [Ritepro, a Subsidiary of Bray].
 - (g) Model: (Size Designation)-15-A-2-3-4-1-3-0. [210 15-(Size Designation)-XET].

Bray Valve Notes: The inlet is to incorporate a contoured shape and optimum diameter for a Venturi effect for high flow, capacity and low pressure drop. The disc shall have a convex profile that supports flow both upper and lower surfaces in the full open position creating a lifting force. The spring-loaded disc is to close before flow reversal to reduce water hammer. Basis of Design: Check valves on pump protection parallel pumps to a common header to employ an external lever and compression spring. Ritepro SA40. Check valves in line used for non-return to use an internal spring. Ritepro 210. Testing: Valves to be 100% hydro tested and marked in accordance with ASME B16.34 or API 598, zero permissible leakage. Installation: All valves to be installed per the manufacturer's instructions for installation, orientation, and check action.

- (4) Manual Balancing Valve:
- (a) Rating: 300 PSI, ANSI Class 150 Flanged End.
 - (b) Body & Seat: ASTM A536 Grade 40-60-18 Ductile Iron.
 - (c) Seat & Stem Seals: EPDM.
 - (d) Brand: Victaulic Tour & Anderson.
 - (e) Model: 789 Flanged End Only.

9. Flanges and Accessories – Hydronic Systems:

- a) Chilled Water and Heating Hot Water (40°F through 210°F) Service:
- i) Flanges: Forged Pipe Flange, ASME B16.5, ASTM A105 Carbon Steel, Class 150, 1/16 inch Raised Face.
NOTE: Use flat face flanges for connection to equipment equipped with flat face flanges.
 - ii) Bolting: ASTM A307 Grade B Heavy Hex Bolts and Stud Bolts, ASTM A563 Grade A Heavy Hex Nuts. Length of bolts and studs per ASME B16.5, Table 8.
 - iii) Gaskets: Spiral Wound Metal Gasket with Outer Gauge Ring, ASME B16.20, Flexible Graphite Filler Material, 304 SS Gauge Ring, Class 150, Garlock Style RW.
- b) Ice Storage Chilled Water (Less than 40°F) Service:
- i) Flanges: Forged Pipe Flange, ASME B16.5, ASTM A182-F316 Stainless Steel, Class 150, 1/16 in. Raised Face.
NOTE: Use flat face flanges for connection to equipment equipped with flat face flanges.
 - ii) Bolting: ASTM A193 Grade B8M, 316 Stainless Steel Hex Bolts and Stud Bolts, ASTM A194 Grade 8M, 316 Stainless Steel Hex Nuts. Length of bolts and studs per ASME B16.5, Table 8.



- iii) Gaskets: Spiral Wound Metal Gasket with Outer Gauge Ring, ASME B16.20, Flexible Graphite Filler Material, 304 SS Gauge Ring, Class 150, Garlock Style RW.
10. Hydronic piping systems requiring glycol are to use a propylene glycol solution mixture designed for an outdoor temperature of 0 degrees F.

23 21 16 Hydronic Piping Specialties

1. Strainers - Cast iron "Y" type with removable, cleanable stainless-steel screens having 1/32" perforations through 2" and 1/16" perforations above 2". Each strainer blow-down connection shall be piped with a ball valve and hose connection. Strainers sizes 8" and above shall be installed at a maximum height of 5'-0" above the floor.
2. Check valves shall be of the silent, center guided spring-loaded type with screwed ends up to and including 2" and wafer type above 2". All trim shall be 316 stainless-steel with a carbon steel body. Triple-duty valves shall not be used. Swing check valves are **prohibited**.
3. Pressure relief valves shall be constructed of the following materials:
 - a) Bronze body.
 - b) Trim - stainless steel.
 - c) Springs - stainless steel.
4. All relief valves shall conform to ASME standards and be National Board certified.
5. Expansion Tanks - Diaphragm type steel tanks complete with charging valves, drain valve and system connection. A/E to specify the expansion tank precharge and operating pressure when filled.
6. Air and dirt separators – Basis of Design to be Spirotherm. Acceptable manufacturers are B&G and Wessels.
 - a) New and renovation (where space permits) work: Combination air and dirt separator.
 - i) Standard velocity systems use model Spirovent Dirt.
 - ii) High velocity systems use model Spirovent Dirt HV.
 - b) Renovation work: Separate air and dirt separators.
 - i) Standard velocity systems – Air separator use model Spirovent Air.
 - ii) Standard velocity systems – Dirt separator use model Spirotrap.
 - iii) High velocity systems – Air separator use model Spirovent HV
 - iv) High velocity systems – Dirt separator use model Spirotrap HV.
 - c) Air separator to be equipped with automatic air vent, model Spirotop.
 - d) Dirt separator to be equipped with drain valve assembly (ball valve and hose adapter).
 - e) Provide flanged or threaded connections in accordance with inlet and outlet piping.
7. Unions and flanges:
 - a) Install accessible unions or flanges in all supply and return connections to equipment and specialties as required to facilitate the removal and or servicing of equipment such as:
 - i) Heat exchangers.
 - ii) Pumps.



- iii) Chillers.
- iv) Steam traps.
- v) Unit heaters.
- vi) Control valves.
- vii) Expansion joints.
- viii) Pressure reducing valves.
- b) All equipment provided with flanged connections. All flanges shall be faced, drilled and spot faced to ASME Standards. Unions and flanges in steel pipe shall be:
 - i) Unions shall be ground joint, malleable iron, screw type, conforming to ASTM A-197 and ANSI 16.3.
 - ii) Flanges shall be forged steel conforming to ASTM A-181 and ANSI B16.5.
 - iii) Unions and flanges shall be 150 lb. or 300 lb. rated to meet system design requirements.
 - iv) Unions and flanges in copper piping shall be wrought copper, ground joint, solder ends, conforming to ANSI B16.22.
 - v) Flanges 4" and above shall be secured using B-7 bolts. Flange gasket material shall be Klinger #C-4501.
- 8. Separable Sockets - Stainless steel with extension necks to suit insulation thickness. Sockets shall be of the proper length to assure accurate readings.
- 9. Air Vents - High capacity, float activated, non-modulating 150 PSIG, cast iron body, stainless steel trim designed to prevent air from entering the system when pressure falls below atmospheric pressure on manual type consists of a capped ball or valve.
- 10. Balancing Provisions – All systems shall be designed using the following general balancing provisions:
 - a) Refer to Part 8 in Section 23 21 13 for approved balancing valve manufacturer and model.
 - b) The designer shall indicate on the drawings the locations and size of all balancing provisions, which shall be provided as follows:
 - i) In each heating and/or cooling circuit.
 - ii) On all cooling and heating coils.
 - iii) On all supply main piping adjacent to pumps.
 - iv) Entrance to chillers and heat exchangers.
 - c) All measuring devices shall be installed per manufacturer's recommendations.
- 11. All non-potable water systems (i.e. HVAC Systems and irrigations systems must be provided with an approved individual backflow preventer and in a location in accordance with the Philadelphia Water Department Cross Connection Control [Manual, 7th Edition, 2017](#).
 - a) The basis of design shall be Watts, Series LF909 reduced pressure zone assemblies with drain assembly and air gap model 909AG-F (no substitutions for either component).
 - b) The basis of design configuration shall include one full-size reduced pressure zone assembly installed in parallel to permit continuous, uninterrupted water service during testing and maintenance.
 - c) Each assembly shall be provided with FM-approved epoxy-coated flanged OS&Y gate valves.
 - d) A sanitary drain shall be provided directly below the assemblies for relief valve discharge.



12. On the larger carbon steel (3 in.) to copper connections use grooved end dielectric waterways. In the smaller applications use threaded by grooved end dielectric waterways.
13. Hose kits not furnished by the unit manufacturer are to be manufactured by Flow Design Inc. or Hays Fluid Controls.
14. Air Scoop to be inline type, constructed of carbon steel with 150 psi ANSI flanged connections and female pipe threaded connections for vent and drain connections. Provide flow arrow indicating direction of flow. Basis of Design is to be ASC or approved equal.

23 21 23 Hydronic Pumps

1. All pumps shall be base mounted, stainless steel fitted, flexible coupled and rated for 175 PSI. Pumps shall be constructed with the following components:
 - a) Bronze shaft sleeve.
 - b) Alloy steel shaft.
 - c) Cast iron casting and companion flanges. Some pumps may require ductile iron companion flanges. Pump flanges, mating flanges, flange gasketing and bolting shall meet the requirements of ANSI/ASME B31.1, Table 112. Spiral-wound metallic gasket with flexible graphite filler and outside gauge (centering) ring, are preferred.
 - d) Re-greaseable lubricated ball-bearings rate for an average life of 250,000 hours.
 - e) Extended grease fittings and bottom relief plugs. Grease fittings shall extend to the exterior of the insulation boxes on chilled water pumps.
2. Motors supplied with pumps shall be of the NEMA premium efficiency type, manufactured in the USA and selected so that the motor cannot become overloaded at any point on the pump curve.
3. Provide all pumps with self-aligning, positive drive, end face shaft mechanical seals.
4. Horizontal pumps are the preferred type of pump by the University. Vertical pumps are acceptable but need to be reviewed with the University for approval.
5. Split-case double inlet pumps are preferred to end suction in all primary pumping applications and must be used on all systems having a flow rate more than 500 GPM.
6. Circulating pumps of up to 3 horsepower shall be equipped with bypass and isolation valves.
7. Where used, end suction pumps shall include suction diffusers and installed per the required number of pipe diameters of straight pipe at the inlet to the pump, as per manufacturer's recommendation.
8. The installing contractor shall coordinate with the pump manufacturer or an authorized representative to provide start-up services which shall include, but not be limited to, the following:



- a) Checking of alignment, absence of pipe strain, lubrication, rotation, and vibration (axially, horizontally and vertically).
 - b) Take suction and discharge pressure gauge readings and compare such with the pump nameplate data.
 - c) Submit five (5) copies of a full report to the University's Project Manager.
9. Refer to Section 23 07 16 "HVAC Equipment Insulation" for chilled water pump insulation requirements.
10. All pumps shall be mounted on 4-inch housekeeping pads with vibration isolation as recommended in the current edition of the ASHRAE HVAC Applications Handbook.
11. The centrifugal pumps shall comply with ANSI/ASME B73.1 and shall be equipped with oil-lubricated bearings. When floor mounted, they shall have a horizontal axis. Acceptable manufacturers are Flowserve, Goulds, or Griswold.
12. Approved pump manufacturers: Large – Bell & Gossett and Goulds. Recirculating or Fractional – Armstrong and Taco.

23 22 13 Steam and Condensate Heating Piping

1. Drexel University considers a steam service "High Pressure" when the steam operating pressures are greater than 15 PSIG, and "Low Pressure" when the steam operating pressures up to and including 15 PSIG.
2. Aboveground Steam and Steam Condensate Piping:
 - a) Steam Low Pressure: Carbon steel, ASTM A53 Grade B-Type ERW or S, Schedule 40.
 - b) Steam High Pressure:
 - i) Piping up to and including 2-inch NPS: Carbon steel, ASTM A53 Grade B-Type S, Schedule 80.
 - ii) Piping 2-1/2-inch NPS and larger: Carbon steel, ASTM A53 Grade B-Type ERW, Schedule 40.
 - c) Steam Condensate: Carbon steel, ASTM A53 Grade B-Type S, Schedule 80.
3. Underground Piping - Drainable, dryable, testable system consisting of 10-gauge spiral weld steel conduit with epoxy coating. Conduit shall be sized to house a minimum foam glass insulation thickness of 2 inches. The design shall specify and indicate all thrust blocks, anchors, moment guides, oversized elbows, and expansion loops necessary for a complete system. Include all end seals, gland seals and pipe supports. A Holiday detector shall be used during the installation to determine if any faults exist in the conduit coating. Provide cathodic protection for all underground systems.
 - a) Underground steam piping systems shall be A53B-Type S, seamless carbon steel, Schedule 40 pipe.
 - b) Underground condensate piping systems shall be A53B-Type S, seamless carbon steel, Schedule 80 pipe or Schedule 10 stainless steel pipe. Condensate generates or contains carbonic acid that attacks carbon steel. Therefore, using Schedule 80 pipe will provide a 30 to 40 year expected life. Where insulation is not required on condensate piping (because



- the heat will not be recovered), installing Schedule 10 stainless steel pipe may be more economical than using Schedule 80 seamless carbon steel pipe.
4. Pipe Fittings – Steam and Steam Condensate:
 - a) Pipe fittings include elbows, tees, couplings, unions, pipe plugs, pipe caps, crosses, reducing couplings, and reducing bushings.
 - b) Steam Low Pressure:
 - i) Up to and including 2-inch NPS:
 - (1) Malleable Iron, ASME B16.3, ASTM A197, Class 300 (XS/XH).
 - ii) 2-1/2-inch NPS and larger:
 - (1) Carbon Steel Butt Welding Fittings, ASME B16.9, ASTM A234 WPB, Schedule STD.
 - c) Steam High Pressure:
 - i) Up to and including 2-inch NPS:
 - (1) Forged Carbon Steel, ASME B16.11, ASTM A105, Class 2000 or 3000.
 - ii) 2-1/2-inch NPS and larger:
 - (1) Carbon Steel Butt Welding Fittings, ASME B16.9, ASTM A234 WPB, Schedule XS.
 - d) Steam Condensate:
 - i) Up to and including 2-inch NPS:
 - (1) Forged Carbon Steel, ASME B16.11, ASTM A105, Class 2000 or 3000.
 - ii) 2-1/2-inch NPS and larger:
 - (1) Carbon Steel Butt Welding Fittings, ASME B16.9, ASTM A234 WPB, Schedule XS.
 5. Valves – Steam and Steam Condensate:
 - a) The system shall be designed for the provision of isolating valves at all equipment, hydronic circuits, control valves, individual pieces of equipment and all branch mains. Valves associated with pressure vessels shall be installed in compliance Chapter 3a of The Pennsylvania Code, “Boiler and Unfired Pressure Vessel Regulations”.
 - b) Steam Low Pressure:
 - i) Up to and including 2-inch NPS:
 - (1) Shutoff Service and Gauge & Instrument Isolation:
 - (a) Threaded Ball Valve.
 - (b) Rating: 1500 PSI WOG or 2000 PSI WOG, 150 PSI Steam.
 - (c) Body: Two-Piece, ASTM A105 Carbon Steel.
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: RPTFE.
 - (f) Latch-Lock Lever & Nut: Stainless Steel.
 - (g) Brand: Apollo Valves. [Flow-Tek, a Bray Subsidiary].
 - (h) Model: 73A-14(Size Designation) - 27 Series. [S90-(Size Designation)-3-R-R-L].



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- (2) Modulating (Bypass) Service:
 - (a) Threaded Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Bonnet: Forged ASTM A105N Carbon Steel.
 - (d) Disc: AISI-410.
 - (e) Seat: Stellite.
 - (f) Packing: Graphite.
 - (g) Brand: RP&C Valve, Bonney Forge.
 - (h) Model: F80D.
 - ii) 2-1/2-inch NPS and larger:
 - (1) Shutoff Service:
 - (a) Flanged Gate Valve, OS&Y.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Bonnet: Cast WCB Carbon Steel.
 - (d) Disc: Flexible Wedge, CA-15 or 13% CR Overlay.
 - (e) Seat Rings: Hardfaced.
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions.
 - (h) Model: Figure 47.
 - (2) Modulating (Bypass) Service:
 - (a) Flanged Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 150.
 - (c) Body & Bonnet: Cast WCB Carbon Steel.
 - (d) Disc: 13% CR Overlay.
 - (e) Seat Rings: Hardfaced.
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions.
 - (h) Model: Figure 143.
 - c) Steam High Pressure:
 - i) Up to and including 2-inch NPS:
 - (1) Shutoff Service Only:
 - (a) Threaded Gate Valve, OS&Y.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Bonnet: Forged ASTM A105N Carbon Steel.
 - (d) Wedge: AISI-410.
 - (e) Seat: AISI-410 + Stellite.
 - (f) Packing: Graphite.
 - (g) Brand: RP&C Valve, Bonney Forge.
 - (h) Model: EF56D.



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- (2) Shutoff Service and Gauge & Instrument Isolation:
- (a) Threaded Ball Valve.
 - (b) Rating: 2000 PSI CWP. [2200 PSI CWP, 435 PSI WSP].
 - (c) Body: Two-Piece, ASTM A216 Type WCB Carbon Steel. [Three-Piece, ASTM A216 Gr. WCB Carbon Steel].
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: Xtreme. [Tek-Fil & Graphite packing (firesafe)].
 - (f) Lever & Nut: Zinc Plated Carbon Steel.
 - (g) Brand: Metso Automation – Jamesbury. [Flow-Tek, a Subsidiary of Bray].
 - (h) Model: (Size Designation)-A-Z(-)-22-36-XT. [FP21(Size Designation)-3-J-G-L].
- NOTE: *Fire-Tite & Xtreme Seat Required.*
- Bray Valve Note: *As standard Triad Series valves feature hex head bolts to join end connections to the tapped valve center section. This design, in lieu of a through bolt design, ensures precise alignment of the end caps – minimizing potential problems such as bolt shrinkage and elongation in severe temperature and thermal cycling applications. Less bolting movement reduces the chance for body seal failure. *Valves on insulated lines should utilize packed stem extension (media containment unit)**
- (3) Modulating (Bypass) Service:
- (a) Threaded Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Bonnet: Forged ASTM A105N Carbon Steel.
 - (d) Disc: AISI-410.
 - (e) Seat: Stellite.
 - (f) Packing: Graphite.
 - (g) Brand: RP&C Valve, Bonney Forge.
 - (h) Model: F80D.
- ii) 2-1/2-inch NPS and larger:
- (1) Shutoff Service (non-Bray Valves):
 - (a) Flanged Gate Valve, OS.
 - (b) Flanged Gate Valve, OS&Y.
 - (c) Rating: ANSI Class 300.
 - (d) Body & Bonnet: Cast WCB Carbon Steel.
 - (e) Disc: Flexible Wedge, CA-15 or 13% CR Overlay.
 - (f) Seat Rings: Hardfaced.
 - (g) Packing: Graphite.
 - (h) Brand: Crane Energy Flow Solutions.
 - (i) Model: Figure 33.



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- (2) Shutoff Service (Bray Valves for 2-1/2-inch up to 6-inch):
 - (a) Flanged Ball Valve.
 - (b) Rating: AMSE Class 300, Zero Leakage.
 - (c) Body: ASTM A216 Gr WCB Carbon Steel.
 - (d) Disc: (Ball) ASTM A351 Gr CF8M.
 - (e) Seat and Packing: Tek Fil & Graphite.
 - (f) Stem: 316 Stainless Steel.
 - (g) Packing: Graphite.
 - (h) Brand: Flow-Tek, a Subsidiary of Bray.
 - (i) Model: F30-2-R-(Size Designation)-3-J-L-G.
 - (3) Shutoff Service (Bray Valves 6-inch and above):
 - (a) Flanged Triple Offset Butterfly Valve.
 - (b) Rating: AMSE Class 300, Zero Leakage.
 - (c) Body: WCB Carbon Steel.
 - (d) Disc: WCB Carbon Steel.
 - (e) Stem: 17-4PH Stainless Steel.
 - (f) Packing: Graphite.
 - (g) Brand: Tri Lok, a Subsidiary of Bray.
 - (h) Model: G1-(Size Designation)-11075-4R5.
 - (4) Modulating (Bypass) Service:
 - (a) Flanged Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 300.
 - (c) Body & Bonnet: Cast WCB Carbon Steel.
 - (d) Disc: 13% CR Overlay.
 - (e) Seat Rings: Hardfaced.
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions.
 - (h) Model: Figure 151.
- d) Steam Condensate:
- i) Up to and including 2-inch NPS:
 - (1) Shutoff Service Only:
 - (a) Threaded Gate Valve, OS&Y.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Bonnet: Forged ASTM A105N Carbon Steel.
 - (d) Wedge: AISI-410.
 - (e) Seat: AISI-410 + Stellite.
 - (f) Packing: Graphite.
 - (g) Brand: RP&C Valve, Bonney Forge.
 - (h) Model: EF56D.



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- (2) Shutoff Service and Gauge & Instrument Isolation:
- (a) Threaded Ball Valve.
 - (b) Rating: 2000 PSI CWP. [2200 PSI CWP, 435 PSI WSP].
 - (c) Body: Two-Piece, Stainless Steel ASTM A351-CF3M/CF8M. [Three-Piece, ASTM A216 Gr. WCB Carbon Steel].
 - (d) Ball & Stem: 316 Stainless Steel.
 - (e) Seat & Packing: Xtreme. [Tek-Fil & Graphite packing (fire safe)].
 - (f) Lever & Nut: Stainless Steel.
 - (g) Brand: Metso Automation – Jamesbury. [Flow-Tek, a Subsidiary of Bray].
 - (h) Model: (Size Designation)-A-Z(-)-36-36-XT. [FP21(Size Designation)-3-J-G-L].
- NOTE: *Fire-Tite & Xtreme Seat Required.*
- Bray Valve Note: *As standard Triad Series valves feature hex head bolts to join end connections to the tapped valve center section. This design, in lieu of a through bolt design, ensures precise alignment of the end caps – minimizing potential problems such as bolt shrinkage and elongation in severe temperature and thermal cycling applications. Less bolting movement reduces the chance for body seal failure. *Valves on insulated lines should utilize packed stem extension (media containment unit)**
- (3) Modulating (Bypass) Service:
- (a) Threaded Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Bonnet: Forged ASTM A105N Carbon Steel.
 - (d) Disc: AISI-410.
 - (e) Seat: Stellite.
 - (f) Packing: Graphite.
 - (g) Brand: RP&C Valve, Bonney Forge.
 - (h) Model: F80D.
- (4) Check Valve:
- (a) Threaded Check Valve, Bolted-Cover.
 - (b) Rating: ANSI Class 800.
 - (c) Body & Cover: Forged ASTM A105N Carbon Steel.
 - (d) Disc: AISI-410.
 - (e) Gasket: F316 + Graphite.
 - (f) Brand: RP&C Valve, Bonney Forge.
 - (g) Model: F98D.



- ii) 2-1/2-inch NPS and larger:
 - (1) Shutoff Service (non-Bray Valves):
 - (a) High Performance Butterfly Valve.
 - (b) Rating: ANSI Class 300.
 - (c) Body: ASTM A216 Carbon Steel, Lug Style.
 - (d) Stem: ASTM A564 Type 630 Stainless Steel.
 - (e) Disc: ASTM A351 CF8M Stainless Steel.
 - (f) Seat: TFM.
 - (g) Packing: Grafoil.
 - (h) Brand: Cameron WKM MB-1 Dynacentric.
 - (i) Model: (Size Designation) – B5-313-02-S02-14-WG.
 - (2) Shutoff Service (Bray Valves for 2-1/2-inch up to 6-inch):
 - (a) Flanged Ball Valve
 - (b) Rating: ANSI Class 300, Zero Leakage.
 - (c) Body: ASTM A216 Gr WCB Carbon Steel.
 - (d) Stem: 316 Stainless Steel.
 - (e) Disc: (Ball) ASTM A351 Gr CF8M.
 - (f) Seat and Packing: Tek Fil & Graphite.
 - (g) Packing: Grafoil.
 - (h) Brand: Flow-Tek, a Subsidiary of Bray.
 - (i) Model: F30-2-R--(Size Designation)-3-J-L-G.
 - (3) Shutoff Service (Bray Valves 6-inch and above):
 - (a) Flanged Triple Offset Butterfly Valve.
 - (b) Rating: ANSI Class 300, Zero Leakage.
 - (c) Body: WCB Carbon Steel.
 - (d) Stem: ASTM A564 Type 630 Stainless Steel.
 - (e) Disc: WCB Carbon Steel.
 - (f) Seat and Packing: Tek Fil & Graphite.
 - (g) Packing: Grafoil.
 - (h) Brand: Tri Lok, a Subsidiary of Bray.
 - (i) Model: G1-(Size Designation)-11075-4R5.
 - (4) Modulating (Bypass) Service:
 - (a) Flanged Globe Valve, OS&Y.
 - (b) Rating: ANSI Class 300.
 - (c) Body & Bonnet: Cast WCB Carbon Steel.
 - (d) Disc: 13% CR Overlay.
 - (e) Seat Rings: Hardfaced.
 - (f) Packing: Graphite.
 - (g) Brand: Crane Energy Flow Solutions.
 - (h) Model: Figure 151.



- (5) Check Valve:
 - (a) High Performance Check Valve.
 - (b) Rating: ANSI Class 300.
 - (c) Body: Wafer Style, ASTM A216 Carbon Steel.
 - (d) Seal: EPDM. [Metal Seat].
 - (e) Disc, Arm & Pin: 316 Stainless Steel.
 - (f) Brand: Crane Energy Flow Solutions – Uni Check. [Ritepro, a Subsidiary of Bray].
 - (g) Model: (Size Designation) – 30-A-0-3-4-1-3-0. [30-(Size Designation)-SMZ].

Bray Valve Note: The inlet is to incorporate a contoured shape and optimum diameter for a Venturi effect for high flow, capacity and low pressure drop. The disc shall have a convex profile that supports flow both upper and lower surfaces in the full open position creating a lifting force. The spring-loaded disc is to close before flow reversal to reduce water hammer. Basis of Design: Check valves on pump protection parallel pumps to a common header to employ an external lever and compression spring. Ritepro SA40. Check valves in line used for non-return to use an internal spring. Ritepro 210. Testing: Valves to be 100% hydro tested and marked in accordance with ASME B16.34 or API 598, zero permissible leakage. Installation: All valves to be installed per the manufacturer's instructions for installation, orientation, and check action.

6. Flanges and Accessories – Steam and Steam Condensate:

- a) Steam Low Pressure:
 - i) Flanges: Forged Pipe Flange, ASME B16.5, ASTM A105 Carbon Steel, Class 150, 1/16 inch Raised Face.
 - ii) Bolting: ASTM A193 Grade B7 Heavy Hex Bolts and Stud Bolts, ASTM A194 Grade 2H Heavy Hex Nuts. Length of bolts and studs per ASME B16.5, Table 8.
 - iii) Gaskets: Spiral Wound Metal Gasket with Outer Gauge Ring, ASME B16.20, Flexible Graphite Filler Material, 304 SS Gauge Ring, Class 150, Garlock Style RW.
- b) Steam High Pressure:
 - i) Flanges: Forged Pipe Flange, ASME B16.5, ASTM A105 Carbon Steel, Class 150, 1/16 inch Raised Face.
 - ii) Bolting: ASTM A193-B7 Heavy Hex Bolts and Stud Bolts, ASTM A194-2H Heavy Hex Nuts. Length of bolts and studs per ASME B16.5, Table 11.
 - iii) Gaskets: Spiral Wound Metal Gasket with Outer Gauge Ring, ASME B16.20, Flexible Graphite Filler Material, 304 SS Gauge Ring, Class 300, Garlock Style RW
- c) Steam Condensate:
 - i) Flanges: Forged Pipe Flange, ASME B16.5, ASTM A105 Carbon Steel, Class 300, 1/16 inch Raised Face.

NOTE: Use flat face flanges for connection to equipment equipped with flat face flanges.
 - ii) Bolting: ASTM A193 Grade B7 Heavy Hex Bolts and Stud Bolts, ASTM A194 Grade 2H Heavy Hex Nuts. Length of bolts and studs per ASME B16.5, Table 11



- iii) Gaskets: Spiral Wound Metal Gasket with Outer Gauge Ring, ASME B16.20, Flexible Graphite Filler Material, 304 SS Gauge Ring, Class 300, Garlock Style RW.

23 22 16 Steam and Condensate Heating Piping Specialties

1. Unless otherwise specified by code, safety valves shall be constructed of the following materials:
 - a) Carbon steel body.
 - b) Trim - stainless steel.
 - c) Springs - stainless steel.
2. The discharge piping from all safety valves shall be piped to a drip pan elbow and then to a safe discharge point on the exterior of the building. The drain connections from each drip pan elbow shall be piped to a floor drain.
3. Steam Traps:
 - a) All low pressure (15 PSI and below) shall be venturi-type by Steamgard, or if not available float and thermostatic traps having bodies and caps of ASTM-A278 Class 30 cast iron or SG ductile. All internals including float, main valve head/seat, thermostatic air vent, and air vent head/seat shall be stainless steel.
 - i) Up to and including 2-inch NPS: Steamgard model EP HA.
 - ii) 2-1/2 – inch NPS and larger: Steamgard model UD.
 - iii) Float and Thermostatic Traps: SpiraxSarco Model (FTI, FT or FTB), Watson McDaniel Model (FTT, FT, WFT, or FTE) or as approved equal.
 - b) All high pressure (above 15 PSI) steam traps shall be venturi-type by Steamgard or if not available of the thermodynamic type. Both disc and seat shall be of hardened stainless steel.
 - i) Up to and including 2-inch NPS: Steamgard model EP HL.
 - ii) 2-1/2 – inch NPS and larger: Steamgard model UD.
 - iii) Thermodynamic: Spirax Sarco Model UTD30 with blow-down includes universal connector and module to 450 PSIG, Watson McDaniel Model UTD450 with UC450SB includes universal connector with blow-down to 450 PSIG; TD42L with blow-down (integral strainer), TD600LS with Strainer and Blowdown, TD52L and TD600L are non-module types, or as approved equal.
 - iv) Utilize inverted bucket or orifice traps for large, constant condensate loads, such as main steam distribution piping. Inverted bucket basis of design to be Watson McDaniel Model IB, or as approved equal.
 - v) Utilize thermodynamic traps for small, constant condensate loads.
 - vi) Utilize float and thermostatic traps for modulating condensate loads, such as heating converters.
 - c) Where Steamgard traps are utilized, the installing contractor shall contact Steamgard for proper sizing and selection of trapping equipment for the application.
 - d) Do not install traps in areas which may be subjected to freezing temperatures under normal conditions.
 - e) Small terminal devices, such as fan coils, unit ventilators, and convector units are to use Hoffman 17C or Watson McDaniel TA125 thermostatic traps, in lieu of SpiraxSarco.



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4. Pressure Reducing Stations:
 - a) The installation of pressure reducing stations must comply with ASME B 31.1.
 - b) Hand-controlled bypasses around reducing valves may be used if the bypass has no greater capacity than the reducing valve. Hand controlled bypasses may be used around reducing valves at greater capacity than the reducing valve if the system or unfired pressure vessel has adequate relief or safety valve protection or meets the requirements of the high-pressure system.
 - c) A pressure gauge must be installed on the low-pressure side of a reducing station.
 - d) Pressure reducing valves shall be Spence Engineering Co., Type ED, Watson McDaniel Model HD Main Valve (same F-F as Spence ED regulator) Ductil Iron, or Spirax Sarco approved equal. Consideration shall be given to the operating range (lbs./hr. flow) of the system and the use of parallel valves to prevent erosion of the valve and seat.
 - e) Steam metering should be pressure-compensated and performed on the high-pressure side of the PRV station and should be an inline vortex-shedding flowmeter (Yokogawa or Rosemount pressure transmitter and flowmeter preferred). The pressure transmitter should be equipped with a two-valve manifold and the flowmeter should be installed with the shedder bar in the horizontal position.
 - f) A/E must follow manufacturer's installation requirements/instructions.
 - g) A/E to design steam system for a step down in two stages from delivery pressure to less than 15psig working pressure.

 5. Strainers:
 - a) Steam, 15 PSIG or less, 2-inch and smaller: Forged steel threaded or socked welded strainer.
 - b) Steam, 15 PSIG or less, larger than 2-inch: ANSI Class 150 flanged, cast carbon steel strainer.
 - c) Steam, greater than 15 PSIG, 2-inch and smaller: Forged steel threaded or socked welded strainer.
 - d) Steam, greater than 15 PSIG, larger than 2-inch: ANSI Class 300 flanged cast carbon steel strainer.
 - e) Condensate, 2-inch and smaller: Forged steel threaded or socked welded strainer.
 - f) Condensate, larger than 2-inch: ANSI Class 150 flanged, cast carbon steel strainer.

 6. Flash Tanks: ASME-rated horizontal tanks size to assure dryness of the steam released and to avoid carry-over of water by the steam. Basis of design to be Watson McDaniel Model WFLV, or as approved equal. Consideration shall be given to flash steam heat recovery or domestic water preheat systems in lieu of wasting the flash steam.

 7. Condensate Coolers: All steam condensate systems shall be fitted with a tank-type condensate cooler properly sized to limit the maximum discharge temperature to 140°F. Where condensate is collected near domestic hot water heaters, condensate will be piped to preheat (economize) stored water.

 8. Vacuum breakers are required for any steam coil. Basis of design shall be Hoffman Specialty Model 62 or Watson McDaniel Model WVBSS Stainless Steel.
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23 23 00 Refrigeration Piping

1. All piping for refrigeration systems shall be type ACR copper tubing conforming to ASTM B-280. All tubing shall be hard drawn.
2. Fittings shall be wrought copper conforming to ASNI B16.22.
3. All joints shall be brazed using fast flow cadmium bearing silver brazing alloys composed of 45% silver, 15% copper, 16% zinc and 24% cadmium.
4. All refrigeration system piping arrangements, pitching, and sizing shall be as recommended by the manufacturer and indicated on the drawings.
5. All refrigeration systems shall be tested, evacuated, and charged by the installing contractor. The contractor shall verify, in writing, that the system has been tested, evacuated, and charged per in accordance with A/E specifications and industry standards, whichever is more stringent.
6. All systems shall be designed with the following:
 - a) Service valves located at the compressor, condensing unit, branch piping.
 - b) Liquid line sight and moisture indicators at the condenser or receiver and at the entrance to the expansion valve. Field installed receivers are **prohibited**.
 - c) Liquid line filters with a valved bypass to permit changing and/or bypassing of the filter without system shutdown.
7. The A/E shall include a requirement that start up and service of refrigeration systems shall be done by EPA-certified technicians and refrigerants shall be handled and reclaimed in accordance with EPA requirements.

23 23 23 Refrigerants

1. Refrigerants used in HVAC and other cooling equipment must be approved by [Facilities Operations or the University Engineer](#) during the Design Phase of any project.
2. The design of all refrigeration equipment 75 tons and larger must include an analysis addressing the noise impact upon surrounding areas and the aesthetic impact if located on the exterior of the building.
3. Prior to the selection of compressor unit, i.e., reciprocating, centrifugal, screw or scroll, the Engineer of Record must submit an analysis of the various compressor types, conclusions, and recommendations to the University for approval. The analysis shall address operating efficiency; costs associated with noise control implementations, maintenance, service, availability from manufacturer, refrigerant type, part load performance, electrical characteristics, and estimated construction cost.
4. All refrigeration system specifications must be specified to include factory start-up and servicing. The factory start-up shall include the check-out of all controls, safety components



and performance characters. Facilities Management shall actively observe the testing and start-up of the systems.

5. Small individual packaged split systems are discouraged. Prior approval for the use of such must be obtained from the University's Project Manager or Facilities Management Department.
6. All air-cooled condensers must contain condenser fan modulation controls as a means of capacity control for low ambient operation. Condenser fan speed control is not required where associated equipment is equipped with airside economizer cycle. Condenser fan dampers are not permitted.
7. Mechanical rooms shall contain a refrigerant detector with an audible and visual alarm. The installation shall be in accordance with the City of Philadelphia's Fire Code and Mechanical Code.
8. Refrigeration units or systems having a refrigerant circuit containing more than 220 pounds (100 kg) of Group A1 or 30 pounds (14 kg) of any other group refrigerant shall be provided with approved emergency signs, charts, and labels in accordance with NFPA 704 and the City of Philadelphia's Mechanical code.
9. Mechanical contractor is responsible for coordinating with equipment manufacturer regarding final pipe sizing and additional required accessories based on the final layout prior to installation.
10. During the design and selection of equipment, the A/E is responsible for specifying refrigerants in compliance with Section 608 of the U.S. Clean Air Act, effective January 2017.

23 25 00 HVAC Water Treatment

1. The specifications shall require the Mechanical Contractor to engage, as a subcontractor, the services of the University's Water Treatment Contractor (Rochester Midland Corporation) to provide the following:
 - a) Chemical cleaning of new and existing systems for each project.
 - b) Disinfection of new and existing systems for each project.
 - c) Provision of all chemicals and equipment for the following systems as applicable:
 - i) Condenser water.
 - ii) Closed re-circulating systems.
2. The A/E and mechanical contractor shall determine if any existing systems need to be included in the water treatment scope of work.
3. The make-up water piping to each system (condenser, glycol, re-circulating, etc.) shall contain a water meter to monitor make-up water quantities. Each make-up water system is to be equipped with a backflow preventer, refer to Part 12 in Section 23 21 16 for approved manufacturer and model.



4. All water treatment systems are to be located indoors. Systems located outdoors are **prohibited**.
5. The following treatment parameters shall be maintained:
 - a) Condenser Water Systems:
 - i) Phosphate: 5-10 parts per million.
 - ii) Molybdate / Polymeric Silicate: 5-10 parts per million (as MoO₄).
 - iii) Triazole Inh: 2-5 parts per million.
 - iv) pH: 7.5-8.5.
 - v) Legionella pneumophila: Negative U.V. analysis.
 - vi) Organic Growths: None to trace. Field microbiological test maximum 20,000 organisms per milliliter 24 hours after biocide addition.
 - vii) Cycles of Concentration: Concentration 4-6 (1,600-2,400 micro-ohms conductivity).
 - viii) Corrosion Rates:
 - (1) Steel: Less than 5.0 mils per year.
 - (2) Copper: Less than 1.5 mils per year.
 - b) Closed Recirculating Systems:
 - i) Catalyzed Sodium Sulfite (as SO₃): 30-50 parts per million.
 - ii) Phenolphthalein Alkalinity: 10-50 parts per million.
 - iii) pH: 8.0-9.5.
 - iv) Corrosion Rates:
 - (1) Steel: Less than 5.0 mils per year.
 - (2) Copper: Less than 1.5 mils per year.
6. Contact information for the University's Water Treatment Contractor: Rochester Midland Corporation – Vince Marcucci, 856-207-6302 and vmarcucci@rochestermidland.com.
7. The chemical treatment bleed piping is to be connected in the common condenser water supply pipe header where it enters the penthouse. The chemical treatment supply piping is to be connected in the common condenser water supply pipe header prior to the condenser water pumps. The chemical treatment sample piping is to be connected in the common condenser water supply pipe header after the condenser water pumps.
8. Each Closed System to include the following water treatment equipment:
 - a) One (1) bypass filter feeder, model FTF-5HP7; rated 300 PSI, 3/4-inch inlet/outlet connections.
9. Provide automatic water treatment equipment. Each Open Recirculating System to include a fully automatic water treatment controller:
 - a) Walchem 600 Series programmable controller includes automatic inhibitor feed; dual biocide feed; conductivity regulated bleed-off, conductivity sensor and remote flow-switch assembly.
 - b) One (1) make-up contact water meter, sized for makeup control, pre-wired into controller.
 - c) Three (3) electronic metering diaphragm pumps for inhibitor and biocide feed. Pulsatron model C plus pump, 12 GPD, 120 PSI, 115 VAC, includes discharge & suction tubing, foot valve and backflow injector.



- d) One (1) solenoid valve, sized for bleed-off control, installed & wired into controller.
- e) One (1) corrosion coupon station, PVC sch. 80, 1-inch threaded connections, pre-assembled with four (4) coupon ports; includes pre-installed 4 – 28 GPM flowmeter.

10. System Flushing:

- a) Thoroughly flush each closed system(s) with raw water to remove loose mill scale and debris. Remove and clean all strainers and flush low points before chemical cleaner is added to the system.
- b) Add system cleaner Flushout™ 624L at 2 gallons per 1,000 gallons system water for the removal of oil, mill scale and iron oxides. Circulate for a minimum of 24 hours and flush. Repeat fill and flush procedure as often as required as per the instructions of the water treatment representative until water is sufficiently clean and clear.
- c) Acceptability of water condition to be determined through testing and visual examination of representative water samples, by the water treatment supplier. Copies of test reports should be submitted by the water treatment supplier to the Mechanical Contractor for verification to the Engineer.
- d) Add corrosion inhibitor CLT 407 at 1 gallon per 200 gallon to the final water fill to achieve prescribed Nitrite maintenance levels for corrosion protection.

11. Ion Pitch Non-Chemical Descaler – Condenser Water System:

- a) Electronic control unit that produces an oscillating radio-frequency electric field to control scale.
- b) Contractor to install a removable spool piece in the location of the device for future device maintenance.
- c) Device has a wall-hung controller, which requires 120V power.
- d) Manufacturer: Onvector LLC (no substitutions).
- e) Model: RF-(pipe size). Current models range from 2 to 14 inch in pipe diameter.
- f) Contact is Daniel Cho: phone 856-438-0320 or 610-453-1937 and email is dcho@energyonvector.com.

23 31 00 HVAC Ducts and Casings

- 1. The use of duct liner for acoustical purposes is only permitted with University approval prior to incorporating into a system's design. Its use will only be permitted where it is impractical or not feasible to utilize other sound attenuating devices, such as inline duct silencers or elbow silencers. Double walled ducts consisting of an outer wall of galvanized sheet metal, an inner wall of perforated galvanized sheet metal with insulation sandwiched between the layers is permitted but may prove cost prohibitive.
- 2. All Low-Pressure ductwork shall be designed in accordance with SMACNA Standards modified as follows:
 - a) Radius elbows with an outer line radius of 1.5 times the duct width are preferred to square elbows.
 - b) All square elbows must be constructed with double thickness turning vanes.
 - c) Air extractors and splitter dampers are not permitted.
 - d) Maximum duct transition angles shall be 3-inches per foot per side.



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- e) Minimum duct gauge shall be:
 - i) 24 for ducts 1" and up to and including 30".
 - ii) 22 for ducts 31" and up to and including 43".
 - iii) 20 for ducts 44" and up to and including 60".
 - iv) 18 for ducts 61" and greater.
 - f) All transverse joints shall be of the pocket lock type with a minimum height of 1" and maximum spacing of 8'-0". Refer to SMACNA standards for pocket type locks in duct construction requiring a rigidity classification beyond the 1" height and 8' spacing.
 - g) Specify a Seal Class "A" for all systems. Project specifications shall clearly define the modified standard in addition to referencing SMACNA standards. Solvent-based sealants that are flammable when curing are **prohibited** in occupied buildings.
3. Medium and High-Pressure Duct Construction:
- a) Prior approval must be attained from the University's Project Manager or Facilities Management Department for the use of medium and high-pressure systems.
 - b) Follow SMACNA medium and high-pressure duct construction standards.
 - c) Specify sealing requirements.
 - d) Consideration must be given to the lowest practical velocity and pressure criteria, which will fit within the structure and provide adequate service.
4. All duct systems must be designed to meet the sound level requirements listed in General Section I, entitled "Noise and Vibration Control".
5. Drawings must have adequate notation, which correlates each duct and terminal device (reheat chill or VAV box) with the central air handling unit from which it is served. The notation must be completed in such a manner as to clearly identify each system and its components without tracing systems between drawings.
6. The drawings shall indicate the pressure classification of duct systems.
7. Shop drawings of all sheet metal ductwork and related equipment must be furnished in a scale of 3/8-inch equals a foot.
8. All materials for all duct systems shall be specified by the designer as follows:
- a) General Ductwork (Supply and Return Air Systems) - Hot dipped zinc-coated galvanized sheet metal conforming to ASTM A525, Class 1.25.
 - b) Stainless Steel – Specify type 316 as the basis of design, however A/E is to verify per application.
 - i) All exhaust systems serving equipment using hazardous gases (fluorine, ammonia, and chlorine) are to be welded stainless steel from the point of connection to the exhaust main.
 - ii) All exhaust systems serving equipment using non-hazardous gases are to be welded stainless steel from the point of connection to the Phoenix valve and then galvanized from the Phoenix valve to the exhaust main.
 - c) Aluminum Duct - ASTM B-209, Alloy Number 3303, Tripen H-14. No aluminum ductwork shall be utilized except where required for chemical compatibility in laboratory exhaust systems.



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- d) Fiber-reinforced plastic (FRP) shall not be utilized except where required for chemical compatibility in laboratory exhaust systems and approval from University [EH&RS](#).
9. All rectangular panels above 10-inches in width must be cross-broken on all four sides.
 10. All ductwork and accessories must be supported from the structure only.
 11. Plenum chambers shall be constructed of 18-gauge metal with 1-1/2" x 1-1/2" x 3/16" galvanized angles up to 10 feet in height. Above 10 feet, angles of 2" x 2" x 1/4" must be used. Angles must be installed on all vertical and longitudinal seams and on a maximum center of 4 feet.
 12. Low pressure round ductwork shall be specified as follows:
 - a) Lock-type spiral seam or lock-type longitudinal seam duct construction.
 - b) Minimum gauge as follows:
 - i) Longitudinal lock - 22 gauge.
 - ii) Spiral lock - 24 gauge.
 - c) Fittings shall have a construction radius of 1.5 times the diameter.
 - d) All branch connectors shall be made with 45-degree laterals on the centerline of duct.
 - e) All seams shall be sealed.
 13. Flexible Ductwork:
 - a) Flexible ducting shall be constructed of wire frames and fiberglass plastic film. Flexible locking plastic tie wraps are not acceptable.
 - b) Ducts shall be aluminum with spiral fabricated triple lock. Pressure drop shall not exceed 0.23 inches of water for 100 feet of duct for 300 CFM in an 8-inch duct.
 - c) Duct shall conform to NFPA 90A and shall be UL listed, Specification 181, Class 1, including insulation.
 - d) Maximum flexible ductwork length to be 5'-0".
 - e) Insulation, where required, shall be on the exterior of the duct.
 14. Ducts penetrating through masonry walls, floors and roofs shall be clearly detailed on the drawings. The details shall, as a minimum, indicate curbs, flashing, counter flashing, fire dampers, sleeves, sealing and weatherproofing.
 15. Horizontal exterior rectangular ducts shall be fabricated with all longitudinal seams at the bottom and installed with a top surface slope of 1/4-inch per foot. Supporting shall be detailed on the drawings.
 16. Specify special duct sealing and weatherproofing requirements for all exterior duct applications. Refer to Section 23 07 13 "Duct Insulation".
 17. Kitchen range (Type 1) and dishwasher (Type 2) exhaust hoods and ductwork shall be designed, constructed, and installed in accordance with NFPA and 2018 International Mechanical Code requirements.
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18. Clothing dryer exhaust systems shall meet the requirements of the 2018 International Mechanical Code, Section 504 and the clothing dryer manufacturer's exhaust requirements. If no guidance is available from the manufacturer, and as a design minimum, all clothing dryer exhaust systems shall meet the requirements of the "Service Manual for Exhausting Dryers" by Whirlpool Corporation. (Service Manual No. LIT603197-B). Clothing Dryer Exhaust shall follow manufacturers design parameters for length and allowable bends. Dryer exhaust ductwork should be properly pitched and drained.
19. Shower exhaust systems shall be constructed of material suitable to avoid corrosion and sloped to drain provisions. When the shower exhaust is mixed with a volume of general exhaust air equal to 200% of the shower exhaust, standard galvanized may be used. Toilet rooms with showers need not comply with the requirement.
20. Laboratory duct material must be reviewed and approved by the University's Project Manager or Environmental Health and Radiation Safety Department. Acceptable duct materials are as follows:
 - a) Plastic coated steel.
 - b) Stainless steel.
 - c) Plastic ducts such as Dynel reinforced polyester. When using plastic ductwork, all fire code and sprinkler code requirements must be addressed.
21. Internal duct devices shall be equipped with fully accessible access doors.
22. Fire dampers are **prohibited** in hazardous exhaust ducts.
23. Automatic fire protection systems are **prohibited** in laboratory hazardous exhaust ducts.
24. All round ductwork connections to VAV's are to have a straight run of duct equal to 2-1/2 to 3 times the duct diameter, i.e. 10-inch diameter duct should be 25 to 30 inches long. Remainder of branch ductwork back to main to be round or rectangular and sized for maximum VAV CFM as scheduled.
25. Duct joint sealant to be silicone base type. Water based sealants are **prohibited**. Approved manufacturers are United McGill, 3M Products or approved equal.

23 33 00 Air Duct Accessories

1. Each duct to individual diffusers and registers and branch ductwork shall have an individual balancing damper, approved manufacturers are Ruskin, Tamco or approved equal. Shop made dampers are **prohibited**. Dampers in diffusers and registers shall be used for fine-tuning the airflow only.
2. Specify flexible connections not less than 3" wide at the inlet and outlet of all rotating equipment and at all building expansion joints. The connector fabric shall be fire retardant and asbestos free.



3. Access doors shall be hinged and be constructed of a minimum 22-gauge materials. The doors shall be installed with stiffening angle supports frame. Minimum door size shall be 16"x16". Access doors must be installed both upstream and downstream of all duct mounted equipment including but not limited to:
 - a) Coils.
 - b) Fire, smoke and combination fire and smoke dampers.
 - c) Automatic dampers.
 - d) Filters.
 - e) Controls.
 - f) Fans.
4. Fire dampers shall be of the out-of-air stream design, Style B. Basis of Design to be Ruskin or approved equal. All projects will conform to the following:
 - a) The locations of all fire dampers must be indicated on the drawings as required meeting applicable codes.
 - b) Both NFPA and SMACNA design standards must be referenced as a standard for the installation of the dampers.
 - c) Each fire damper shall be tested to ascertain proper operation.
5. Intake and exhaust louvers shall be designed within the following parameters:
 - a) Approved manufacturers are Ruskin, Tamco, or approved equal.
 - b) Intake:
 - i) Maximum face velocity: 600 FPM.
 - ii) Maximum water penetration: Less than 0.15 oz. per ft. sq. free area. 15 Minute duration.
 - iii) Maximum pressure drop: Less than 0.15 in. w.g.
 - iv) Maximum free area: 57% of face area.
 - v) When intake louver is a part of an airflow measurement station, A/E is to follow the airflow measurement station manufacturer's installation requirements.
 - c) Exhaust:
 - i) Maximum face velocity: 1,250 FPM.
 - ii) Maximum free area: 57% of face area.
 - iii) Maximum pressure drop: 0.20 in. w.g.
 - d) Drainable type.
 - e) Coordinate bird and insect screens with system type. Screens are **prohibited** in dryer exhaust systems.
6. Duct coils shall be supported independently of the connected ductwork.
7. Modulating dampers shall be sized for linear airflow control within the angle of rotation with minimum pressure drop. The units shall be constructed of a minimum of 16-gauge galvanized steel frames and blades having a maximum width of 6-inches. Each blade shall be constructed with edge seals and shall be sealed to minimum 1/2-inch steel angles. End bearings shall be of the self-lubricating type. Maximum damper leakage shall be 2% when closed across a 4-inch static pressure differential.



23 33 19 Duct Silencers

1. Approved duct silencer manufacturers are VAW Systems, Industrial Acoustics Company, Vibro-Acoustics, Price and Pottorff.
2. Sound attenuators shall be installed on all systems as required to meet the specified noise criteria levels in General Section I, entitled "Noise and Vibration Control", of the Guide.
3. Factory fabricated and test traps in accordance with ASTM E477, 2013 edition.
4. Casings are to be constructed with materials specified for duct system. Outer casing minimum 22 gauge; interior casing (rectangular silencers) minimum 26 gauge perforated.
5. Provide packless type traps for corrosive or fume exhaust systems.
6. For packed type, provide fiberglass cloth liner for offices, classrooms, auditoriums, etc. and plastic or mylar encased packing to prevent fume absorption or packing erosion for laboratories and healthcare.
7. Packing is to be an inorganic mineral or glass fiber of density sufficient to obtain specified acoustic performance. Maximum flame spread/smoke developed/fuel contributed: 25/50/50 when tested in accordance with ASTM E84, NFPA 255 or UL 723.
8. Make units airtight by use of a duct-sealing compound. Construct traps to withstand a differential air pressure of 8 inches w.g. inside to outside of casing.
9. Sound traps at Vane Axial fan inlets and discharges shall match fan diameter connection and internal hub size/design.
10. A/E is to verify size and shape of all silencers and accurately display them on the final construction drawings, especially elbow type silencers.

23 34 13 Axial HVAC Fans

1. Axial Fans are **prohibited** except in fume hood exhaust applications. Axial fans used in fume hood applications shall be Strobic Air [Technologies Tri-Stack](#) fans.
2. Fans shall be provided with disconnect switches, companion flanges, sound attenuators and spark resistant motors as required to suit application.
3. All fans shall be direct drive. Belt drives are **prohibited** except where stipulated by code.

23 34 16 Centrifugal HVAC Fans

1. All fans shall be installed to permit servicing of the fan bearings, motor, and drive package from the floor level without the use of a ladder.



2. All units of capacity 15,000 CFM or larger and installed six feet above the floor or higher must be provided with stable catwalks constructed of structural grade steel and steel grating. Access ladders shall be integral with the catwalks.
3. Centrifugal fans may be of the forward curved, backward inclined or airfoil types. The Engineer shall select the most efficient type for the operating range of the system.
4. Fans serving variable air volume systems shall be controlled using variable frequency drives and airflow measuring stations. Room pressure sensors, inlet vanes, discharge dampers, eddy current clutches, etc. are **prohibited**.
5. Units shall be provided with safety control components such as fire stats, smoke detectors and or smoke dampers as per code.
6. All fans shall be AMCA certified. Provide fans rated for the particular class of operation based upon outlet velocity and static pressure in accordance with AMCA standards.
7. Fans installed in exhaust systems handling corrosive vapors shall be coated or constructed of materials compatible with the intended environment. All laboratory fume hood fans must be reviewed with the Environmental Health and Radiation Safety Office and operated in accordance with the Laboratory Design Standard 2020 (see Appendix A).
8. Units shall be provided with hinged access/inspection doors located in the fan housing.
9. All units shall be provided with belt guards.
10. Units installed outdoors shall be provided with weather resistant covers.
11. Shafts and bearings shall be designed for an average life of 250,000 Hrs.
12. Provide exterior units with scroll drains. Drains on units serving corrosive or toxic systems shall be installed with a valve.
13. Units serving flammable vapor systems shall be of spark resistant construction.
14. All exhaust fans serving fume hoods, isolation areas, or hazardous substances shall be installed with discharge ductwork, which extends a minimum of 10'-0" above the roof and 2'-0" above surrounding screens, parapet walls, etc. The discharge duct shall terminate in a reducer to provide a discharge velocity, which assures the mixing of the effluent above the buildings near wave. Discharge ductwork must be self-supporting or structurally supported. Guy wires are **prohibited**.
15. All fans must be properly identified. Fans serving fume hoods or isolation rooms must be identified by the isolation room or room in which the fume hood is located. Each fan shall be labeled with the following:
 - a) Fan Number issued by Facilities Management.
 - b) System and area served (or fume hood and room number).



16. Each unit shall be provided with a disconnect switch and each mechanical room and roof area where mechanical equipment is located shall be provided with an electrical receptacle rated for 120V, 20 Amps.
17. Fans serving fume hoods or isolation rooms shall be on emergency power.

23 34 23 HVAC Power Ventilators

1. Mixed flow induced dilution fans must be used for all laboratory and fume hood exhaust systems. Basis of Design to be Strobic Air Corporation. Another acceptable manufacturer is Greenheck Vektor series.
2. Fans are to be tested in accordance with the current edition of the following standards, at a minimum:
 - a) ANSI/AMCA Standard 99, "Standards Handbook".
 - b) ANSI/AMCA Standard 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating".
 - c) ANSI/AMCA Standard 300, "Reverberant Room Method for Sound Testing of Fans".
 - d) NFPA 45, "Standard on Fire Protection for Laboratories Using Chemicals".
 - e) UL/cUL 705, "Power Ventilators".
3. Motor bearing life to be 150,000 hours, at a minimum.
4. Fans, plenums, curbs, etc., are to have a corrosion resistant coating.
5. A/E to design fan system(s) with manufacturer's roof curb.
6. Bypass dampers are to be controlled via the BAS to mix outside air with the primary exhaust air. All bypass sections are to have a rain hood and bird screens.
7. Exhaust Fan Rotations: For multiple fan assemblies using a rotation schedule, the A/E is to design the system such that individual fan dampers, bypass damper, and motorized ductwork dampers operate to keep the building negative. This is to all be via the BAS.
8. When there are multiple exhaust ductwork branches connected to the exhaust air plenum, the A/E is to design the system to maintain the required negative pressure in each branch via a motorized damper and air monitoring station. The plenum pressure shall be maintained at 0.25-inches greater than the largest branch pressure. Pressurization is to be controlled via the BAS.
9. Warranty: Fan manufacturer shall provide a 7-year parts warranty from time of purchase to include fan, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings, and belts. This warranty shall be held solely by the fan manufacturer. All warranty claims, as defined above, shall be the sole responsibility of the fan manufacturer.



23 36 00 Air Terminal Units

1. Approved manufacturers are Anemostat, Kruger, Price, Titus, Trane, and Enviro-Tec.
2. Casing material to be steel, ASTM A653/A653M, lock-forming quality, G90 galvanized for galvanized duct systems. Use ASTM A240, Type 304 stainless steel for stainless steel duct systems. Use Type 304L when unit connections are welded to ductwork. Follow SMACNA Standards and Section 23 31 00 of the Guide.
3. Casing liner, where permitted, use a minimum 3/4-inch thick closed-cell foam insulation in conformance to NFPA 90A.
4. Leakage:
 - a) Casing Leakage: Maximum 1 percent of flow at 2-inch w.g.
 - b) Damper Leakage: Maximum 3 percent of flow at 4-inch w.g.
5. Coordinate controller location and orientation with sheet metal shop drawings to provide access for service.
6. Reheat Coils: Hot water or electric type as specified in Section 23 82 16 of the Guide. Mount coils, including headers and return bends, entirely within insulated casing. Provide access panel in bottom of unit casing to service water coils. Size coil for maximum cooling airflow CFM. The University normally does not have the reheat system on during the cooling season, in non-laboratory spaces, as an energy saving measure. Electric type shall use SRC control.
7. Factory set airflow requirements for each unit as shown. Use airflow across sensor to determine setpoint.
8. Maximum NC level schedule based on maximum airflow with inlet pressure of 1.0-inch static pressure. Sound pressure level shall not exceed specified NC curve at any frequency band. Refer to Section J, Noise and Vibration Control, for space sound levels. Provide sound attenuator as required to meet sound level criteria.
9. Prime Professional to select unit based on maximum airflow being in the mid-range, approximately, of the unit. Approximate airflow velocities are to be 2,000 FPM max. and 500 FPM min.
10. Unit manufacturer is to provide an enclosure for the approved BAS manufacturer's controller.
11. Controllers are per Division 25.

23 36 00.1 Fume Hood and Laboratory Fume Hood Controls

1. Constant Volume Labs
 - a) Fume Hoods:
 - i) Fume Hood Alarming only:
 - (1) Fume hood Monitor: Phoenix Controls model FHM530-ENG.



- (2) DP Switch: Dwyer model ADPS-03-2-N (range .2 to 2.0"WC).
 - ii) Fume Hood Alarming and Constant Volume Control:
 - (1) Fume hood Monitor: Phoenix Controls model FHM530-ENG.
 - (2) DP Switch: Dwyer model ADPS-03-2-N (range .2 to 2.0"WC).
 - (3) Constant Volume Air Valve: Phoenix Controls Model CEVB series sized for required flow.
 - b) Room Control:
 - i) Supply Air:
 - (1) Constant Volume Air Valve: Phoenix Controls Model TSVA Series sized for required flow.
 - ii) Temperature Control:
 - (1) Discharge Temperature Sensor: Phoenix Controls Model PTS102-D-04.
 - (2) Space Temperature Sensor: Phoenix Controls Model PTS102-R-OS.
2. Variable Volume Labs.
- a) Fume Hoods:
 - i) Fume Hood Control:
 - (1) Fume hood Monitor: Phoenix Controls model [FHD130-ENG-FHV](#).
 - (2) Sash Sensor: Phoenix Model VSS4-0100-A (or as required by hood sash).
 - (3) Zone Presence Sensor: Phoenix Model ZPS320.
 - (4) Variable Volume Exhaust Valve: Phoenix Model EXVB series sized for required flow.
 - b) Room Control:
 - i) Supply Air:
 - (1) Variable Volume Air Valve: Phoenix Controls Model MAVA series sized for required flow.
 - ii) General Exhaust:
 - (1) General Exhaust Air Valve: Phoenix Controls Model EXVA series sized for required flow.
 - iii) Point Exhaust:
 - (1) Constant Volume Air Valve: Phoenix Controls Model CEVA Series sized for required flow.
 - iv) Temperature Control:
 - (1) Discharge Temperature Sensor: Phoenix Controls Model PTS102-D-04.
 - (2) Space Temperature Sensor: Phoenix Controls Model PTS102-R-OS.

23 36 00.2 Air Quality Monitoring System

- 1. Constant Volume Labs.
 - a) Not Required.
- 2. Variable Volume Labs.
 - a) Aircuity Components:
 - i) Information Management Server (IMS).
 - (1) Internet Access shall be provided at IMS Location.
 - (2) One IMS Per Building to interface to Lab Control System (LCS) via hardwired connection:



- (3) One Indoor Air Quality Command per Lab from Air Data Router (ADR).
- (4) One Total Flow Feedback (Exhaust) from LCS to Air Data Router (ADR).
- (5) 120V power Required at 20 Amp.
- ii) Aircuity 700 Sensor Suite shall contain the following:
 - (1) TVOC Sensor PN: SEN-TVC-1.
 - (2) Optical Particle Sensor PN: SEN-PAR-1.
 - (3) Dew Point/CO2 Sensor PN: SEN-C2D-3.
 - (4) Variable Volume Exhaust Valve: Phoenix Model EXVB series sized for required flow.
 - (5) Each Sensor suite shall monitor up to 20 Lab spaces (each space 600 FT² max).
 - (6) Each Sensor Suite Shall have on supply Air Reference Probe.
 - (7) Each Sensor suite shall have a vacuum pump HFP100.
- iii) Aircuity Air Data Router (ADR):
 - (1) Each Router shall be mounted in an accessible location without need to enter Lab.
 - (2) Each ADR shall monitor up to four (4) Lab Spaces.
 - (3) Each ADR shall be equipped with EXP2 Expansion Point Module to interface to Lab Control System (LCS).
 - (4) Each ADR shall be networked to other ADR and to the Sensor Suite via Aircuity Structured Cable to deliver air samples to Sensor Suite.
- iv) Probes:
 - (1) In most cases, the general exhaust is the ideal location for the probe to sample the lab air and compare it to the supply air. Probe for duct mounting is DBP200 series.
 - (2) Room sensors can be used if required. The room sensor is the RS200 series.
- b) System Overview:
 - i) Provide Monitoring of all lab spaces.
 - (1) Small Labs (less than 600 ft²) shall have one sensor per lab preferably in General Exhaust Ductwork.
 - (2) Large labs (Greater than 600 ft²) shall have one sensor per every 600 ft² preferably in General Exhaust Ductwork.
 - ii) One ADR (Air Device Router) per every four monitored spaces shall be mounted outside of the lab space in an area that can be accessed.
 - (1) ADR shall have one (1) AO and one (1) AI per lab space for interface to LCS (Lab Control System).
 - iii) Each Sensor Suite shall be equipped with sensors and vacuum pump (HFP100) to pull samples from each space and to compare the samples from the supply air.
 - (1) Sensor suite shall be mounted in an accessible location outside the research space.
 - (2) Access is required on a regular basis as the sensors are changed every six (6) months.
 - (3) Each Sensor suite shall monitor up to twenty (20) Spaces. Additional Sensor suites can be added to the network as required.
 - iv) IMS (Information Management System) shall be mounted near one of the sensor suites.
 - (1) Internet connection required for networking to Aircuity Central Monitoring and Adviser Services.



23 37 13 Diffusers, Registers and Grilles

1. Approved manufacturers are Anemostat, Kruger, Price, Titus, and Tuttle & Bailey.
2. General Requirements:
 - a) Construction Material: Steel, unless noted otherwise. Coordinate material with University Facilities.
 - b) Finish exposed surfaces with baked off-white powder coat unless specified otherwise.
 - c) Furnish frames appropriate to surrounding construction material.
 - d) All return/exhaust registers in the ceiling are to have fixed louvers with a deflection.
 - e) Except as specified below, furnish units with volume control damper in neck, adjustable through face without removal. The following units do not require volume control dampers:
 - i) Transfer grilles.
 - ii) Return grilles into plenum ceilings.
 - iii) Linear slot diffusers.
3. Design criteria as follows:
 - a) Air outlets shall be selected to result in a maximum occupied space velocity of 50 FPM.
 - b) Throws based upon a terminal velocity of 100 FPM, shall not exceed 1/2 the distance between adjacent diffusers or 100% of the distance between the outlet and the wall.
 - c) All units shall be provided with opposed blade dampers.
 - d) Aluminum units shall be installed in wet areas.
 - e) Linear diffusers shall be designed and specified for use at perimeter glass areas in all VAV applications.
 - f) All linear diffusers are to have a minimum of two (2) slot openings. Diffusers located along the room perimeter are to have one (1) opening down and the other angled. Diffusers located in the center are to have both openings angled.
 - g) All supply and return units shall have a maximum neck velocity of 500 FPM.
4. Furnish tools required to change deflection of air outlets or inlets.
5. Accessories:
 - a) Alignment bars for continuous length linears.
 - b) Insulated square to round adapters.
 - c) Insulated linear supply and return air plenums on all sides.
 - d) Continuous length perforated plate, sized for uniform velocity, mounted in plenum above linear diffusers where plenum duct connection has no volume damper and where plenum connections exceed 30 inches on center.
 - e) Blank-Off Plates: Matte black painted. Permitted only on linears where shown.
6. Ductsox:
 - a) Approved manufacturers are Ductsox, Fabricair and KE Fibertec.
 - b) System shall be installed with U-Track suspension system along with SkeleCore IHS consisting of an internal 360-degree hoop system, spaced (5) five foot on center.
 - c) Fabric shall be Verona porous fabric (2 CFM/sq. ft.) with linear vents.



23 38 13 Commercial-Kitchen Hoods

1. The design and installation of commercial kitchen exhaust hoods and associated air, ductwork, and fire suppression components and systems shall be in accordance with the requirements and limitations of the following references and others as required:
 - a) 2018 International Mechanical Code.
 - b) 2018 International Fire Code.
 - c) NFPA 17A, “Standard for Wet Chemical Extinguishing Systems”.
 - d) NFPA 96, “Standard for Ventilation and Fire Protection of Commercial Cooking Operations.
 - e) UL 710, “Exhaust Hoods for Commercial Cooking Equipment”.
 - f) UL “Heating, Cooling, Ventilating, and Cooking Equipment Directory”.
2. Type I hoods shall be installed where cooking appliances produce grease or smoke, such as occurs with griddles, fryers, broilers, ovens, conveyor ovens, ranges, and wok ranges.
 - a) An approved automatic fire suppression system complying with the International Building Code and International Fire Code where Type I hoods are required
 - b) Where fire suppression systems are required under Type I hoods, the system shall be interwired with shunt trip breakers and gas solenoid valves of equipment located below the hood for power and fuel shutoff during system actuation in accordance with NFPA 17A.
 - c) Type I hoods shall be constructed of stainless steel not less than 0.037-inch (20-gauge) thick.
 - d) Type I hoods shall be secured in place by non-combustible supports.
 - e) Ducts serving Type I hoods shall be independent of all other exhaust systems and constructed of steel not less than 0.055-inch (16-gauge) or stainless steel not less than 0.044-inch (18-gauge) thick. Joints, seams, and penetrations, as well as duct-to-hood joints, shall be made with a continuous liquid-tight weld or braze made on the external surface of the duct system.
3. Type II hoods shall be installed where cooking or dishwashing appliances produce heat, steam, or products of combustion and do not produce grease or smoke, such as steamers, kettles, pasta cookers, and dishwashing machines. Refer to the Code for notable exceptions.
 - a) Type II hoods shall be constructed of stainless steel not less than 0.024-inch (24-gauge) thick.
4. Makeup air shall be supplied during the operation of commercial kitchen exhaust systems that are provided for commercial cooking appliances. The amount of makeup air shall be equal to the amount of exhaust air.
5. Following installation, test ventilators serving commercial exhaust hoods for compliance with specified requirements and those of the authority having jurisdiction. Perform testing after air-handling systems have been balanced and adjusted.
6. Smoke Test:
 - a) Perform a smoke test with cooking equipment served by ventilator turned off.
 - b) Perform test with supply and exhaust fans serving the food service kitchen area turned on.
 - c) Move a smoke bomb around the perimeter of cooking equipment at the top surface.



- d) No visible smoke shall escape from the ventilator canopy into the room.
- e) Submit a field-test report indicating the dates and times of tests and certify the test results.

23 38 16 Fume Hoods

1. The design and installation of fume hoods and associated systems shall comply with the Laboratory Design Standard [2024](#). A copy of this Standard & Design Guide is included in Appendix A.
2. Refer to Section 23 31 00, “HVAC Ducts and Casings” and Section 23 33 00, “Air Duct Accessories” for requirements and limitations of ductwork and accessories serving fume hoods.
3. Refer to [Sections 23 34 16, “Centrifugal HVAC Fans” and 23 34 23, “HVAC Power Ventilators”](#) for requirements and limitations associated with fans serving fume hoods.
4. All fume hoods must be properly identified in accordance with the requirements of the Laboratory Design Standard [2024](#) (see Appendix A).

23 41 00 Particulate Air Filtration

1. Water and oil wash systems are **prohibited**.
2. Carbon-type filters are permitted for special applications requiring the removal of gases only after review and approval by the University’s Project Manager or Facilities Management Department.
3. Pre-filters for all packaged air handling equipment shall be V-Bank mini-pleat fiberglass disposable type with pleat separators, polyurethane pack-to frame sealant, polystyrene enclosing frame equal to Camfil Farr Durafil ES filter. Filters are to be arranged for maximum surface area. The maximum filter velocity shall not exceed 400 FPM. Static pressure shall be calculated using the manufacturers recommended maximum. The filter system shall have an average efficiency of 35% (MERV 8) as tested in accordance with ASHRAE Standard 52.2 “Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size”, current edition. A magnahelic gauge to monitor pressure shall be provided. The magnahelic gauge shall be located and oriented to permit viewing without the need for a ladder.
4. Final filters for all packaged air handling equipment shall be V-Bank mini-pleat fiberglass disposable type with pleat separators, polyurethane pack-to frame sealant, polystyrene enclosing frame equal to Camfil Farr Durafil ES filter. Filters are to be arranged for maximum surface area. The maximum filter velocity shall not exceed 500 FPM. Static pressure shall be calculated using the manufacturers recommended maximum. Filters are to be arranged for maximum surface area. The filter system shall have a minimum efficiency of 65% (MERV 11) as tested in accordance with ASHRAE Standard 52.2 “Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size”, current edition. Final filters shall be installed at the discharge of the unit with a magnahelic gauge to monitor



pressure increase. Engineers are to select this filter MERV rating only if the selected equipment cannot handle a MERV 13 filter.

5. Final filters for all 100% outside air equipment shall be V-Bank mini-pleat fiberglass disposable type with pleat separators, polyurethane pack-to frame sealant, polystyrene enclosing frame equal to Camfil Farr Durafil ES filter. Filters are to be arranged for maximum surface area. The maximum filter velocity shall not exceed 500 FPM. Static pressure shall be calculated using the manufacturers recommended maximum. Filters are to be arranged for maximum surface area. The filter system shall have a minimum efficiency of 90% (MERV 13) as tested in accordance with ASHRAE Standard 52.2 “Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size”, current edition. Final filters shall be installed at the discharge of the unit with a magnahelic gauge to monitor pressure increase.
6. HEPA filters shall be installed terminally or at the unit as required.
7. Any deviation from the above standard filters must be submitted to the University’s Project Manager, Facilities Management Department, and EH&RS for review and approval.
8. Sufficient filters to service the equipment for one year, after occupancy by the owner shall be included with all HVAC equipment. Contractor to provide two (2) sets of filters for future use.
9. Replaceable filters shall be fully accessible without the need to move or relocate adjacent components or other items.
10. Contractor to provide one (1) spare set of indicated air filters for each type of equipment required filters.
11. Pre and final filters are to be selected based on a minimum replacement period of three (3) months using Philadelphia air conditions.
12. Flat-type filters for terminal equipment, i.e. fan coil units, blower units, etc. are acceptable by the University.

23 52 00 Heating Boilers

1. All boilers must be equipped with ANSI/ASME CSD-1 controls (NFPA 85 controls for boilers with an input larger than 12.5 million MBH) and be ASME-stamped in compliance with the Pennsylvania Code, latest edition.
2. Application and approved manufacturers:
 - a) Residential and smaller commercial non-condensing cast iron sectional heating boilers (steam or hot water, gas, or oil): Weil-McLain, Peerless Boilers, and HB Smith.
 - b) Large commercial non-condensing domestic hot water generators (gas only – copper fin tube): A.O. Smith Corporation, Camus, RBI, and Lochinvar LLC.
 - c) Large commercial non-condensing boilers, non-domestic hot water generator type (commercial firetube or water tube, gas and/or oil): Cleaver-Brooks, and Superior.



- d) Industrial type boilers (packaged industrial water tube, gas/oil – NFPA 85): Babcock & Wilcox Company, Cleaver-Brooks Nebraska, and Superior.
 - e) Large Commercial condensing domestic hot water generators: A.O. Smith, RBI, Lochinvar, and Camus.
 - f) Large commercial condensing (gas only) boilers, non-domestic hot water generator type: Fulton Endura, Camus Advantus, RBI, Aerco Benchmark, and Lochinvar.
3. Prime Professional is to coordinate with University Facilities regarding equipment integration to the building's BAS system. University Greek and Fraternity Houses require local control.
 4. Heating hot water system temperatures are to reset based on outside air temperatures, at a minimum.
 5. A/E is responsible for identifying and documenting what natural gas pressure and pipe main is locally available at the building with PGW. This information shall be used for determining overall equipment load and pipe sizing. No equipment is to be selected below 4.5-in. w.g., which is PGW's minimum guaranteed system supply.
 6. A clearly marked manually operated remote emergency shutdown switch or circuit breaker shall be located just outside the boiler room door and marked for easy identification. If there is more than one door to the boiler room, there should be a switch located at each boiler room door.
 7. A disconnect means capable of being locked in the open position shall be installed at an accessible location at the boiler. This disconnect shall be an integral part of the boiler or adjacent to it.
 8. A/E shall refer to Items 6 in Section 23 11 23 of this Guide, Facilities Natural Gas Piping, and include as required.
 9. Condensing type boilers are to have a 5-year parts and labor warranty specified by boiler manufacturer. This does not include general maintenance and cleaning.
 10. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, condensing flue gas service. UL-listed vents fabricated from stainless steel must be used with boilers.
 - a) Kit: Boiler manufacturer shall furnish complete system, UL-1738 listed, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
 11. Heating Boilers(s) Local Emergency Manual Shutdown Switch:
 - a) In compliance with ASME Boiler & Pressure Vessel Code – Rules for Construction of Heating Boilers, Section IV, Article 6, provide manually operated remote heating plant shutdown switch or circuit breaker.
 - b) Install it just outside the boiler room door and mark it for easy identification.
 - i) Install the switch just inside the door if the boiler room door is on the building exterior.
 - ii) Provide a switch at each door, if there is more than one door to the boiler room.



12. Install piping from condensing equipment drain connection to a condensate neutralization tank and from the tank to the nearest floor drain. Drain piping shall be at least full size of connection; provide PVC, stainless steel, aluminum, or polypropylene for the drain piping. The condensate is acidic.
13. Boiler Venting & Combustion Air:
 - a) Install flue venting kit and combustion-air intake ductwork. Do not exceed the boiler manufacturer's maximum allowable combined pressure drop of vent and combustion-air systems.
 - i) Pitch flue vent back toward the boiler a minimum of 1/4-inch per foot.
 - ii) Ducted Combustion Air Application: Keep ducting pressure losses to a minimum.
 - b) Connect full size to boiler connections.
14. Performance Tests:
 - a) Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b) Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - c) Perform field performance tests to determine capacity and efficiency of boilers.
 - i) Test for full capacity.
 - ii) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
 - d) Repeat tests until results comply with requirements indicated.
 - e) Provide analysis equipment required to determine performance.
15. A/E to coordinate with item 7 in section 23 11 23, Facilities Natural Gas Piping, for contractor required forms to the City of Philadelphia.

23 57 00 Heat Exchangers for HVAC

1. All heat exchangers shall be constructed in accordance with the ASME Pressure Vessel Code, bear the ASME "U" Stamp and be registered with the National Board of Boiler and Pressure Vessel Inspectors.
2. All heat exchangers shall be rated for 150 PSIG operating pressure at 300°F or 300 PSIG if operating steam pressure is greater than 15 PSIG.
 - a) Steam heat exchangers are to be fitted with a vacuum breaker.
 - b) Automatic control valves for heat exchangers are to be normally closed.
3. All nozzles shall be 150 lb. ASA rated flanges or ANSI Class 300 if the operating steam pressure is greater than 15 PSIG.
4. U-tube heat exchangers shall be used in all steam to hot water applications. Chilled water isolating and condenser water free cooling shall be designed around the use of plate and frame heat exchangers. Where condenser water systems are equipped with heat exchangers, provide 100% redundancy to allow for cleaning without service interruption.



5. U-tube heat exchangers shall be constructed as follows:
 - a) Shell - steel.
 - b) Tubes - 3/4" OD copper with a maximum tube velocity of 7.5 feet per second.
 - c) Heads - cast iron.
 - d) Tube sheets - brass or stainless steel.
 - e) Tube supports - brass or stainless steel.
 - f) Minimum scale factor - 0.002 ft²-hr-°F/btu.
 - g) Maximum water side pressure drop - 12 feet of water.

6. Plate and frame exchangers shall be constructed as follows:
 - a) Plates - type 304 or 316L stainless steel, based on size of plate. Plates shall be equipped with gaskets that do not use adhesive for sealing or attachment (use clip-on type gaskets only).
 - b) Frames - carbon steel with baked epoxy enamel paint.
 - c) Heat transfer coefficient - greater than 1,000 Btu/ft²-hr-°F.
 - d) Future capacity allowance: Size frame and bars for future addition of 30 percent more plants.
 - e) AHRI Certified.
 - f) Basis of design: AlfaLaval and Bell & Gossett.

7. All systems shall be designed to assure adequate service and maintenance clearances for tube pulling and frame dismantling.

23 63 13 Air-Cooled Refrigerant Condensers

1. The use of split-systems and packaged air-cooled units is permitted only under the following conditions:
 - a) Central chilled water is not available, and the space cooling load and layout prohibits the use of an air- or water-cooled chiller system.
 - b) Prior review and approval by the University's Project Manager or Facilities Management Department.

2. The design and location of condensing units must consider the effects of noise, aesthetics, and service access.

3. Equipment installed on rooftops shall comply with the following:
 - a) Must be accessible through a stairway, not a ladder, which directly accesses the roof where the unit is to be located.
 - b) The access door to the roof will be large enough to allow the passage of maintenance equipment and supplies.
 - c) Shall be designed with vibration isolation type curbs to reduce noise and vibration transmission to the structure and occupied spaces.
 - d) Shall be installed at least ten (10) feet from the perimeter of the roof. Any variance in the actual installation location from the intended location must be approved by the Department of Environmental Health and Radiation Safety and Facilities Management.



4. All duct, conduit and piping penetration through the roof shall be installed using prefabricated pipe and duct curbs. The designer is responsible for determining the type of roofing material used, the state of the existing warranty and ascertain that the existing warranty remains in effect after all modifications have been completed.
5. Systems requiring low-ambient operation shall use condenser fan speed controls. Damper systems are not permitted.
6. All split-system units in excess of 2,000 CFM must be designed for economizer operation and have relief provisions during economizer operations.
7. All package rooftop systems shall be equipped with economizers and relief provisions. Units in excess of 5 tons capacity shall use return air fans or powered exhaust.

23 64 16 Centrifugal Water Chillers

1. All chillers above 300 tons shall be of the centrifugal type.
2. Refrigerants used in centrifugal water chillers must be approved by the University [Engineer](#) during the design phase of any project.
3. The maximum energy consumption at full load, 42°F leaving water temperature and 85°F entering condenser water temperature shall be 0.57 kW/ton, [at a minimum](#). Chiller to be selected with the option for operating with a 40°F leaving water temperature.
4. Drawings shall indicate routing of refrigerant relief piping and shall be designed with recovery systems if code mandated.
5. A/E to provide speed controls on chillers to improve part load performance.
6. Where the system design will utilize variable-flow through the condenser and/or evaporator of a centrifugal chiller, the flow through each evaporator, and/or condenser shall be monitored by a flanged, in line, magnetic flow meter of a brand and quality as specified elsewhere in this document.
 - a) Unit control: Hard-wire connection for control of start/stop, water setpoint, demand limiting, etc. Integration system for general monitoring.
 - b) Condenser and evaporator shall be equipped with an Allen-Bradley 836T differential pressure switch with indicator to function as the chiller safety.
7. Preferred manufacturers [are Carrier and Trane](#). A/E to confirm with Facilities Management [and University Engineer](#) for approval of other manufacturers.

23 64 26.13 Air-Cooled, Rotary-Screw Water Chillers

1. Preferred manufacturers [are Carrier \(model 30XV\) or Trane \(model ACR\)](#). A/E to confirm with Facilities Management for approval of other manufacturers. [A/E to provide noise level criteria, which meets or exceeds section J. Noise and Vibration Control](#).



2. The maximum energy consumption at full load, 42°F leaving water temperature and 52°F entering water temperature. Chiller to be selected with the option for operating with a 40°F leaving water temperature.
3. A/E to provide speed controls on chillers to improve part load performance.
4. Where the system design will utilize variable-flow through the condenser and/or evaporator of a rotary-screw chiller, the flow through each evaporator, and/or condenser shall be monitored by a flanged, in line, magnetic flow meter of a brand and quality as specified elsewhere in this document.
 - a) Unit control: Hard-wire connection for control of start/stop, water setpoint, demand limiting, etc. Integration system for general monitoring.
 - b) Condenser and evaporator shall be equipped with an Allen-Bradley 836T differential pressure switch with indicator to function as the chiller safety.

23 65 00 Cooling Towers

1. Preferred manufacturers include Evapco, Baltimore Air Coil, and Marley.
2. All cooling towers shall have the following characteristics:
 - a) Modular cell, induced-draft type with vertical discharge, cross flow, and counter flow arrangements.
 - b) Gear driven fans are preferred. Provide a close-coupled oil sight glass visible from the exterior of the tower on gear driven units. Maintenance and/or inspection of the fan motor and drive assembly shall not require personnel to enter the water distribution plenum.
 - c) Propeller-type fans which are individually adjustable and replaceable.
 - d) Fill, louvers, and drift eliminators shall be constructed of 15 Mil PVC Capable of service up to 125°F and supported by hot-dipped galvanized structural tubing, stainless steel, or non-corroding material. Drift losses shall not exceed 0.005% of the design GPM. Fill shall be elevated above the cooling tower basin to permit cleaning.
 - e) Basins (hot and cold), framework, casing, fan deck and fan cylinder shall be constructed of one of the following options:
 - i) Fiberglass reinforced polyester, stainless-steel, and PVC.
 - f) Design criteria shall be based upon 95°F entering water temperature, 85°F leaving water temperature, and 78°F wet bulb ambient air temperature.
 - g) Provide a steel ladder, ladder extension (length to be within 6 inches of roof), cell partitions, fan cylinder extensions and hot water basin covers. Hot water basin covers shall be hinged to facilitate access.
 - h) The cooling towers shall be located so that the hot water basin is the highest point in the condenser water system. The difference in elevation between the condenser pump impeller and the cold-water basin shall be such that the net positive suction head available entering the pump will be greater than the pump requirements when using a fluid vapor pressure of 14 PSIA.
 - i) Cooling towers shall be located in areas that are fully accessible.
 - j) Tower efficiency shall not be reduced by cosmetic screening.



- k) The location of the tower shall take into consideration the effects of tower noise upon adjacent occupied spaces and consideration of the building's wake and prevailing wind, etc.
 - l) The tower, less motor, shall be warranted for five (5) years.
 - m) Provide a freestanding ladder and platform system with railings to permit maintenance access to the fan motor, fan drive system, inlet basins, outlet dampers, and any other appurtenances that require adjustment or maintenance. The ladder and platform system shall be constructed of structural steel and shall incorporate a lifting device (articulating crane arm, etc.) to facilitate the removal and installation of the fan motor and gear drive.
 - n) Cooling tower fan motors shall be driven by ABB variable speed drives, [refer to Section 26 29 23 for model number and specification](#)
 - o) Cooling towers will have vibration switches in the fan control circuit.
 - p) Stainless steel cooling tower sump screens are to be provided.
 - q) Freeze protection in basins for winter operation.
3. Unit control via BAS system.
 4. Provide sound attenuation around exterior motor to direct motor noise up. Attenuation to be designed based on the following:
 - a) Do not restrict airflow around the motor.
 - b) Do not impact the motor shaft.
 - c) Waterproof housing.
 - d) Easily removable for maintenance accessibility.
 5. Ion pitch non-chemical descaler equipment to be incorporated in the condenser water system serving the chilled water system. Refer to Item 11 in Section 23 25 00 of the design guide for manufacturer and specification.

23 72 00 Air-to-Air Energy Recovery Equipment

1. A/E is to determine which type and/or combination of equipment below is to be used for the project.
2. Wheels:
 - a) Preferred manufacturers are Airxchange Inc., Novel Aire Technologies, FlaktGroup Semco, and Thermowheel.
 - b) Wheels are not allowed in equipment receiving exhaust air from laboratories.
 - c) Unit accessories:
 - i) Media shall have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E84.
 - ii) Media shall be sealed with an acid type resistant coating, coated with antimicrobial agent, and have bacteria-static properties.
 - iii) Media shall be washable.
 - iv) Purge section shall be factory set with limited cross contamination.
 - v) Rotor assembly shall be structurally designed to allow the wheel to freely rotate, withstand the air pressure, and field replacement.
 - vi) Frost prevention shall be controlled by the BAS vendor.



- vii) All controls are to be the BAS vendor.
 - viii) Contractor to ensure wheel(s) are free to rotate prior to air balance testing.
3. Heat Pipe:
- a) Preferred manufacturer is Heat Pipe Technology. A/E to confirm with Facilities Management for approval of other manufacturers.
 - b) Unit accessories:
 - i) Coils as per section 23 82 16, Air Coils, of the design guide.
 - ii) All controls are to be the BAS vendor.
 - iii) A/E to coordinate the slope of the heat pipe assembly to ensure maximum heat transfer.
 - iv) Design shall meet ASHRAE Standard 34, current edition, at a minimum.
4. Glycol Wrap Around Loop:
- a) Unit accessories:
 - i) Coils as per section 23 82 16, Air Coils, of the design guide.
 - ii) All controls are to be the BAS vendor.

23 74 13 Packaged, Outdoor, Central-Station Air-Handling Units

1. Preferred manufacturer and model for rooftop air handling units is Trane IntelliPak or approved equal and approved by the University Facilities.
2. Unit must include communication card ([Lon/BACnet MS/TP/Modbus](#)) to allow for direct BAS control.
3. Refer to Section 23 82 16 “Air Coils” for design standards relating to coils integral with air handling units.
4. All units must be floor-mounted within Mechanical Rooms or be semi-custom rooftop units. Any necessary deviation from this standard dictated by site conditions must be reviewed and pre-approved by the University’s Project Manager or Facilities Management Department.
5. Equipment installed on rooftops shall be installed at least ten (10) feet from the perimeter of the roof. Any variance in the actual installation location from the intended location must be approved by the Department of Environmental Health and Radiation Safety and Facilities Management. University approval of equipment installed within ten (10) feet from the perimeter of the roof does not relieve the Contractor from the responsibility of complying with Code requirements regarding the provision of appropriate guards at the perimeter of the roof (Currently, section 1013.5 of the 2018 International Building Code).
6. Each air handling unit must be provided with a pre-filter section(s) and final filter section (where required), capable of housing the filters specified in Section 23 41 00. The ATC subcontractor shall provide all control dampers (outdoor and return air). All dampers shall be fully accessible for lubrication.



7. Units shall have the following construction features:
 - a) Reinforced insulated double wall galvanized steel or aluminum panels, with interior perforated steel.
 - b) Removable access panels. Access panels more than 40 lbs. or 3-foot x 6-inches in size shall be hinged, gasketed and provided with non-locking lever type handles.
 - c) Filter section access doors shall be hinged.
 - d) Drain pans shall be double-wall and constructed of welded stainless steel with 1-inch, 3/4 lb. insulation sandwiched between the pans. Cross break and pitch to threaded drain connections. Provide stacked cooling coils with drip pans and drain connections to main drain pan, main pan to be sized for all drain pan loads. Extend drip pans 3 inches from entering air side of coil face and 6 inches from leaving air side of coil face.
 - e) Coil sections shall be provided with tracks extended the full length of unit to provide for the easy removal of all coils.
 - f) Fans shall be double width, double inlet centrifugal type fans. The Engineer shall select the most efficient fan available (i.e. airfoil, forward curved, backward inclined).
 - g) Low-pressure fans shall be used for duties of up to 3" of total static pressure. Medium and high-pressure fans shall be used for systems with total static pressures between 3" and 6".
 - h) Fan bearings are to be self-aligning, pillow block, re-greasable ball bearings rated for an average life of L10/200,000 Hrs. All units shall be provided with extended lubrication lines to allow lubrication from the exterior of the unit.
 - i) Fan shafts and fans shall be rated for continuous operation and shall be statically and dynamically balanced in all planes. Fan drives shall be selected for a 1.2 service factor.
8. All units 5,000 CFM and larger must be provided with a return air fan. The return air fan can be a centrifugal fan set, integral or independent cabinet fan, or axial type fan and must be mounted to permit servicing without the use of a ladder. Units which are not floor mounted and are mounted in excess of six feet above the floor must be provided with stable catwalks constructed of structural grade steel and steel grating. Access ladders shall be integral with the catwalk.
9. Units serving variable air volume systems shall be fitted with variable frequency drive packages as manufactured by ABB, [refer to Section 26 29 23 for model number and specification](#). Inlet vanes, discharge dampers, eddy current drives, etc. are not permitted.
10. All damper motors and actuators shall be located outside of the unit casing. Provide NEMA rated enclosures or NEMA rated actuators for outdoor locations.
11. The Engineer will ascertain that adequate service space exists for the removal of coils, fans, fan shafts etc. without disturbing surrounding equipment.
12. Field erected air handling units must meet the above requirements and shall be constructed in accordance with SMACNA standards. Integral unit fans or independent fan sets may be used.
13. The Engineer will review the noise and vibration levels of the units and provide isolation equipment as required to meet the levels in General Section G "Noise and Vibration Control."



14. Safety control components such as fire stats, smoke detectors and/or smoke dampers shall be provided per code requirements.
15. Central station units shall be designed to function as a smoke removal system in all buildings required by code to contain such.
16. All doors on air handling units are to open outwards. Manufacturer is to provide necessary door gaskets and handles to create an airtight seal.

23 74 33 Dedicated Outdoor-Air Units

1. Preferred manufacturers are Air Flow Equipment, AnnexAir, Munters Corporation, Nortek Air Solutions, [Trane Horizon](#), and Reznor.
2. Unit accessories:
 - a) Coils as per section 23 82 16, Air Coils, of the design guide.
 - b) Filters as per section 23 41 00, Particulate Air Filtration, of the design guide.
 - c) Air to air energy recovery equipment as per section 23 72 00, Air-to-Air Energy Recovery Equipment, of the design guide.
 - d) Bypass around to air energy recovery equipment.
 - e) Service corridor with two entrance doors on opposite ends, if possible.
 - f) All controls are to be the BAS vendor.
 - g) A/E to review selections with Owner prior to creating construction documents.

23 75 13 Custom-Packaged, Outdoor, Central-Station Air-Handling Units

1. Preferred manufacturers are Air Enterprises, Buffalo Air Handling, Energy Labs Inc., Haakon Industries, Ingenia Technologies, Nortek Air Solutions, TMI Climate Solutions, and Ventrol Air Handling Systems.
2. Unit accessories:
 - a) Cabinet thickness: 2-inches for airflow up to 20,000 CFM and 4-inches for airflow at and above 20,000 CFM.
 - b) Cabinet Construction: Outdoors shall be aluminum and indoors shall be painted galvanized.
 - c) Insulation: Foam or fiberglass.
 - d) Factory Testing: A/E to provide criteria based on project basis.
 - e) Coils as per section 23 82 16, Air Coils, of the design guide.
 - f) Filters as per section 23 41 00, Particulate Air Filtration, of the design guide.
 - g) Air to air energy recovery equipment as per section 23 72 00, Air-to-Air Energy Recovery Equipment, of the design guide.
 - h) Bypass around to air energy recovery equipment.
 - i) Service corridor with two entrance doors on opposite ends, if possible.
 - j) All controls are to be the BAS vendor.
 - k) A/E to review selections with Owner prior to creating construction documents.



23 81 23 Computer-Room Air-Conditioners

1. Mainframe computer rooms shall be equipped with space-mounted down discharge, top return air opening, chilled water units. Where chilled water is not available year-round, air-cooled and glycol units may be required to provide 24/7/365 cooling. The units shall be installed on raised floors and be capable of maintaining space temperature and humidity within 1°F and 2-1/2% RH of set point. Units shall be manufactured by Liebert with the following components:
 - a) 1-inch of 1.5-lb. fiberglass insulation.
 - b) 1,750 RPM motors.
 - c) Fan bearings designed for a minimum average life of 100,000 hours.
 - d) Serviceable filter sections which can be accessed without shutting off unit.
 - e) Microprocessor based electronic control system.
 - f) Infra-red self-cleaning humidifiers with stainless steel evaporator pans, water safety shut-offs and overflow alarm system.
 - g) Automatic start-up after power failure shutdown.
 - h) Alarm system to monitor system-operating characteristics.
2. Design the air conditioning systems in multiple units such that space temperature and humidity levels can be maintained in the event of the loss of 50% of the available units up to a maximum of three (3) units, whichever is the most stringent.
3. Units are to be integrated into the building's BAS system. A/E is to coordinate with Liebert representative to provide additional equipment and software as required to provide a fully functional system.
4. Air conditioning unit cooling coil condensate drainage shall be designed for gravity discharge. Where condensate needs to be lifted, use a Little Giant condensate pump and locate the pump outside of the room. Provide a duplex outlet for the pump.

23 81 26 Split-System Air-Conditioners

1. Approved manufacturer is Liebert. Mitsubishi, Sanyo and Daikin manufacturers will need to be reviewed and accepted by Facilities prior to design.
2. Air conditioning unit cooling coil condensate drainage shall be designed for gravity discharge. Where condensate needs to be lifted, use a Little Giant condensate pump. Provide a duplex outlet for the pump. If unit is used for an IT closet the pump is required to be outside the room.
3. Provide a wall mounted wireless controller for the air conditioning unit.
4. Condensing units will be sized for ambient air temperature of 95°F db/78°F wb when located on grade and 105°F db/80°F wb when located on roof.
5. Split DX systems that will be operated during ultra-low ambient conditions (<40°F, i.e. Server rooms or Tele/Data Closets) shall be equipped with both hot gas bypass and head pressure control.



- a) Provide DX for small IT systems.
- b) Provide glycol system for large IT systems.
6. Refrigerant piping shall be sized based on the approved manufacturer, routing, load, number of fittings, etc. Contractor shall not base the pipe size solely on the contract drawings.
7. Equipment for larger IT systems shall be selected with heating options.
8. Equipment shall be provided with EC motors.
9. A/E to coordinate with University Facilities and IT Manager to determine if dehumidification control, i.e. refrigerant based, hot gas reheat coil, etc., is required in IT room equipment.

23 81 46 Water-Sources Unitary Heat Pumps

1. Preferred manufacturer and model for water source heat pumps is ClimateMaster, Tranquility 30® Two-Stage Series (horizontal or vertical), ClimateMaster, Tranquility Modular (TRM) Series (vertical stacked), or Cold Point Corp/Adirondack Air, Model GET (vertical stacked). Deviation from these manufacturers and models requires approval from University Facilities.
2. Coordinate layout and installation of water-source heat pumps and suspension components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system components, and partition assemblies. All manufacturer-recommended service clearances shall be maintained.
3. Units shall be specified to be furnished with building-standard controls (Andover or Automated Logic) installed at the factory, for large-scale projects. Field installation on small-scale projects is allowed. Room sensors shall be provided by the building controls manufacturer.
4. Factory-installed safeties shall include:
 - a) Antirecycle timer.
 - b) High-pressure cutout.
 - c) Low-pressure cutout or loss of charge switch.
 - d) Internal thermal-overload protection.
 - e) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35°F (2°C).
 - f) Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
5. Units shall be furnished with manufacturer's hose kits:
 - a) Hose kits shall be designed for minimum 400 psig working pressure, and operating temperatures from 33°F to 211°F. Tag hose kits to equipment designations.
 - b) Hose length shall be 36 inches. Minimum diameter shall be equal to water-source heat-pump connection size.
 - c) Isolation Valves: Two-piece bronze-body ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is



- combination shutoff type with memory stop, the isolation valve may be omitted on the return.
- d) Provide a wye-type strainer with blow down valve in supply connection.
 - e) Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.
 - f) Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.
6. All piping and electrical conduit shall be installed to not restrict access for service and maintenance purposes
 7. Units shall be provided with the manufacturer's standard form in which the manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within five years from date of Substantial Completion. Failures include, but are not limited to, refrigeration components.
 8. A/E to include the UltraQuiet package, or approved equal, option for sound sensitive spaces.

23 82 14 Chilled Beams

1. Deviations from the requirements listed in this section require University Facilities concurrence in writing.
2. When chilled beams are used throughout the building or at least most areas, the vapor barrier is critical for the building exterior. (If they are used in just limited areas, then the vapor barrier is indispensable around those specific areas.)
3. Chilled beams are to be in conformance with manufacturer's recommendations. Many of the selection programs will check the layout to verify that air velocities and expected temperature gradients are all within acceptable range.
4. Chilled beams are to be supported from structure with straps, hangers, or uni-strut. Support via ceiling grid is not applicable.
5. A/E to confirm supply air temperature to active type chilled beams and coordinate with chilled beam manufacturers provided in specifications. Some chilled beams have the capability of going as low as 55°F, while others require a room temperature of 72°F (neutral air temperature).
6. Static air pressure drop to be below 0.5 inches and noise level below NC 30 (NC 25 is better and normally very achievable with the proper selections) with acoustical testing in accordance with ANSI S12.51.
7. Water pressure drop to be below 10 feet and flow velocities not to exceed 4 fps.



8. Supply air ductwork can be connected in series up to two (2) chilled beams for some manufacturers, three (3) chilled beams with others. A/E to coordinate selections and connections with approved chilled beam manufacturers provided in specifications.
9. Coordinate locations and layout of chilled beams versus heat producing equipment or exhaust hoods if present. Chilled beam layouts shall not compromise light fixture distribution.
10. Supplemental supply air devices, if present, should not blow directly into supply air from the chilled beams.
11. Provide “wing walls” to chilled beams located in areas with exposed structure (no ceiling). Product shall be a manufacturer accessory.
12. Locate returns/exhausts in line with the ends of the chilled beams, if possible.
13. Provide a separate chilled water supply branch to each zone of temperature control, with an automatic valve, strainer, and isolation valve. The return branch should have a circuit setter and isolation valve. Automatic valve shall be integrated with BAS.
14. Waterside should always have individual connections for each chilled beam.
15. Each individual chilled beam should have a circuit setter, and branch circuits isolation valves.
16. Automatic controls are to be in place to maintain a chilled water temperature 3°F above dew point, with mixing valve. A humidity sensor doesn’t need to be installed in all spaces, however, a sampling of typical spaces or at least one of each type of space. The BAS needs to calculate dew point after measuring RH.
17. A reverse return loop is not that critical provided that balancing valves are provided where required.
18. Provide condensation sensors as a backup in case the BAS sequences fail. Sensor by Consense Corp. model CG-ICM-P or approved equal.
19. When rooftop air handling units provide different summer and winter supply air temperatures, all chilled beams are to be a four (4) pipe configuration.
20. Access to all chilled beam serviceable components (filters, valves, etc.) must be provided.
21. Where chilled beams are located near outside doors and operable windows, they must have condensate drains piped to drain.
22. Approved manufacturers are Trox, Semco, Titus, Price, Kruger and Dadanco. Confirm the chilled beam layout based on all approved manufacturers.



23 82 16 Air Coils

1. This section applies to all DX, chilled water, hot water and steam coils.
2. The design characteristics of the coils shall be as follows:
 - a) Maximum face velocity:
 - i) Central air handling unit coils: 500 FPM.
 - ii) Duct mounted hot water heating coils: 700 FPM.
 - iii) Duct mounted cooling coils: 500 FPM.
 - b) Minimum & maximum tube velocity (hot & chilled water): 2 FPS minimum, 8.5 FPS maximum and piping shall be sized to limit pressure drop to 4 ft. w.c. per 100 feet of equivalent pipe.
 - c) Maximum water side pressure drop: 15 ft. of water.
 - d) Maximum air side pressure drop:
 - i) Central Units:
 - (1) Heating coils: 0.50".
 - (2) Cooling coils: 1.50" (wet).
 - ii) Duct-mounted:
 - (1) Heating coils: 0.25".
3. DX coils rated above five (5) tons shall use a thermostatic expansion valve in lieu of capillary tubes or orifices. Below five (5) tons either method is acceptable. If equipment requires a VFD compressor, provide an electronic expansion valve.
4. Preheat coils, if used, shall be of the steam or hot water type in all applications and are mandatory in all applications resulting in a mixed air temperature below 50°F. Preheat coil Basis of Design is to be Cooney Freeze Block.
5. All coils shall be installed in a counter flow arrangement. All coils shall be ARI Standard 410 certified, factory tested with air at 325 PSIG and rated for a 250 PSIG operating pressure up to 300°F.
6. Coils shall be constructed of the following materials:
 - a) Primary Surface - Tubes - minimum 5/8" OD copper with die formed return bends silver soldered to the tubes. Tubes shall be expanded to form a mechanical bond with the secondary surface fins. Minimum tube thickness to be 0.025" for duct mounted coils and 0.035" for equipment mounted coils.
 - b) Secondary Surface - Fins - Die-formed aluminum fins designed to minimize carryover. Fins are to be spaced 10 per inch maximum, maximum fin length to be 10 feet per section and maximum fin height to be 42 inches. Thickness minimum to be 0.008".
 - c) Headers: Seamless copper tubing silver soldered to tubes. Connections shall be of red brass with male pipe threads, silver soldered to the headers. Each header shall contain a 1/4" FPT vent and a 1/4" FPT drain tapping. Connection to headers shall be arranged for counter-flow operation supply connections on the bottom and return connections at the top. Provide all water coils with two (2) headers ("Contractor's Coil"). Provide air vent at top and drain at the bottom.



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- d) Casing: Stainless steel suitable for stacking coils with end tube sheets to support tubes. All coils with finned lengths 60" or greater shall be provided with intermediate tube supports. Casing channels shall be free draining without depressions which may collect water or contaminants. Steam and hot water coils shall be provided with galvanized steel castings.
 - e) Maximum continuous rows: 12 rows.
 - f) DX coils shall be factory dehydrated and sealed prior to shipment.
 - g) Chilled water (non-glycol), hot water, and steam coils to be equipped with Cooney Freeze Block Technology:
 - i) Expansion header that is tied into every return bend.
 - ii) Combination pressure and temperature brass inline relief valve attached to each expansion header.
 - iii) Wind tunnel and climate room tested with AHRI certification.
 - iv) 30-month guarantee against any freeze related damage to coil. Guarantee shall cover repair of existing or supply of a replacement coil.
7. Coil capacity schedules shall be included in the drawings and list the following:
- a) Number of rows and fin spacing.
 - b) Entering and leaving conditions (DB & WB in cooling applications).
 - c) Airside pressure drop.
 - d) Entering and leaving water temperatures.
 - e) Water pressure drops.
 - f) Airflow in CFM and face velocity.
8. Engineering Professional is to obtain actual facility water temperatures during design. If actual water temperatures cannot be obtained, then design water temperature difference shall meet the following minimums:
- a) Chilled water: 12-15°F.
 - b) Hot water: 30°F.
9. All heating and cooling coils will be equipped with inlet and outlet temperature and pressure gauges, drain valve, and vent or vacuum break, as required.
10. During the design phase the A/E will confirm the steam and chilled water coils are installed at an appropriate height to allow for the associated trap.
11. Approved manufacturers per system type:
- a) Steam integral face and bypass heating coils:
 - i) LJ Wing.
 - ii) Aerofin.
 - iii) Marlo.
 - b) Chilled and Heating Hot Water Coils:
 - i) Cooney Coil.
 - ii) LJ Wing.
 - iii) Aerofin.
 - iv) Heatcraft.
 - v) Trane.



23 82 19 Fan Coil Units

1. Basic unit components:
 - a) Fan speed controller. Select fans at medium speed.
 - b) Unit mounted disconnect.
 - c) Tamperproof, positive-locking, quarter turn fasteners at access door for vertical units.
 - d) Insulation and adhesive shall have maximum flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with ASTM E84.
 - e) Drain pan: Stainless steel, extending full length and width of coil(s); pitch for positive drainage. Coat all sides of pan with fire-retardant, closed-cell foam insulation. Provide pan extension at coil header end of unit and underneath piping package, if required.
 - f) Filters: One-inch-thick throw-away type. Coordinate filter pull direction with ductwork and piping.
 - g) Cabinet construction: A/E to specify gauge, paint finish, pedestal, etc.
 - h) Outside air intake with damper. If a replacement adjust the location to match existing.
 - i) Cabinet piping extension: A/E to specify if required.
2. BAS to provide temperature controller, fan speed control switch, outside air sensor, and control valves. Enclosure must be included with sufficient room to mount the BAS controller.
3. Basis of Design manufacturer to be Trane. Acceptable manufacturers are Nailor Industries and International Environmental Corporation.

23 82 36 Finned-Tube Radiation Heaters

1. All finned tube is to be commercial grade, extend wall to wall unless otherwise noted, seamless copper tube permanently bonded to aluminum fins, wall brackets/backplate.
2. Approved manufacturers are Runtal, Sterling, or approved equal.

23 82 39 Unit Heaters

1. Steam and hot water type:
 - a) Approved manufacturers are Modine, Sterling, McQuay, and Vulcan.
 - b) Casing to be 20-gauge steel with baked enamel finish.
 - c) Coil to be a single row, plate or serpentine aluminum fins on copper tubes, factory tested at 150-psi steam.
 - d) Motor to be single speed, TEFC type with thermal overload protection, resilient mounted with Class B windings.
 - e) Fan to be aluminum blade, steel hub, statically and dynamically balanced.
 - f) Guard to be welded steel, zinc plated.
 - g) Louvers to be aluminum or steel, individually adjustable type.
 - h) Control to provide integral thermostat to cycle fan.
2. Gas fire type:
 - a) Approved manufacturers are Modine, Sterling, McQuay, and Vulcan.
 - b) Casing to be 20-gauge steel with baked enamel finish.



- c) Heating Element to be vertical flues; cast iron or corrosion resistant steel. Use ribbon type burner of cast iron or alloy.
 - d) Motor to be single speed, TEFC type with thermal overload protection, resilient mounted with Class B windings.
 - e) Fan to be aluminum blade, steel hub, statically and dynamically balanced.
 - f) Guard to be welded steel, zinc plated.
 - g) Louvers to be aluminum or steel, individually adjustable type.
 - h) Controls to be factory mounted automatic controls wired to junction box. Features:
 - i) Electric main burner gas valve.
 - ii) Pilot safety-control valve arranged for 100 percent safety shutoff.
 - iii) High limit temperature control, space thermostat, gas pressure regulator and manual gas shutoff valve.
 - i) Thermostat mounted 10 inches below unit to cycle fan and burner.
 - j) A/E is responsible for identifying and documenting what natural gas pressure and pipe main is locally available at the building with PGW. This information shall be used for determining overall equipment load and pipe sizing. No equipment is to be selected below 4.5 in. w.g., which is PGW's minimum guaranteed system supply.
3. Electric type:
- a) Approved manufacturers are Modine, Qmark, and Brasch.
 - b) Fabrication:
 - i) Type to be vertical or horizontal, supported by hanger rods from building structure or with wall bracket and swivel attachment assembly.
 - ii) Casing to be formed steel housing.
 - iii) Air Flow Design to be draw-through or blow through type.
 - iv) Fan to be propeller type, properly secured to motor shaft for direct drive. Statically and dynamically balanced at factory.
 - v) Motor to be single speed, TEFC type with thermal overload protection, shaded pole, permanently lubricated ball bearings requiring no oiling.
 - vi) Discharge Louvers to be steel, individually adjustable for air distribution.
 - vii) Electric Heating Bank to be clad steel sheathed with aluminum fins.
 - viii) Power and Controls to be voltage and phase are to be confirmed with existing conditions or as required for new work.
 - ix) Unit heater shall be UL listed and meet NEC requirements.
 - x) Equip unit heaters with control compartment with electric heat contactors and fuse protection.
 - xi) Control to be provide integral or remote stat to cycle fan.

23 84 13 Humidifiers

1. Humidifiers shall be of the jacketed dry steam or self-contained steam types. Steam grid, pan, wetted drum, air atomizing and power wetted element humidifiers are **prohibited**. Infrared pan type humidifiers are allowed in self-contained Computer Room units only.
2. All humidifiers shall use a steam dispersion manifold located in the main duct, branch duct or within the control unit to evenly dispense steam into the air stream. A normally closed steam control valve shall be used to control the humidifier output via a space humidity sensor wired



in series with a duct-mounted high limit controller. A second blocking steam control valve shall be provided in the steam line entering the humidifier. The valve shall close when the system shuts down and when the outside air conditions do not require humidification.

3. The central steam system may be used as a humidification source and can be directly dispersed into the air stream.
4. All steam humidifiers shall operate with low-pressure steam (less than 15 PSI).
5. Freestanding space humidifiers are **prohibited**.
6. Jacketed dry steam shall contain the following components:
 - a) Steam jacketed dispersion tube.
 - b) Steam separator.
 - c) Separating baffle.
 - d) Steam trap.
 - e) Control valve.
 - f) Final steam separator.
 - g) Re-evaporation chamber.
 - h) Noise attenuator.
7. Self-contained humidifiers shall be of the electrode steam generator type and contain the following:
 - a) Disposable cylinders.
 - b) Microprocessor controls.
 - c) Automatic cylinder fill and drain controls to maintain water conductivity and minimize energy waste. Built-in timers for repetitive drain cycles are **prohibited**.
 - d) Cylinder monitor to discern end of cylinder life.
 - e) 16-gauge steel cabinet with hinged and lockable access door.
 - f) Fill cup to prevent back-siphonage.
8. Designer shall review the control of all humidifiers to ascertain that system response can meet or exceed expected load variations and maintain desired humidity levels.
9. Minimum winter season humidity levels must be maintained which meet indoor air quality standards.
10. The location of humidifiers shall generally be restricted to Mechanical Rooms. Applications which require individual humidifiers which discharge vapor into the duct system serving the space must be provided with watertight sheet metal pans piped to the nearest drain.
11. Approved manufacturers are Armstrong, Dri-Steem, Nortec and Carel.
12. A/E shall confirm the steam and condensate piping connections to the Basis of Design manufacturer and model are equivalent to the substituted manufacturers.
13. Humidifiers located in AHU's shall be sized to cover the entire heating coil section.



XV. DIVISION 25 – INTEGRATED AUTOMATION

25 00 00 Integrated Automation

1. A/E is to coordinate with University Facilities during design phases to provide a complete Building Automation System (BAS) points list for each piece of equipment, VFD, etc. on the project.
2. A/E is to coordinate with BAS Contractor during all design phases to ensure a complete design and compliance with this Guide.
3. BAS system design and components are to be industry proven and widely accepted practices/equipment.
4. Prime Contractor is required to contract with the BAS Contractor directly. Contracting the BAS Contractor under Division 23 is **prohibited**.
5. Prime Contractor is to award the BAS contract in the same timeframe as the award of contracts to Divisions 22, 23 and 26, etc.
6. All systems more than 7-1/2 tons (packaged and split type included) shall be controlled via a pneumatic/electronic control system interfacing with the existing campus central control systems. DDC control must be supplied by Andover Controls/Schneider Electric or Automated Logic Controllers for University City Campus and Johnson Controls for Center City Campus or Siemens for Queen Lane Campus.
 - a) Andover Controls/Schneider Electric: The Tri-M Group, LLC (Rob Koenig, 610-496-4885).
 - b) Automated Logic: Ecosave Automation, Inc. (Jason George, 215-284-9702).
 - c) Johnson Controls: (James Pellegrino, 215-290-6351).
 - d) Siemens: (John Wiese, 215-668-1438).
7. It is the University's intent to limit controls system to one type per building. In the case of new buildings or complete removal and upgrade of existing control systems, either Andover Controls/Schneider Electric or Automated Logic would be acceptable. In the case of an extension of, or addition to, an existing control system (from one of the vendors listed in item 6 above), the new components shall be from the same manufacturer as the existing system. Project documentation should be project-specific and written to avoid any ambiguity regarding which controls manufacturer is acceptable.
8. All new equipment is to be provided with software and hardware necessary for University Facilities to have the ability to troubleshoot and/or configure any field equipment. Equipment manufacturer is to provide software and hardware as part of closeout package.
9. All required sensors and devices are to be included in a BAS building installation for stand-alone controlled operation. The BAS should operate without requiring outside network input(s).



10. The following is a list of **prohibited** installations:
 - a) Refer to part 1.k under Division 23 for additional **prohibited** items.
 - b) BACNet IP communication. BAS system may utilize BACnet MS/TP for communication to field equipment.
 - c) Automation or Control System brands other than Andover Controls/Schneider Electric or Automated Logic for University City Campus, Andover Controls/Schneider Electric for the Academy of Natural Sciences, and Johnson Controls or Siemens for non-University City Campuses.
 - d) Campus Ethernet-based interfaces to field equipment (use Modbus RTU or similar direct-wired interface such as BACnet MS/TP). Any field equipment that only supports BACnet IP must be converted to BACnet MS/TP.
 - e) Network interfaces to field equipment utilized for necessary control functions (start/stop, current limit, set points, operating mode, etc. – use hard-wired control points only).
 - f) Stand-alone controls where a BAS is available.
 - g) HVAC paddle-type flow switches (use differential pressure or electronic flow switches).
 - h) Paddle wheel (turbine) flow meters.
 - i) Non-“Hot-Tap” insertion flow meters (use magnetic meters only).
 - j) Airflow measuring devices other than multi-point thermal dispersion or Pitot traverse stations are selected and installed in compliance with AMCA Standard 203.
 - k) Wireless control elements, i.e. valves, dampers, relays, etc.

25 05 48 Vibration and Seismic Controls for Integrated Automation

1. A/E to determine if vibration and seismic controls are required for the project.
2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

25 08 00 Commissioning of Integrated Automation

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the integrated automation systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power and fire alarm connections to the integrated automation equipment.
 - b) Prior to completion of installation, submit “System Verification Checklists” to Engineer of Record and Owner for review.
 - c) Verify proper installation and performance of all integrated automation devices provided.
 - d) Complete System Verification Checklists and manufacturer’s pre-start checklists prior to scheduling acceptance and operating tests.



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- e) Provide an integrated automation system technician to assist during functional performance testing.
 - f) Participate in the functional performance tests as required to achieve design intent.
 - g) Participate in O&M Training as required by project specifications.
 - h) Provide an HVAC and BAS system technician to assist during functional performance testing.
 - i) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - j) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - k) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
 - l) Provide written certification documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the Integrated Automation Trade Representative re-certifying that he has inspected the work and that it has been completed and functioning as designed. This certification must be submitted prior to the final verification.
 - m) Provide set of record as-built drawings to the Engineer of Record for inclusion into record documents.
3. Functional Performance Tests:
- a) Each major system will be tested. This will be coordinated and witnessed by the Owner. Witnessing the functional performance tests will serve as a compliment to the O&M Training. No tests will be performed until the system and related subsystems have been started and documented through point-to-point checklists and other documentation.
4. Owner Orientation and Training:
- a) The installing contractor shall provide the Owner comprehensive training in the understanding of the systems and operation and maintenance of each major piece of equipment.
 - b) The installation contractor or manufacturer's representative will provide the training. This training should include **firsthand** operational training. The Owner may choose to videotape this training for future use.
 - c) The training shall include start-up, operation in all modes possible, shutdown and any emergency procedures.
 - d) The manufacturer's representative shall provide instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Qualified service engineers employed by the manufacturers, or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed. The start-up and shutdown modes of operation shall be demonstrated. Emergency operations shall be demonstrated.



- e) The Contractor shall attend all sessions and shall add to each session any **specific** information relating to the details of installation of the equipment as it might impact on the operation and maintenance.

25 12 00 Integrated Automation Network Gateways

1. Air Handling Unit (AHU) and Roof Top Air Handling Unit (RTU):
 - a) The following hardwired I/O points are required for each. Network interfaces must not be used for the items listed below:
 - b) Analog (4 to 20 mA, 0 or 2 to 10 VDC) inputs to the BAS from the AHU and RTU:
 - i) Filter Differential Pressure (each back of filters – via differential pressure transmitter).
 - ii) Outside Air Humidity.
 - iii) Outside Air Temperature (one per building).
 - iv) Outside Air Airflow Station (one per building).
 - v) Mixed Air Temperature.
 - vi) Return Air CO₂.
 - vii) Return Airflow Station.
 - viii) Return Air Humidity.
 - ix) Return Air Temperature.
 - x) Return Air Fan VFD Feedback (speed).
 - xi) Supply Airflow Station.
 - xii) Supply Air Humidity.
 - xiii) Supply Air Temperature. (Upstream of reheat coil, if required).
 - xiv) Supply Air Temperature. (Downstream of reheat coil, if required).
 - xv) Supply Air Static Pressure Sensor.
 - xvi) Supply Air Fan VFD Feedback (speed).
 - c) Analog (4 to 20 mA, 0 or 2 to 10 VDC) outputs from the BAS to the AHU and RTU:
 - i) Exhaust Air Damper.
 - ii) Mixed Air Damper.
 - iii) Outside Air Damper.
 - iv) Return Air Fan VFD Speed.
 - v) Supply Air Fan VFD Speed.
 - vi) Chilled Water Coil Control Valve.
 - vii) Heating Hot Water Coil Control Valve.
 - viii) Heating Reheat Hot Water Coil Control Valve (if required).
 - ix) Humidifier Control Valve.
 - d) Digital (contact closure) inputs to the BAS from the AHU and RTU:
 - i) Fire Alarm Return Air Smoke Detector (independent of supply duct detector and general fire alarm – coordinate with fire alarm contractor).
 - ii) Fire Alarm Supply Air Smoke Detector (independent of return duct detector and general fire alarm – coordinate with fire alarm contractor).
 - iii) Return Air Fan VFD Alarm/Fault.
 - iv) Return Air Fan VFD POR.
 - v) Supply Air Fan VFD Alarm/Fault.
 - vi) Supply Air Fan VFD POR.
 - vii) Freezestat Alarm.



- viii) High Supply Static Pressure Alarm.
 - ix) Low Return Static Pressure Alarm.
 - x) Isolation Damper End Switch Alarm/Fault (for 100% make-up units).
 - e) Digital (contact closure) outputs from the BAS to the AHU and RTU:
 - i) Return Air Fan VFD Start/Stop.
 - ii) Supply Air Fan VFD Start/Stop.
2. Chiller – Air or Water Cooled:
- a) The following hardwired I/O points are required for each chiller. Network interfaces must not be used for the items listed below:
 - b) Analog (4 to 20 mA, 0 or 2 to 10 VDC) inputs to the BAS from the chiller:
 - i) Running Load Amps, %.
 - ii) Entering Evaporator Water Temperature.
 - iii) Leaving Evaporator Water Temperature.
 - iv) Entering Condenser Water Temperature.
 - v) Leaving Condenser Water Temperature.
 - vi) Evaporator Water Flow from Magnetic Flow Meter (if variable flow – one for each chiller).
 - vii) Condenser Water Flow from Magnetic Flow Meter (if variable flow – one for each chiller).
 - c) Analog (4 to 20 mA, 0 or 2 to 10 VDC) outputs from the BAS to the chiller:
 - i) Current Limit, % (Chiller must respond immediately to reduction in current sent by this output).
 - ii) Chilled Water Temperature Setpoint.
 - d) Digital (contact closure) inputs to the BAS from the chiller:
 - i) Chiller Proof of Run.
 - ii) Chilled Water Pump Proof of Run (one for each pump – via VFD or current switch).
 - iii) Chilled Water Proof of Flow (if constant flow – one for each exchanger on each chiller – via differential pressure transmitter).
 - iv) Chiller Isolation Valve Position (one for each valve).
 - v) Chiller Alarm/Fault Indication (Requiring Manual Reset).
 - vi) Chiller Alarm/Fault Indication (Auto Reset).
 - vii) Condenser Water Pump Proof of Run (one for each pump – via VFD or current switch).
 - viii) Condenser Water Proof of Flow (if constant flow – one for each exchanger on each chiller – via differential pressure transmitter).
 - e) Digital (contact closure) outputs from the BAS to the chiller:
 - i) Chiller Start/Stop.
 - ii) Chilled Water Pump Start/Stop (one for each pump).
 - iii) Condenser Water Pump Start/Stop (one for each pump).
3. Fan Coil Unit (FCU):
- a) The following hardwired I/O points are required for each FCU. Network interfaces must not be used for the items listed below:
 - b) Analog (4 to 20 mA, 0 or 2 to 10 VDC) inputs to the BAS from the FCU:
 - i) Supply Air Temperature.
 - ii) Return Air Temperature.



- iii) Space Temperature Sensor with Local Occupancy Override and Setpoint Adjustment.
 - c) Analog (4 to 20 mA, 0 or 2 to 10 VDC) outputs from the BAS to the FCU:
 - i) Heating Water Coil Control Valve.
 - ii) Chilled Water Coil Control Valve.
 - iii) Outside Air Damper Modulation.
 - d) Digital (contact closure) inputs to the BAS from the FCU:
 - i) Supply Air Fan POR.
 - ii) Condensate Pan Overflow Switch.
 - iii) Low Temperature Limit (Freezestat).
 - iv) Supply Air Fan Speed Command – Low, Medium, High (Via Space Temperature Sensor).
 - e) Digital (contact closure) outputs from the BAS to the FCU:
 - i) Supply Air Fan Start/Stop.
 - ii) Supply Air Fan Speed Control – Low, Medium, High.
4. Pumps:
- a) The following hardwired I/O points are required for each pump. Network interfaces must not be used for the items listed below:
 - b) Analog (4 to 20 mA, 0 or 2 to 10 VDC) inputs to the BAS from the pump:
 - i) Differential Pressure Transmitter.
 - ii) Pump VFD Feedback (speed).
 - c) Analog (4 to 20 mA, 0 or 2 to 10 VDC) outputs from the BAS to the pump:
 - i) Pump VFD Speed.
 - d) Digital (contact closure) inputs to the BAS from the pump:
 - i) Pump VFD Alarm/Fault.
 - ii) Pump VFD POR.
 - e) Digital (contact closure) outputs from the BAS to the pump:
 - i) Pump VFD Start/Stop.
5. VAV Terminal Unit (VAV):
- a) The following hardwired I/O points are required for each VAV. Network interfaces must not be used for the items listed below:
 - b) Analog (4 to 20 mA, 0 or 2 to 10 VDC) inputs to the BAS from the VAV:
 - i) Supply Airflow Station.
 - ii) Reheat Coil Supply Air Temperature.
 - iii) Room Space Temperature Sensor with Local Occupancy Override and Setpoint Adjustment.
 - c) Analog (4 to 20 mA, 0 or 2 to 10 VDC) outputs from the BAS to the VAV:
 - i) Reheat Coil Control Valve.
 - ii) Perimeter Radiation Control Valve (for any Perimeter Radiation within the VAV's zone).
 - d) Digital (contact closure) inputs to the BAS from the VAV:
 - i) Supply Air Fan POR. (Fan-powered Terminals Only).
 - e) Digital (contact closure) outputs from the BAS to the VAV:
 - i) Supply Air Fan Start/Stop (Fan-powered Terminals Only).



25 35 00 Integrated Automation Instrumentation and Terminal Devices for HVAC

1. A/E is to coordinate with University Facilities to coordinate requirements for, but not limited to the following:
 - a) Specify a desired DP for valve sizing or a guideline to exceed the coil DP to avoid valve sizing issues.
 - b) Specify close-off requirements.
 - c) Specify spring return vs. fail last position.
 - d) Specify if electronic fail-safe is OK vs. spring return.
 - e) Specify analog (2-10V) vs. tri-state (drive open/drive closed) actuation.
2. Control Valves (manual or automatic) shall be Belimo electronic globe valves with mechanical spring return for primary systems such as central plant, air handlers, and rooftop units, all even if they are supplied as part of a pre-manufactured or bundled package.
 - a) Two-way, NPT: G2 series with stainless steel trim.
 - b) Two-way, Flanged: G6 series with stainless steel trim and Class IV leakage.
 - c) Three-way, NPT: G3 series with stainless steel trim.
 - d) Three-way, Flanged: G7 series with stainless steel trim and Class IV leakage.
3. Control Valves (automatic) shall be Belimo electronic CCV (characterized disc) valves for all terminal equipment such as VAVs, fan coils, unit heaters, and perimeter radiation, even if they are supplied as part of a pre-manufactured or bundled package.
 - a) Two-way, NPT: BxxS series with stainless steel trim.
 - b) Three-way, NPT: Bxx3 series with stainless steel trim.
4. Gauge/Differential Pressure Transmitters – Wet Services:
 - a) Input Power: Class 2; 15 to 30 Vdc, 24 Vac nom. 50/60 Hz.
 - b) Maximum Current Draw: DC: 125 mA; AC: 280 mA.
 - c) Output: 3-wire transmitter; user-selectable 4 to 20 mA (clipped & capped)/0-5 V/0-10 V.
 - d) Surge Damping: Electronic; 1 or 5 second averaging.
 - e) Test Mode: Overrides output to full-scale (20 mA, 5 V, 10 V).
 - f) Zero Adjust: Pushbutton auto-zero & digital input (2-pos terminal block).
 - g) Status Indication: Dual-color LED: Green = Normal, Green Blinking = Low > High Red = Overrange, Red Blinking = Overpressure Green/Red Blinking = Underpressure.
 - h) Zero Offset (Bidirectional and Port Swap modes only): 0.5%.
 - i) Housing Material: White powder-coated aluminum NEMA 4, IP65.
 - j) Fittings: 1/8" NPT female thread, 17 to 4 PH stainless-steel.
 - k) Pressure Ranges (selectable) 0 to 50 psig (Gauge): 0 to 5/10/25/50 psid (Differential).
 - l) 0 to 100 psig (Gauge): 0 to 10/20/50/100 psid (Differential).
 - m) 0 to 250 psig (Gauge): 0 to 25/50/125/250 psid (Differential).
 - n) Accuracy at 25 °C: Ranges A and B: $\pm 1\%$ F.S. typical, Range C: $\pm 1.5\%$ F.S. typical, Range D: $\pm 2\%$ F.S. typical.
 - o) Long Term Stability: $\pm 0.25\%$ per year.
 - p) Media Compatibility: Media compatible with 17 to 4 PH stainless-steel.
 - q) Proof Pressure: 2x maximum F.S. range.
 - r) Burst Pressure: 5x maximum F.S. range.



- s) Temperature Compensated Range: 0 to 50 °C (32 to 122 °F); TC Zero $\leq \pm 1.5\%$ of product F.S. per sensor; TC Span $\leq \pm 1.5\%$ of product F.S. per sensor, (2 sensors per unit).
 - t) Media Temperature Limits: -20 to 85 °C (-4 to 185 °F); 0 to 90% RH non-condensing.
 - u) Operating Environment: -10 to 50 °C (14 to 122 °F); 10 to 90% RH non-condensing.
 - v) Field Connection: Provide 2-valve stainless-steel Transmitter Manifold.
 - w) Manufacturer: Veris.
 - x) Model: PWL Series.
 - y) Alternate Manufacturer: Modus.
 - z) Alternate Manufacturer Model: W30 Series.
5. Gauge/Differential Pressure Transmitters – Air Service:
- a) Current Output: 12 to 36 VDC at 21.5 mA.
 - b) Volts Output: 12 to 36 VDC at 6 mA.
 - c) Accuracy: $\pm 0.5\%$ or $\pm 0.25\%$ Full scale (NIST included).
 - d) Signal Output: 1-5V at 10K Ω , 4-20mA @545 Ω (loop powered).
 - e) Sensor Type: Capacitive.
 - f) Adjustments: (Z/S) Zero $\pm 10\%$ & Span $\pm 10\%$ trim POTs.
 - g) Normal Measurement Range: 0 to 10"WC, Uni- or Bi- Directional.
 - h) Overpressure: (Burst) ± 25 psid (172.4 kPa).
 - i) Max Operating Pressure: (Proof) ± 15 psid, (± 103 kPa).
 - j) Operating Temperature: 35 to 135°F (2 to 57°C).
 - k) Operating Humidity: 10 to 95% Non-condensing.
 - l) Wetted Parts: Silicone.
 - m) Media Compatibility Inert: dry air.
 - n) Process Connection: 3/16-inch OD brass, for 1/4-inch OD tubing.
 - o) Wiring: 5 Exposed terminals 2-(4-20mA), 3-(Volts).
 - p) Mounting: 2 , #10 screws (horizontal position).
 - q) Enclosure Rating :Stainless steel, NEMA 2.
 - r) Manufacturer: Ashcroft.
 - s) Model: XLdp Series.
 - t) Alternate Manufacturer: Veris.
 - u) Alternate Manufacturer Model: PX3 Series.
6. Magnetic Flowmeters – Ice Storage Chilled Water, Chilled Water, and Heating Hot Water Services:
- a) Accuracy:
 - (i) $\pm 1.0\%$ of reading from 1 to 20 ft/s.
 - (ii) $\pm 0.5\%$ of reading at the calibrated velocity .
 - (iii) ± 0.01 ft/s at flow rates less than 1 ft/s.
 - b) Flow Range: 0.1 ft/s to 20 ft/s (200:1 turndown).
 - c) Sensing Method: Electromagnetic sensing (no moving parts).
 - d) Pipe Size Range:
 - (i) Standard Configuration: 6 - 12" nominal diameter.
 - e) Input Power: 20 - 28 VDC, 50 @ at 24 VDC; 20 - 28 VAC, 60 Hz, 40 VA.
 - f) Liquid Temperature Range: 15°F to 250°F.
 - g) Ambient Temperature Range: -20°F to 150°F.
 - h) Operating Pressure: 400 psi maximum.



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- i) Pressure Drop:
 - (i) Standard Configuration: 0.1 psi at 12 ft/s in 3-inch pipe, decreasing as line size increases.
 - j) Output Signal Provided: Analog Output (Isolated):
 - (i) Selectable: 4-20 mA, 0-10 V or 0-5 V.
 - (ii) Frequency Output: 0-15 V peak pulse, 0-500 Hz.
 - (iii) Scalable Pulse Output: Isolated solid state dry contact.
 - (iv) Contact rating: 50 VDC, 100 mA maximum.
 - (v) Pulse Duration: 0.5, 1, 2 or 6 seconds.
 - k) Material: Wetted metal components: 316 Stainless Steel.
 - l) Approvals: NSF/ANSI 61/372 version.
 - m) Manufacturer: Onicon.
 - n) Model: FSM-3 Super Mag Hot Tap Insertion.
 - o) Alternate Manufacturer: Badger.
 - p) Alternate Manufacturer Model: M2000 Electromagnetic Flow Meter (Inline).
7. Airflow measuring stations:
- a) Approved manufacturers are Ebtron, Inc. or Air Monitor Corporation (no substitutions).
 - b) A/E is to design airflow metering equipment in accordance with manufacturer's installation requirements and placement guidelines.
 - c) Meter is to be designed for the minimum and maximum air velocities provided by the A/E. The University requires a minimum air velocity of 400 FPM.
 - d) Factory install piezometer ring on direct drive fans in AHU/RTU.
 - e) Ebtron, Inc.:
 - i) Duct and plenum probes: Advantage Gold Series GTC116-P'D' with probe model GP1-'D' sensor density.
 - ii) Outside air intake (no duct run): Series AIR-IQ/GTC-PD Dual analog + RS-485 Output – 'C' Density, dual array.
 - f) Air Monitor Corporation:
 - i) Duct mounted configuration: Model Fan-Evaluator (Fan-E) with factory fabricated transmitter.
8. Gas flow meters:
- a) For gas metering (natural, lab, etc.), require that University be contacted by the design professional with the process/application information to determine the acceptable metering method.
9. Vortex Flowmetering System – High Pressure Steam Service:
- a) General Requirements – Steam Meter Sizing, Selection, and Installation Design:
 - i) Metering shall only be performed at locations where the normal steam operating pressure is greater than 50 PSIG. Metering of low-pressure steam is not permitted.
 - ii) All saturated steam meters shall be pressure compensated. Where superheat is expected, steam meters shall be pressure and temperature compensated.
 - iii) Steam meter sizing shall be performed prior to meter selection.
 - iv) To correctly size the steam meter, the design engineer shall first determine the minimum, maximum, and normal operating flow rates and pressures.



- v) Using the minimum, maximum, and normal operating flow rates and pressures, as determined by the design engineer, the steam meter vendor shall size the steam flowmeter for maximum turndown.
- vi) The design engineer shall utilize the results of the steam meter vendor's sizing to design the physical installation per the steam meter manufacturer's installation instructions, standard drawings, and ANSI/ASME B31.1 Code for Pressure Piping.
- vii) Meter run piping shall be the same pipe size as the nominal meter size. The meter run shall be complete with (at least) the minimum required straight runs of upstream and downstream piping, as indicated on the standard drawings and manufacturer's installation instructions. Reductions and/or enlargements of the piping shall occur before and/or after the meter run.
- viii) Bypasses around steam meters are not required.
- ix) Shedder bars on vortex flowmeters used for steam service shall be installed in the horizontal position when installed in horizontal pipe runs.
- b) Vortex Flowmeter Pipeline Element:
 - i) Type: ANSI-Flanged Vortex Flowmeter.
 - ii) Accuracy: $\pm 1.00\%$ of Rate.
 - iii) Repeatability: $\pm 0.2\%$ of Rate.
 - iv) Output: Two wire 4 to 20 mA DC.
 - v) Integrated Indicator (LCD display): Full dot-matrix LCD.
 - vi) Body: Stainless Steel, ASTM CF8M.
 - vii) Flanges: Stainless Steel, ASTM CF8M.
 - viii) Shedder Bar: Stainless Steel.
 - ix) Manufacturer: Yokogawa.
 - x) Model: DY(size code) -DBLBA2-2D /SCT.
- c) Pressure Transmitter:
 - i) Type: High Performance Gauge Pressure Transmitter.
 - ii) Accuracy: $\pm 0.55\%$ of Span.
 - iii) Stability: $\pm 0.1\%$ of URL for 7 Years.
 - iv) Output: Two wire 4 to 20 mA DC.
 - v) Integrated Indicator (LCD display): Full dot-matrix LCD.
 - vi) Body: Stainless Steel, ASTM CF8M.
 - vii) Flange & Process Connector: Stainless Steel, ASTM CF8M.
 - viii) Diaphragm: Hastelloy C-276.
 - ix) Capsule Gasket: Stainless steel, Teflon-coated 316L.
 - x) Manufacturer: Yokogawa.
 - xi) Model: EJA430E-DAS4G-U32DN/FF1/D1.
- d) Two-Valve Manifold for Pressure Transmitter:
 - i) Type: Two-Valve Block & Bleed.
 - ii) Body: Stainless Steel, ASTM A479-316.
 - iii) Seat: Carbide Ball.
 - iv) Stem Seal: Teflon Pressure-Core.
 - v) Flange Seal Standard: Taylor Mount Flange Seals.
 - vi) Manufacturer: Yokogawa.
 - vii) Model: M618SCT/MT/VSH/W9.



- e) Temperature Sensor & Transmitter (Superheat Applications Only):
 - i) Type: High Accuracy Temperature Transmitter.
 - ii) Accuracy: $\pm 0.05\%$ of Span.
 - iii) Stability: $\pm 0.1\%$ of URL for 2 Years.
 - iv) Output: Two wire 4 to 20 mA DC.
 - v) Integrated Indicator (LCD display): Full dot-matrix LCD.
 - vi) Sensor: 100 Ohm Pt RTD.
 - vii) Sensor Style: Spring Loaded Sensor with Thermowell.
 - viii) RTD Accuracy: $\pm 0.10\%$ of resistance at 0°C .
 - ix) Element Lead Configuration: Three Wire Single.
 - x) Connection Head: Aluminum, Epoxy Coated.
 - xi) Extension Type: Nipple-Union-Nipple, 316 Stainless Steel.
 - xii) Immersion Length: Shall be determined by pipe size.
 - xiii) Thermowell Type: Reduced Tip, Threaded, $\frac{3}{4}$ in. NPT Process Connection.
 - xiv) Thermowell Material: 316 Stainless Steel.
 - xv) Manufacturer: Yokogawa/Burns Engineering.
 - xvi) Model: Yokogawa YTA310-DA2DN/FU1/N4/D2 with Burns Engineering Model No. TSE-200C-10A2E3B(Immersion Length) RT3/03.
 - f) Flow Conditioner (For Vortex Flowmeters, 2-inch NPS and larger):
 - i) Type: Flanged, Meter Run, 7D.
 - ii) Body: 316 Stainless Steel.
 - iii) Flanges: Carbon Steel, ANSI Class 300.
 - iv) Manufacturer: Vortab Company.
 - v) Model: VMR-(pipe size)-3-6 (one required for each steam flowmeter, 2 inch and larger).
 - g) Flow Computer:
 - i) Type: Multi-Function, Field Mount.
 - ii) Display Type: LCD.
 - iii) Input Voltage: 85 to 276 VAC.
 - iv) Manufacturer: Kessler-Ellis Products.
 - v) Model: MS-748-L-1-0-V-MB.
10. Demand control ventilation is to be designed for all non-lab HVAC systems. A/E is to calculate CO₂ limit levels on a per project basis.
- a) CO₂ sensor:
 - i) Veris CW Series Indoor Air Quality Sensor with display.

25 50 00 Integrated Automation Facility Controls

1. BAS contractor to provide insulation behind all wall mounted thermostats and humidistats.
2. All thermostats and humidistats located in high traffic areas are to have covers to limit damage.
3. A/E and BAS Contractor are to locate thermostats and humidistats in a room such that they are not affected by the following:
 - a) Heat producing equipment.
 - b) Air from a diffuser blowing directly on it.



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- c) Direct sunlight directly on it.
 - d) Behind a door and/or furniture.
4. Electrical Contractor and BAS Contractor are to coordinate grounding of BAS equipment.
 5. All BAS signal wiring shall be installed exposed or in areas subject to damage shall be in metal conduit (EMT, IMC, or Rigid). Wiring installed within hollow core walls, above drop-in tile ceilings, and within equipment enclosures shall be plenum cable fixed firmly to the permanent building structure within a raceway system. Attachment of cables with plastic zip ties or loose/unsupported installation across ceilings is prohibited.
 6. All BAS signal wiring shall be installed in separate conduits from AC power wiring (including AC power feeds to fire alarm and BAS devices).
 7. All digitally controlled systems will include the necessary hardware to permit remote network connection and programming (modem access at a minimum). Program editing must be able to be performed remotely from any location. Where special software is needed for remote editing, ten copies of the software and licenses are to be provided.
 8. Pneumatic devices shall be limited to the following components:
 - a) E.P. and P.E. switches and transducers.
 - b) Damper and valve actuators.
 - c) Pilot positioning devices.
 - d) Gauges.
 - e) Pressure sensors.
 9. All new pneumatic systems shall include duplex compressors each, adequately sized to handle 80% of the anticipated peak load, compressor alternating controls to assure equal run time, a pneumatic tank sized to provide minimum storage capacity of 8 hours in the event of power loss and a mechanical filter dryer system capable of reducing the dew point temperature of the air to +20°F at a pressure of 25 PSIG.
 10. All pneumatic tubing shall be run in Type "L" soft or hard copper with soldered joints (95-5 solder). Compression-type connections are permitted at connections to equipment only. Minimum tubing size shall be 1/4-inch (0.030-inch Type L wall thickness).
 11. All control valves (chilled, condenser, hot water, and steam) shall be of the throttling plug (water) or V-port (steam) repacking type. Valves 2" and smaller shall have threaded brass bodies. Valves above 2" shall be flanged and have iron bodies. All valves shall be provided with stainless steel stems and metal seats. Refer to part 2 of Section 25 35 00. Plug types as follows:
 - a) Steam - Linear characteristic - V-port.
 - b) Modulating water service - Equal percentage plug.
 - c) Two position - Flat seat/quick opening.
 12. All BAS graphics are to show the associated room numbers and equipment (AHUs, VAVs, BAS controllers, etc.) locations. Graphics to include a dynamic link to the primary equipment
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that serves the terminal unit (i.e. AHU serving the VAV) as well as a link to the schedule for that piece of equipment. Also, include a dynamic link to return to the main building riser or overall campus plan. No “dead ends” allowed.

13. Each project shall provide control panels in the quantities and locations necessary to properly house all control equipment. Panels shall be provided with hinged covers and key operated locks. Top conduit access to panels is **prohibited** and conduit shall enter panel from side or bottom.
14. A tele/data port will be provided by the University IT for the main BAS controller (if a new main controller is required for the project) connection to the campus Ethernet. Connection to the Campus Ethernet shall be limited to one location per building if possible.
15. A/E to coordinate with BAS controls representative and lighting (harvesting) system representative during the design phases for a fully functioning/integrated system.
16. The drawings and specifications shall, as a minimum, include the following:
 - a) General system description, sequence of operations, and plans detailing the system architecture, points list, flow diagrams, electrical diagrams, etc.
 - b) Shop drawing and submittal requirements:
 - i) System Architecture.
 - ii) Instrument Index.
 - iii) System Flow Diagrams.
 - iv) Electrical Diagrams.
 - v) Sequence of Operations.
 - vi) Control Valve Schedules.
 - vii) Damper Schedules.
 - viii) Point to point wire termination legends are to be provided for all control panels and devices.
 - ix) Air Flow Measuring Station Schedules.
 - x) Panel Layout/Diagrams.
 - xi) Instrument Compressed Air System.
 - xii) User Interface Graphics.
 - xiii) Symbols, Definition and Abbreviations.
 - xiv) System Units and Accuracy.
 - xv) Special Warranties.
17. The units must be capable of responding to control signals from the BAS and providing status information to the BAS. The BAS will provide the following minimum inputs for each unit:
 - a) Occupied/Unoccupied Mode.
 - b) Fan Unit Run, supply and return.
 - c) Fan speed, supply, and return.
 - d) Warm-up/Pre-cool.
 - e) Heating command, modulation, or stages.
 - f) Cooling command, modulation, or stages.
 - g) OA Damper, RA damper, EA damper Position (modulating).
 - h) Demand Limit.



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- i) Remote Setpoint Adjust.
 - j) Emergency response.
 - k) Dehumidification.
18. The BAS must be able to read the following unit information from each unit:
- a) Fan Command/Fan Status.
 - b) Fan Speed Command/Status.
 - c) Cooling Command/Cooling Status Stages.
 - d) Heating Command/Heating Status Stages.
 - e) Return Air Temperature and Enthalpy.
 - f) Outdoor Air Temperature and Enthalpy.
 - g) Supply Air Temperature.
 - h) Economizer Command damper command.
 - i) Alarm Status: Fire and Freeze.
 - j) Duct pressure.
 - k) MA temperature.
 - l) Return Air Humidity.
19. Advanced Pressure Monitor:
- a) All Laboratory (animal, chemical, biology, etc.) spaces are to be equipped with a pressure monitor. Monitor is to be located on the wall in the corridor at the entrance into the laboratory space. Positive and negative notification will be as per the Construction drawings and specifications.
 - b) Advanced Pressure Monitor:
 - i) Display monitor is to be located outside of laboratory next to entrance door.
 - ii) Provide non-network connected pressure monitors as indicated on the drawings complete with pressure pick-up ports for space and reference locations.
 - iii) Pressure monitors shall have a 4.3" color TFT touch screen capable of displaying the following information:
 - (1) Space differential pressure in inches of water column ("WC) or Pascals (Pa) and an optional pressure slide bar in relation to configured alarm set points.
 - (2) Intended space pressure relationship (Positive, Negative, Neutral or Standby).
 - (3) A four-color, touch selectable, customizable message banner shall display the room condition to staff.
 - (a) The message banner size shall be selectable between the left-hand 1/3rd of screen or the full screen. When in full screen mode, any alarm condition shall return the message banner to the left-hand 1/3rd size.
 - (b) Selection of different message banners shall also be capable of setting the occupancy state.
 - (c) Upon any alarm condition, the message banner shall turn red and display "Alarm".
 - (4) Room ID (user configurable).
 - (5) With the addition of a remote pressure transducer, the pressure monitor shall be capable of monitoring two spaces and toggling the display with all variables listed above between the two spaces.



- c) Pressure monitors shall have the following minimum environmental and performance specifications:
 - i) IP-54 rated housing, resistant to spray washdown.
 - ii) Resistant to decontamination chemicals (e.g. VHP, Clidox, Formaldehyde, sodium hypochlorite 3-6%).
 - iii) Standard accuracy RSS of at least $\pm 0.5\%$ full scale (non-linearity, hysteresis, and non-repeatability).
 - iv) Optional high accuracy RSS of at least $\pm 0.25\%$ full scale (non-linearity, hysteresis, and non-repeatability).
 - v) Integral zero and span adjustment.
 - vi) Temperature effect on zero/span shift $\pm 0.03\%$ FS/ $^{\circ}$ F.
 - vii) Pressure ranges, selected by engineer, shall be up to ($\pm 0.05"$ to $\pm 1.0"$ WC).
 - viii) Temperature Range: 32 to 120 $^{\circ}$ F.
- d) Monitor configuration can be copied to an external USB memory device for the purpose of duplicating configuration on like devices.
- e) Pressure setpoints shall be externally switchable between positive, negative, and neutral modes.
- f) Home screen language shall be selectable between English and French.
- g) Firmware upgradable via USB port.
- h) Alarms:
 - i) Programmable visual alarm and adjustable audible alarm.
 - ii) Programmable durations for audible alarm delay and silence periods.
 - iii) Alarm on insufficient duct static pressure.
 - iv) Includes (8) optional methods of alarm configuration to minimize nuisance alarms.
- i) Inputs:
 - i) Analog Inputs (AI-1, AI-2):
 - (1) Multi-function input signal of 0-10VAC, 0-5VAC or 4-20 mA.
 - (2) Used for secondary (remote) pressure transducer input or switching pressure alarm setpoints to equal and opposite ranges.
 - ii) Digital Input (DI-1):
 - (1) DI can be used for door status indication (contact open = door open, closed = door closed) or valve pressure switch indicator.
 - (2) DI is alarmable; visual on the LCD, yellow on door open.
 - (3) DI is configurable; door open can disable alarm.
- j) Outputs:
 - i) Analog output (AO-1):
 - (1) A filtered output signal of the primary room pressure differential.
 - (2) Range is field selectable for 0-5Vdc, 0-10Vdc or 4-20mA.
 - (3) Speed of response shall be appropriate for high-speed pressure control algorithms with a 100ms speed of response maximum, 3-time constants.
 - ii) Alarm contact digital output (DO-1):
 - (1) SPDT, contact rating of 2.0A @ 30VAC/VAC, 0.6A @ 125VAC.
 - (2) Adjustable alarm deadband of 0-10% of setpoint.
 - iii) Installation:
 - (1) Pressure monitor shall fit into standard commercially available triple-gang, double-deep electrical boxes (e.g. RACO 697, Appleton M3-350).



- iv) Acceptable Products:
 - (1) Phoenix Controls model APM200-ENG-ANU.

- 20. The BAS to notify University Operations via BAS alarm and [EH&RS](#) via text message upon failure of all major equipment, especially serving laboratory areas, i.e. air handling units, exhaust fans, chillers, boilers, etc.



XVI. DIVISION 26 – ELECTRICAL

26 05 00 Common Work Results for Electrical

1. The A/E shall be responsible for providing a well investigated and designed electrical system. These systems shall conform to NEC, local codes, and good electrical practices. It is the A/E's responsibility to verify both the above and the Department of Facilities Management agreement with the proposed systems.
2. Each system shall be designed and installed in accordance with the latest edition of the applicable Standards, including, but not limited to:
 - a) NFPA Standards.
 - b) Institute of Electrical and Electronics Engineers (IEEE).
 - c) National Electrical Manufacturers Association (NEMA).
 - d) Illuminating Engineering Society of North America (IES).
 - e) Americans with Disabilities Act Accessibility Guidelines (ADAAG).
 - f) ASME A17.1/CSA B44 Safety Code for Elevators and Escalators.
 - g) Factory Mutual System (FM).
 - h) Underwriters Laboratory, Inc. (UL).
 - i) American National Standards Institute (ANSI).
 - j) American Society for Testing and Materials (ASTM).
3. Increased energy demand caused by new or added equipment shall be listed in all proposals. Additionally, any increased energy use shall be called out and included with any products submitted for use by bidders other than that which is specified.
4. All equipment is to be individually scheduled.
5. All new equipment is to be provided with software and hardware necessary for University Facilities to have the ability to troubleshoot and/or configure any field equipment. Where software is required, the equipment manufacturer and/or contractor is to provide software and hardware as part of the closeout package.
6. General:
 - a) Equipment, assemblies, and materials may only be specified if they carry Underwriters Laboratories (UL or cUL) or Intertek ETL listings.
 - b) Incompatibility of materials will not be allowed e.g., aluminum boxes or fittings with steel conduit.
 - c) All motors on cooling towers, air handling units and energy recover units more than 2,000 CFM and circulating pumps shall be equipped with variable speed drives equipped with integral electrical bypass or full electromechanical bypasses. The manufacturer shall only be ABB, [refer to Section 26 29 23 for model number and specification](#).
 - d) Motor Filter Protection:
 - i) A "dV/dTGuard" or "PWM Output Filter", minimizes motor failures due to Insulated Gate Bipolar Transistor (IGBT) based drives that are connected by long leads. Motors controlled by variable frequency drives that are installed some distances away often fail because of high voltage induced insulation breakdown. The extremely fast



switching time of the IGBT drive is reflected by the steep edges (dV/dT 's) of the PWM voltage waveform. When uncontrolled, these high dV/dT 's result in voltage wave reflections which can become additive at the pulse level yielding a voltage overshoot or spikes. This voltage overshoot damage the motor and cable insulation and lead to motor failure as the length of the motor cables increase. The combined inductance, capacitance, and resistance of the "PWM Output Filter" shall be specifically designed to reduce voltage waveform dV/dT . In so doing, the "dV/dT Guard" shall also minimize parasitic resonance interaction between the inductive and the capacitive elements within the long leads. Left unguarded, this conductor resonance phenomenon would likewise contribute to the formation of motor-damaging voltage spikes.

- ii) The dampened, low pass filter consists of a gapped, three phase, iron core inductor; AC-rated, polypropylene capacitors; and wire-wound resistors. The filter shall be rated for application at a maximum fundamental system frequency of 60 Hz at nominal system voltages up to 600 V. The filter shall operate at a maximum carrier frequency of 8 kHz at 40% of fundamental voltage. The ambient temperature of operation shall be 40°C. The maximum distance from the drive to the input terminals of the V1k filter shall be 10 feet. The motor filter shall be required for applications with lead distances between the drive and the motor that range from 50 ft. to 3,000 ft. and have motors that are greater than 40 HP @ 480 VAC or 20 HP @ 208/230 VAC and are installed more than 50 feet away from the VFD. All cooling tower applications that contain a VFD, regardless of motor size, shall have a "dV/dT Guard" motor filter.
 - iii) Enclosure shall be designed to conform to standards NEMA 1 or NEMA 3R if outdoors. Enclosure shall be constructed from steel with enamel finish. Enclosure openings shall be provided to allow for airflow convection cooling. Provisions shall be made to allow for permanent conduit entry sites. Enclosure shall have a removable cover that shall not at any time disrupt the conduit connections.
 - iv) The "dV/dT Guard" motor output filter shall be warranted free from defects in both materials and in workmanship for a period of one year from the date of installation or for a maximum of two years from the date of purchase, whichever comes first.
 - v) Approved Manufacturers are only:
 - (1) TCI, Trans-coil LLC: Sample part number #V1K80A01.
 - (2) MTE Corporation: Sample part number #DVAGB0055.
7. Raceways:
- a) All conduits shall be 3/4-inch (minimum size) rigid galvanized steel or I.M.C., with the following exceptions:
 - i) Un-galvanized EMT may be used with insulated bushings and throat fittings in interior walls and above false ceilings except in hazardous or corrosive applications.
 - ii) Flexible metal conduit (MC) may be used for interior light fixtures above suspended ceilings and connections to vibrating equipment, such as motors. The maximum allowable length is six feet.
 - iii) Plastic-covered flexible metal conduit or all-plastic flexible conduit (Sealtite) may be used in wet environments with a separate ground wire.
 - iv) PVC conduit shall be acceptable for outdoor underground lighting feeds. PVC conduit will use proper PVC fittings and boxes. Minimum size shall be 3/4".



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- v) Conduit under slabs or exterior below grade may be Schedule 80 PVC or Schedule 40 encased in 6" of concrete.
 - b) UL rigid galvanized conduit must be generally used with threaded couplings only.
8. Conductors:
- a) All conductors shall be THHN copper, 600-volt rated (minimum size #12 for power and #14 for all lighting and control) except where special conditions (high temperatures, gasoline, or oil, etc.) require other insulations to be used.
 - b) Three-phase color-coding, Phase A, B, and C order - 480/277 volt shall be brown, orange, yellow, and 208/120 volt shall be black, red, blue.
9. Grounding:
- a) All conduits and flexible metal conduit shall contain a grounding conductor.
 - b) Conduit is not to be used as a grounding conductor.
10. Electrical Boxes:
- a) All boxes shall be pressed galvanized steel or cast. Rigid conduit connections shall be secured in place by double locknuts and insulated bushings.
11. Lighting:
- a) Illumination levels: All areas to be designed in accordance with the Lighting Level stipulated in Section 26 51 00, "Interior Lighting".
 - b) Exterior: Exterior lighting shall be 277 volt except where not available or practical. Preferred walkway lighting to be LED or in with prior approval of University Architect or Facilities, other sources may be discussed and must be specifically approved.
 - c) Exterior Pole Lighting:
 - i) All poles to be style approved in the following: Master Plan; Design for the Public Realm Lighting Appendix; or with prior approval of University Architect.
 - ii) Pole top fixtures shall be cut-off type with Type V light pattern or Type III.
 - iii) Poles shall have a baked poly "Gray" finish.
 - iv) Pole top lighting shall be LED, whereas all other exterior lighting shall be High Pressure Sodium where approved.
 - v) Roadway fixtures shall be Cobra Head type that matches existing in photometric performance. All poles shall be one-piece spun aluminum.
 - d) Interior: Interior lighting shall be LED with appropriate drivers or power supplies suitable for a minimum of 120 volt except for compacts. All new or replacement lamps are to be LED. The use of incandescent lamps in any application requires prior approval.
 - e) Exit/Egress: Exit lights shall be LED with diffused lens and connected into a multi-volt, code-approved source with emergency generator backup. If a generator is not available, the lights shall have a self-contained power pack, charger, and transfer relays.
 - f) Design Consultants and/or A/E is to coordinate with University Project Manager and Facilities to limit the variety of light fixtures and lamp types used on a project. When at all possible, new construction designs shall incorporate the fixture solutions and luminaires called out within the *Lighting Application Standards Appendix Lighting Application Standards Appendix*. These fixture standards shall be accessible by contacting: Facilities Department or the University Architect's offices.



- g) Lighting fixtures and controls, including all luminaires and lamp standards have been carefully developed by the University and should be acquired and obtained with consultation from the University Facilities Department or by contacting the University lighting supplier Diversified, Inc. at 215-442-0700 or www.diversified-group.com.
- h) Lights are to be located such that they are easily accessible.
- i) A/E to include the light fixture schedule in the electrical drawings.
- j) LED lamps to be DLC or Energy Star type.
- k) All lighting fixtures shall have a minimum warranty of five (5). Special consideration of budget may occur for warranties of seven (7) to ten (10) years.

12. Lighting Controls:

- a) All suitable areas, such as offices, classrooms, breakrooms, lunchrooms, conference rooms, etc. shall use occupancy sensors (IR) as required by the 2018 International Energy Conservation Code.
- b) A large interior area exposed to constant outside light shall use photocell-controlled contactors with bypass switch or BAS controls.
- c) Large interior spaces not suitable for occupancy sensors shall be controlled by low voltage relays and tied into the BAS. A low voltage override button shall be mounted and labeled for each lighting control zone.
- d) Light harvesting systems are to be controlled by multi-technology sensors including photocell (light level) sensors and with override by occupancy sensors connected to the BAS accordingly.
- e) Dimming systems where not required by code shall be approved by the Project Manager and Facilities Management prior to specification or implementation.
- f) Exterior areas shall be controlled by individual and/or master photocell-controlled only by building BAS.
- g) Photocells will connect directly to the BAS, where one exists.
- h) Exterior lighting shall be connected to the BAS. Prime Contractor is to coordinate with Division 25 and 26 regarding control equipment (Div. 25) and fixture type (Div. 26) compatibility.
- i) Network lighting control systems shall be approved by Facilities Management and integrated in the BAS. Hubbell, GE/Current, Leviton, or Lutron shall manufacture these controls systems. Refer to the *Lighting Application Standards Appendix* for more information. These fixture standards shall be accessible by contacting the Facilities Department.

13. Wiring Devices:

- a) All receptacles, wall switches, etc. shall be specification grade.
- b) All 208-to-480-volt power devices shall be heavy duty industrial rating.
- c) All devices shall be grey, except those connected to emergency power, which shall be red, or a dedicated circuit, which shall be orange.
- d) All faceplates shall be type 302 stainless steel with true beveled edges; mounting screws shall match wall plate finish and be installed with slots vertical.
- e) Identify circuit number on reverse side of faceplate for each outlet box containing branch circuitry.



14. Over-current Protective Devices:
 - a) Fuses shall only be used for low voltage control circuits and for motor protection circuits (such as in fused disconnects) in addition to starter overload and short circuit protection.
 - b) All fuses shall be rated for the type of service employed.

15. Basic Methods:
 - a) All electrical systems shall be installed in a **skillful** manner within local and NEC code qualifications subject to the approval of the University Facilities Management.
 - b) All conduits shall be supported in accordance with NEC code requirements. Supporting on pipes, ductwork and/or suspended ceiling are not permitted.
 - c) Where possible all conduits shall be run overhead. Runs from unit substations to motor control centers may, where necessary, be run in slabs or may run from motor control centers to individual motors and shall be home runs between source and equipment.
 - d) Unit substations shall be installed above exterior grade with adequate access from the building, and fresh air exchanges rated at 1.5 times that of the total room volume of the sub-station with manual damper control for fresh air intake to sub-station.
 - e) When used in slabs, conduit fitting to Sealtite connections shall be watertight.
 - f) Direct burial of underground cable is not allowed. All cables will be run through duct banks or conduits. This includes communication, power, and control cables.
 - g) Special attention shall be given to conduit installation methods in mechanical rooms where water or live steam leakage could cause flooding. In these areas conduit runs shall be overhead.
 - h) All motors shall be installed such that the motor box is accessible to maintenance personnel.
 - i) A pad eye shall be provided over motors where necessary for removal.
 - j) All high voltage splicing shall be done by qualified splicers, in accordance with manufacturers recommendations for splicing and terminations and in accordance with the current NEC.
 - k) All conduits for telephone or communications shall be home runs from panel to instrument or device.
 - l) Conduits entering panels with any kind of electronic equipment inside shall enter from the bottom or side of the panel.
 - m) Grounding continuity shall be maintained across building expansion joints where necessary.
 - n) Cable and conduit shall enter electrical panel from side or bottom, top access is **prohibited**.
 - o) Conduits entering the building horizontally from below grade should enter a pull box that is not located above electrical equipment, to allow the conduit to be drained.

16. Emergency, Standby and Optional Standby Power systems are to be designed in accordance with Articles 700, 701 and 702 of the National Electric Code, version as adopted by the City of Philadelphia.

17. All exterior doors with card readers are to be on emergency power.

26 05 48 Vibration and Seismic Controls for Electrical Systems

1. A/E to determine if vibration and seismic controls are required for the project.



2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

26 05 53 Identification for Electrical Systems

1. All electrical equipment shall be required to be labeled to comply with OSHA and ANSI/ASME A13.1-2015 standards for the identification of systems.
2. The marking system shall identify the voltage of the contents.
3. All equipment must be identified using phenolic nameplates and labeled in accordance with the nomenclature used on the drawings and compatible with the MIMS System.
4. All electrical panels installed or entered must have type written updated directories indicating specific circuits and locations. Outlet circuits must be identified with room number locations, lighting circuits must be identified with room number locations, and powered device locations must be included in directory.

26 08 00 Commissioning of Electrical Systems

1. The purpose of the commissioning process is to provide the Owner with a high level of assurance that the electrical systems have been installed in the prescribed manner and operate within the required performance guidelines. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the Owner.
2. The electrical components that shall be included in the commissioning process include, but shall not be limited to, the following:
 - a) Labeling of Circuits and Connected Equipment.
 - b) Main Switchboard Overcurrent Protection Performance.
 - c) Panelboard Installation and Branch Circuit Labeling.
 - d) Distribution Transformer Performance.
 - e) Motor Controllers Compliance.
 - f) Grounding System Performance.
 - g) Interior Lighting System Performance.
3. The commissioning responsibilities of the Installing Contractor shall include the following:
 - a) Review design for provision of power to the appropriate HVAC equipment.
 - i) Verify proper hardware specifications exist for performance as defined by the Contract Documents.
 - ii) Verify proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
 - b) Prior to completion of installation, submit “System Verification Checklists” to Engineer of Record and Owner for review.



- c) Verify proper installation and performance of all electrical system components provided.
 - d) Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling acceptance and operating tests.
 - e) Provide an electrical system technician to assist during functional performance testing.
 - f) Participate in the functional performance tests as required to achieve design intent.
 - g) Participate in O&M Training as required by project specifications.
 - h) Obtain O&M data on all equipment and assemble in binders as required by the project specifications.
 - i) Conduct a maintenance demonstration with hands-on training. Submit record drawings as required by the project specifications prior to the training. Demonstrate proper use, operations and routine maintenance of the elevators and components.
 - j) Submit completed System Verification Checklists documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed.
 - k) Provide written certification documenting that the work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the Electrical Trade Representative re-certifying that he has inspected the work and that it has been completed and functioning as designed. This certification must be submitted prior to the final verification.
 - l) Provide set of record as-built drawings to the Engineer of Record for inclusion into record documents.
4. Start-Up:
- a) The installing contractor shall perform start-up of the electrical equipment. The appropriate contractors and/or manufacturer's representative shall be on-site to perform start-up. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the manufacturer's recommended procedures. The Owner will visit the site to review completeness of installation in conjunction with progress meetings prior to starting equipment.
 - b) Contractors involved in installation, fabrication, manufacturer, control, or designs of equipment shall be present at the time of start-up. A factory-authorized technician shall be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment online and expedite acceptable functional performance.
5. Functional Performance Tests:
- a) Each major system will be tested. A random sample of each subsystem will be tested. The Functional Performance Tests shall be performed in the presence of the Owner and shall serve as a complement to the O&M Training. No tests will be performed until the system and related subsystems have been started, the testing and balancing report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
 - b) The Functional Performance Tests shall include the following, with the Commissioning Agent (if applicable) and/or Owner present:
 - i) The electrical trade representative, with the CA present, shall field test for correct labeling of circuits and equipment by breaking current and observing loss of power



- at circuits or equipment. An “Incorrect Equipment Circuit Identification” report will be prepared by the electrical trade representative and submitted to the Owner.
- ii) The electrical trade representative shall demonstrate: main power disconnect switch and feeder disconnect switches overcurrent and ground fault sensor trip settings by the primary injection method and in accordance with NETA-ATS Section 7.6, switchboard assemblies megger tested in accordance with NETA-ATC Section 7, switchboard metering instrumentation tests in accordance with NETA-ATC Sections 7.10 and 7.11, and switchboard single-phase monitor tests for operation upon loss of a phase voltage.
 - iii) The electrical trade representative shall field test for correct labeling panelboards and branch circuits, including grounding continuity of up to 10% of all circuits in each panel, by breaking current and observing loss of power. An “Incorrect Branch Circuit Wiring” report will be prepared by the electrical trade representative and submitted to the Owner.
 - iv) The electrical trade representative shall demonstrate distribution transformer performance voltage and current measurements in accordance with NETA recommendations, grounding conductor impedance to the building structure measured between two points other than the location of the grounding conductor connections, and ventilation clearance from transformer enclosures to partitions in accordance contract documents requirements.
 - v) Motor controllers shall be demonstrated by the electrical trade representative for compliance with prevailing codes and the contract documents.
 - vi) Grounding System Performance tests shall be performed by the electrical trade representative in accordance with NETA-ATS Section 7.13.
 - vii) The electrical trade representative shall demonstrate luminaire/lamp combinations by inspection, operational tests for lighting control/dimming systems, illumination level measurements in up to 20% of the building area, and interior lighting control performance, including operation of occupancy sensors, automatic time controls, energy management control override timers, manual dimming control, multi-level switching, and other specified lighting controls. The electrical trade representative shall submit an “Incorrect Light Lamping” report to the Owner.
6. Owner Orientation and Training:
- a) The installing contractor shall provide the Owner comprehensive training in the understanding of the systems and operation and maintenance of each major piece of equipment.
 - b) The installation contractor or manufacturer’s representative will provide the training. This training should include **firsthand** operational training. The Owner may choose to videotape this training for future use.
 - c) The training shall include start-up, operation in all modes possible, shutdown and any emergency procedures.
 - d) The training shall include a review of all systems using simplified system schematics including riser diagrams, valve locations, and equipment locations.
 - e) The installation contractor shall provide the Owner with copies of all inspections and acceptance.
 - f) The manufacturer's representative shall provide instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance



- instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Qualified service engineers employed by the manufacturers, or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed. The start-up and shutdown modes of operation shall be demonstrated. Emergency operations shall be demonstrated.
- g) The Contractor shall attend all sessions and shall add to each session any **specific** information relating to the details of installation of the equipment as it might impact the operation and maintenance.
 - h) The installing contractor shall assist in the coordination of yearly testing, calibrating, and servicing as specified in the contract documents.
 - i) The Control Trade Representative shall attend all sessions and be prepared to conduct the controls portion of the training as it relates to each equipment section.
 - j) The Control Trade Representative shall conduct the training session on the controls system hardware and software.
 - k) The Electrical Trade Representatives shall conduct sessions on their respective trades with emphasis on any peculiarities of the systems and maintenance requirements.
 - l) Refer to Section 26 09 23 Lighting Control Devices & Systems, item 9 Required System Commissioning & Start-Up Services for further direction

26 09 23 Lighting Control Devices

1. Coordinate lighting control requirements with the 2018 International Energy Conservation Code.
2. Each area enclosed by ceiling height partitions shall have at least one accessible lighting control to independently control lighting within the area.
3. All enclosed areas larger than 500 square feet shall have an accessible lighting control so that general lighting may be reduced by at least one half throughout the area.
4. The total number of accessible lighting controls within an enclosed area shall not be less than one for each 500 square feet, exceptions being made, on case-by-case basis, for large spaces used as a whole, spaces served by automatic or programmable lighting controls, and controls for security or safety.
5. The use of infrared occupancy sensors shall be investigated for all restrooms, classrooms, offices, breakrooms, lunchrooms, conference rooms, and other areas of intermittent use and shall include dual-technology sensing capabilities that include PIR (passive infrared) with ultrasonic or single technology microwave.
6. Standalone Occupancy Sensors:
 - a) Wall box – Wired:
 - i) Wall mounted motion sensor using passive infrared to detect moving personnel (minimum 300 square foot coverage for desktop activity). When motion is detected, lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Selectable automatic or manual control mode



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- integrated light level sensor, adjustable intensity (0-to-200-foot candles), light level and time delay switches, and compatible with installed LED light sources, drivers or luminaires of any kind.
 - ii) Rating: 0-800 watts at 120V; 0-1200 watts at 277V. UL listed, CBSC Title 24.
 - iii) Basis of Design shall be Lighthawk by Current model LHMTS1-N-***, Leviton model OSSMT-GD xxxx, or Watt Stopper “DW-200-*”, or pre-approved equal.
 - iv) Provide five (5) year product warranty.
 - b) Wall box – Wireless:
 - i) Wireless standalone wall sensors shall be acceptable with prior approval of Facilities and IT.
 - ii) Wireless units shall adhere to the same functional technology requirements as wired sensors.
 - iii) These units shall have integral battery with an operational life of minimum five (5) or be powered by a low-voltage remote power pack source.
 - iv) Wireless sensors shall operate at or around 900MHz and shall NOT be WiFi or 5G.
 - v) Wireless units and accessories shall be manufactured by Current , ETC, Avi-On, or Sensorworx.
 - c) Ceiling Wireless:
 - i) Wireless standalone Ceiling sensors shall be acceptable with prior approval of Facilities.
 - ii) Wireless units shall adhere to the same functional technology requirements as wired sensors.
 - iii) These units shall have integral battery with an operational life of minimum five (5) or be powered by a low-voltage remote power pack source.
 - iv) Wireless sensors shall operate at or around 900MHz and shall NOT be WiFi or 5G wireless.
 - v) Wireless units and accessories shall be manufactured by Current, ETC, Avi-On, or Sensorworx.
7. Prime Professional to coordinate HVAC system and occupancy sensor control through BAS system.
8. System Services for All Lighting Control Systems
- a) Pre-installation visit:
 - i) Conducted by manufacturer or local authorized service representative to review requirements with installer prior to equipment installation and wiring.
 - b) System startup:
 - i) Scheduled upon completion of equipment installation and installation checklists.
 - ii) Startup must be conducted by a manufacturer or local authorized service technician based within 50 miles of project location. Startup shall include:
 - (1) Verify all system devices are functional.
 - (2) Program devices to document sequence of operations.
 - (3) Verify control network communication, if applicable.
 - (4) Name and program network devices into control zones per plans, if applicable.



- c) System Training:
 - i) Training must be done by a factory authorized technician familiar with site installation and programming. Training shall include:
 - (1) Component overview.
 - (2) System function/Sequence of operations.
 - (3) Phone application overview.
 - (4) Network overview and software walkthrough, if applicable.
- d) Diagnostic Support:
 - i) For one (1) year from system startup signoff.
 - ii) Phone support for questions or troubleshooting.
 - iii) Reprogramming of replacement parts.
- e) System Adjustment:
 - i) Within one (1) year of system startup signoff.
 - ii) One site visit to perform minor system adjustments, if needed.
 - iii) Training shall also be performed during this visit, if requested.

26 13 26 Medium-Voltage Metal-Clad Switchgear

1. During the design stages, the Facilities Management Department will be consulted as to the choice of primary supply voltage, its location, and the available capacity.
2. The primary voltage available on campus is 13.2 kV underground services provided by PECO Energy.
3. Unit Substations:
 - a) Outdoor transformers shall be oil or non-PCB dielectric fluid filled.
 - b) Outdoor, medium-voltage, pad-mounted, oil-filled transformers shall also be copper-wound, “K”-rated, and rated for 95 kV BIL.
 - c) Indoor transformers shall be dry type equipped with fans. Temperature indicator and alarm device shall be provided. Alarm devices shall also de-energize the main primary and secondary breaker circuit by means of a shunt trip device.
 - d) Indoor, medium-voltage, unit substation transformers shall be “K”-rated, copper-wound, air-cooled or cast coil-type, rated for 95 kV BIL.
 - e) All transformers shall have proper indicating gauges and shall include amperage, voltage, and phase.
 - f) Primary switches shall be fused load break switches sized for system short circuit current. Provision should be made for spare fuse link storage in switch. Three (3) spare fuses shall be provided with each primary disconnect switch. Switch design is subject to the approval of the University’s Project Manager and University Facilities Management.
 - g) Switchgear shall be provided with barriers to allow maintenance on sections. Where applicable, lifting devices for removal of draw out type circuit breakers shall be provided.
 - h) Primary switch and secondary breaker shall be key interlocked. Other key interlocking schemes shall be covered under the Specifications.
 - i) Liquid-filled transformers shall be provided with a containment area capable of holding the full volume in the unit and include an alarm on floor of containment area connected to the BAS to provide alarm in case of failure.



- j) Where designated by the University an automatic switching sequence shall be provided between the incoming circuit breakers and the normally open tiebreakers.
 - k) Relaying shall be provided on power transmission equipment. This should include instantaneous and time over-current per phase, differential protection across transformers and instantaneous ground protection.
 - l) A pulse type watt-hour demand meter labeled with KWH, volt, amp, and power factor and other pertinent information shall be provided for each circuit so that it can be connected to and monitored by the University's Building Automation System.
 - i) Each unit substation shall be equipped with an electronic power monitoring device, on the low-voltage side of the transformer, capable of displaying individual phase voltages and amperages, three-phase power factor, kWh totalization and kW demand for a fixed, 30-minute window.
 - ii) The power monitor shall also provide a KYZ pulse initiator output of kWh.
 - iii) Basis of design: [Penn Panel and Box](#).
 - iv) Approved manufacturers: Cutler Hammer, Siemens, [ABB](#), and Square-D.
 - m) Electrical substations will be designed and constructed to always operate at 0.95 lagging power factor or better.
 - n) All unit substation rooms shall be ventilated at 1.5 times the total room volume with manual damper control for fresh air to the substation.
 - o) Distribution cable will be Kerite with 0.5 mil copper shielding and rated at 15KV for either 15KV or 2.4KV service. Building services shall always be minimum 4/0 cable.
 - p) [Temperature indicator and alarm device basis of design to be Orion Italia with individual phase temperature, alarms, communication port, etc.](#)
 - q) [Surge arrestors are not required in transformers downstream of the main switchgear, if switchgear has surge protection installed.](#)
4. Service Entrances and distribution panel:
- a) Main and feeder breakers shall be equipped with ground fault protection. Over-current protection shall also be provided with coordination curves supplied by the A/E on breakers 1200 amps and larger.
 - b) A pulse type watt-hour demand meter labeled with KWH, volt, amp, and power factor and other pertinent information shall be provided for each distribution feeder so that it can be connected to and monitored by the University's Building Automation System.
 - i) Each unit substation shall be equipped with an electronic power monitoring device, on the low-voltage side of the transformer, capable of displaying individual phase voltages and amperages, three-phase power factor, kWh totalization and kW demand for a fixed, 30-minute window.
 - ii) The power monitor shall also provide a KYZ pulse initiator output of kWh.
 - iii) Basis of design: Cutler Hammer, IQ DP-4130.
 - c) Circuit breakers shall be provided for secondary feeder circuits. Breaker size shall be coordinated with the main distribution breaker.
 - d) All secondary distribution panels shall contain complete panel schedules with room or equipment designation fed by each breaker.
 - e) All motor power supplies shall contain a fused disconnect switch, or appropriate breaks, or to be provided with a combination starter in accordance with NEMA standards.
 - f) One-third spare capacity shall be included in all designs.



5. Grounding System:
 - a) Drawings shall show grounding systems. Details of the grounding system shall also be provided as opposed to a reference to the NEC only.
 - b) A separate ground conductor in each circuit shall be required.
 - c) Sizing of ground conductors shall be in accordance with NEC specifications.
 - d) Equipment grounds shall be wired to an uninsulated ground bus. Panel neutral bars may not be used for this grounding.
 - e) Normal service ground for substations shall be driven earth ground rods with bare copper conductors.

6. Feeder Circuits:
 - a) Designs shall allow for 30% increase in loading over original sizing.
 - b) Feeder ratings shall not be so large that coordination of relays cannot be obtained due to high percentage load on mains.
 - c) All feeders must be in rigid conduit (not EMT) or in feeder-enclosed bus.

7. Branch Circuits:
 - a) Voltage drops must be taken into account in design. Home runs of 75 feet or more will necessitate an increase of a minimum of one wire size.
 - b) Six duplex receptacles shall be the maximum on any 20 AMP branch circuit.
 - c) Branch circuit panels shall be limited to 42 poles. Circuits shall be protected by thermal magnetic molded case circuit breakers. Fully one-third of these panels shall be spare capacity.
 - d) Circuit breakers shall be a minimum of 20 AMP, with bolted bus connections.
 - e) Individual loads other than receptacle or lighting breakers shall be individually sized to match the loading.

26 29 23 Variable-Frequency Motor Controllers

1. Basis of design to be ABB (no substitutions).
 - a) Model ACH580-PNPT01U-EN, 6 pulse for motors below 30HP.
 - b) Model ACH580-PNPT05U-EN, ultra-low harmonic for motors 30HP and above.

2. A/E to review ABB specifications with Facilities Management and/or University Engineer for project requirements.

3. The drive package as specified herein and defined on the drive schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer to ISO9001 standards.

4. The drive shall provide full rated output from a line of +10% to -15% of nominal voltage. The drive shall continue to operate without faulting from a line of +25% to -35% of nominal voltage.
 - a) Drives shall be capable of continuous full load operation under the following environmental operating conditions:
 - i) Ambient temperature: 5°F to 104°F.
 - ii) Altitude: 0 ft. to 3,300 ft. above sea level.



- iii) Humidity: 5% to 95%, non-condensing.
- 5. A/E to design circuit breaker or disconnect switch for multiple pump or fan arrangements, which contain a backup.
- 6. A/E to design bypass drive for single pump or fan arrangement.
- 7. Product Warranty: Shall be 30 months from the date of shipment from the factory. The warranty shall include parts, on-site labor, and travel time and travel costs, or replacement of the complete drive as determined by the drive manufacturer's technical support.

26 32 13 Engine Generators

1. Generator basis of design is to be natural gas type. Diesel is only allowed if natural gas is not available, pressure is too low, and/or large building loads. A/E to [review with the Facilities Department](#) prior designing.
2. Applicable Codes and Standards:
 - a) The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.
 - i) ANSI S1.13-1971—Measurement of Sound Pressure Levels in Air.
 - ii) CSA 282, 1989 Emergency Electrical Power Supply for Buildings.
 - iii) IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
 - iv) NFPA 30 – Flammable and Combustible Liquids.
 - v) NFPA 37 – Standard For the Installation and Use of Stationary Combustion Engines and Gas Turbines.
 - vi) NFPA 70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
 - vii) NFPA 99 – Essential Electrical Systems for Health Care Facilities.
 - viii) NFPA 110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
 - b) The generator set and supplied accessories shall meet the requirements of the following standards:
 - i) NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
 - ii) UL142 – Sub-base Tanks.
 - iii) UL1236 – Battery Chargers.
 - iv) UL2200. The generator set shall be listed to UL2200 or submit to an independent third-party certification process to verify compliance as installed. The generator set and all accessories shall be CSA certified.
 - c) The control system for the generator set shall comply with the following requirements.
 - i) CSA C22.2, No. 14 – M91 Industrial Control Equipment.



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- ii) EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
 - iii) EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 - iv) FCC Part 15, Subpart B.
 - v) IEC8528 part 4. Control Systems for Generator Sets.
 - vi) IEC Standard 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
 - vii) UL508. The entire control system of the generator set shall be UL508 listed and labeled.
 - viii) UL1236 – Battery Chargers.
 - d) The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
3. Approved automatic transfer switch manufacturers are ASCO 7000 Series, Cummins OTEC, and GE ZT Series.
 4. Generators used for Emergency, Standby and Optional Standby Power systems are to be designed in accordance with Articles 700, 701 and 702 of the National Electric Code, version as adopted by the City of Philadelphia.
 5. When additional emergency circuits need to be added to the existing generator, it is the A/E firm's responsibility for coordinating the new and existing loads with the University Project Manager and Facilities Department to determine if the existing generator has the capacity.
 6. Emergency generators will be provided in new locations. These units shall normally be automatic starting natural gas engine driven with fume detector. The generator horsepower rating must be less than 1,000 HP, if larger A/E to discuss with [EH&RS](#) and Facilities. Documentation of connected load shall be identified as actual load connected and generator sized for 30% over connected load for future loading.
 7. An emergency panel board will be provided to service exit lighting, minimum building lighting needed for evacuation, fire, building alarm systems, telephones, and relay to central control system. University areas and certain laboratories shall also be connected to emergency systems where specified.
 8. Emergency system wiring shall be in separate conduits.
 9. Emergency lighting switches shall not be located in normal lighting panels.
 10. Elevator sump pumps shall be included in the emergency power systems. In certain buildings some lab equipment, HVAC equipment (boiler, one heating hot water pump), and various panels (BAS and security card access) shall be designated to be on emergency power.



11. A minimum of one (1) 20A emergency receptacle per 4,000 sq. ft. to be provided on each floor and designated as emergency. The outlets will be located in accessible areas on each floor (lobby, corridors, etc.).
12. Telecommunications and Data Closet requires the installation of three (3) 20-Amp dedicated 120-volt quad outlets with dedicated #10 wire, neutrals, and grounds on Emergency Power. Dedicated cooling for IT equipment to be on Emergency Power.
13. Contractor shall refer to Section III of the City of Philadelphia Department of Public Health Air Pollution Control Board – Air Management Regulation XV, Control of Emissions from Emergency Generators and Fire Pumps, regarding generator operation to determine if operation is during ozone season.
14. Engine exhaust discharge point to be a cap type with birdscreen. Lid type is **prohibited** due to high wind velocities.
15. Transfer switch is to be capable of having its' exerciser disabled and being able to be programmed to meet the timing requirements of NFPA 110.
16. A/E is to design an exterior connection point for a temporary emergency generator hookup.
17. Drexel Facilities does not require a preset schedule on emergency generators or ATS equipment. Running and testing is manual as per Facilities set calendar.
18. All generators to be secured on a reinforced concrete pad no less than six inches deep.
19. A minimum of one light fixture and one 20A emergency receptacle in the switchgear room or main electrical room shall be on emergency power.
20. Provide generator with security fencing and lighting and label with NFPA 704 labels.
21. A/E to coordinate with item 7 in section 23 11 23, Facilities Natural Gas Piping, for contractor required forms to the City of Philadelphia.

26 32 13.13 Diesel-Engine-Driven Generator Sets

1. Approved diesel gas engine generator manufacturers are Caterpillar Power Systems, Cummins Power Systems, MTU Onsite Energy, and Generac.
2. Refer to section 26 32 13, Engine Generators, for additional information.
3. Generator Set:
 - a) Ratings:
 - i) The generator set shall operate at 1800 rpm. A/E to determine the Volts AC, phase, wire, and hertz per project.
 - ii) The complete generator set shall be rated per ISO8528: A/E to determine the kW at 0.8 PF, if the system is Standby, Prime, Limited time prime or Continuous Duty



- rating, based on site conditions of: Altitude 56 feet, ambient temperatures of 104°F, based on temperature measured at the control for indoor installations, and measured at the air inlet closest to the alternator for outdoor equipment.
- iii) The generator set rating shall be based on emergency/standby service and marked as such per NFPA110.
- b) Performance:
- i) Voltage regulation shall not exceed one percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
 - ii) Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
 - iii) Generator sets shall be designed to allow operation at full rated load in an ambient temperature under site conditions, based on highest ambient condition. Ambient temperature shall be as measured at the air inlet to the generator set for enclosed generator sets, and at the control of the generator set for machines installed in equipment rooms.
 - iv) The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
 - v) Motor starting capability minimum kVA shall be determined by the A/E per project. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
 - vi) The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
 - vii) The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating and shall meet all applicable exhaust emission requirements at the time of commissioning.
 - viii) The generator set shall share real and reactive load proportionally within plus or minus 3% with all other generator sets in the system.
 - ix) The time required to automatically start, accelerate to rated speed and voltage, synchronize and parallel all generator sets to the system bus on a normal power failure shall not exceed 15 seconds, assuming that the generator sets are in an ambient temperature of 59°F or greater, and water jacket heaters are operating properly.
 - x) The generator set and complete sound attenuated enclosure sound levels shall be tested by the manufacturer per ANSI S1.13. Data documenting performance shall be provided with submittal documentation.
- c) Construction:
- i) The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.



- ii) All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.
 - iii) All outdoor equipment shall be enclosed with corrosion-protected materials. Steel components used in enclosures shall be powder coated and baked and shall provide fade and corrosion resistance in compliance to dry film thickness shall be shd3363 of 2H+all a minimum of 1.8 Mils, gloss at 60degrees per ASTMD523 of 80 +/- 10, pencil hardness per ASTM D3363.
- d) Connections:
- i) The generator set load connections shall be composed of silver- or tin-plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings. Generator set feeder distribution shall be wall mounted and compliant to code requirements for conductor sizing, isolation of devices, and isolation of service types.
 - ii) Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
 - iii) Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.
4. Engine and Engine Equipment:
- a) The engine shall be diesel, 4-cycle, radiator, and fan cooled. Minimum displacement volume and number of cylinders shall be determined by the A/E per project. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:
 - i) An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
 - ii) Skid-mounted radiator and cooling system rated for full load operation in the ambient temperature called out in this specification as measured at the generator air inlet, based on 0.5 in H₂O external static head. Radiator shall be sized based on a core temperature which is 50°F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with a 50/50-ethylene glycol/water mixture by the equipment manufacturer. Rotating parts shall be guarded against accidental contact.
 - iii) Electric starters capable of three complete cranking cycles without overheating.
 - iv) Positive displacement, mechanical, full pressure, lubrication oil pump.
 - v) Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
 - vi) Diesel engines shall include an engine driven, mechanical, positive displacement fuel pump and fuel filter(s) with replaceable spin-on canister element(s). Fuel cooler,



suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.

- vii) Replaceable dry element air cleaner with restriction indicator.
- viii) Flexible supply and return fuel lines.
- ix) Engine mounted battery charging alternator, 40-ampere minimum, and solid-state voltage regulator.
- x) Coolant heater:
 - (1) Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
 - (2) The coolant heater shall be installed on the engine with SAEJ20 compliant materials. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using isolation valves to isolate the heater for replacement of the heater element. The design shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - (3) The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection shall be provided for a single AC power connection to the coolant heater system.
 - (4) The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104°F in a 59°F ambient, as a minimum, or the temperature required for starting and load pickup requirements of this specification.
- xi) Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
- xii) Starting and Control Batteries shall be lead acid type, 24-volt DC, sized as recommended by the engine manufacturer for compliance to NFPA110 starting requirements, complete with battery cables and connectors.
- xiii) Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer to meet sound attenuation requirements of the application. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.
- xiv) Provide fully regulated, constant voltage, current limited, battery charger for each battery bank, plus a parallel operating redundant charger for each required charger. The chargers shall be designed for heavy-duty industrial service, primarily to quickly recharge and maintain batteries that start internal combustion engines. Charger shall be rated a minimum of 10 amps and be capable of operating in parallel with another like charger for reliability and added charging capacity.
 - (1) Charger shall provide 4 distinct charge states: "dead battery", "bulk charge", "absorption", and "float". Charge rate shall be temperature compensated to provide proper charging in ambient conditions from -4°F to +131°F.



- (2) Provider LED indication of general charger condition, including charging, fault, and equalize. Provide a 2-line LCD display to indicate charge rate, battery voltage, faults, and provide for charger set up. Charger shall provide relay contacts for fault conditions as required by NFPA110.
 - (3) The charger shall operate properly during fault conditions, including battery disconnection while charging, reversed battery polarity connections, and shorted battery.
 - (4) The charger shall be compliant to the same RFI/EMI and voltage surge performance as are specified for the genset control.
 - xv) Provide a UL or CSA listed sub-base fuel tank suitable for full load operation of the generator set for up to 6 hours for non-laboratory and 12 hours for laboratory spaces and complying with local requirements.
 - xvi) Provide a day tank for each generator set suitable for operating the generator set for at least one hour at full load. Day tank shall be equipped for automatic unattended operation. The tank shall be UL listed, made of aluminized steel with welded construction, and pressure tested to 3 PSI. The day tank shall incorporate an integral fuel pump and motor; 1/4 HP, 120/240 Volt, 1-phase, 2 GPM with 20-foot lift. Provide a hand operated pump to bypass the motor driven pump and valves, for emergency use. The fuel day tank control shall be provided with On/Off/Emergency Run Switch, Test/Reset Switch, AC Circuit Breaker, DC Circuit Breaker, and Indicator lamps:
 - (1) Ready (green) – AC supply & DC control power available.
 - (2) High Fuel (red) – Latching fault, indicates fuel level near overflow, shuts down pump, and closes N/O dry contacts.
 - (3) Low Fuel (red) – Latching fault, indicates pump failure or operating float switch failure, Closes N/O dry contacts.
 - (4) Low Fuel Shutdown (red) – Latching fault, indicates near empty tank, closes N/O contacts which may be used to shutdown generator set to avoid air in the injection system.
 - (5) Overflow to basin (red) – Latching fault, indicates fuel in overflow/rupture basin, shuts down pump, closes N/O dry contacts.
 - (6) Spare (red) – with N/O and N/C dry contacts.
 - (7) Pump Running (green).Contacts shall be rated not less than 2 amps at 30VDC and 0.5 amps at 120VAC. Provide an overflow/rupture basin for the day tank with a minimum capacity of 150% of the day tank volume. Include an overflow alarm to indicate fuel in the basin.
5. AC Alternator and Accessories to be selected by A/E and reviewed with Facilities.
 6. Generator Set Control and Protection. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, protection, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.



The control shall be mounted on the generator set. The control shall be vibration isolated, and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The generator set mounted control shall include the following features and functions:

- a) Control Switches:
 - i) Mode Select Switch: The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - ii) EMERGENCY STOP switch: Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down and be locked out from automatic restarting. The switch shall include a lockout provision for use in safely disabling the generator set for necessary service.
 - iii) RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - iv) PANEL LAMP switch: Operating the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is operated, or after the switch is operated a second time.
 - v) Voltage and Frequency Adjustment: The genset mounted control shall include digital raise/lower switches for adjustment of voltage and frequency.
- b) Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
 - i) Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings more than 100%: red.
 - ii) Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages and shall display all three phase voltages (line to neutral or line to line) simultaneously.
- c) Generator Set Alarm and Status Display:
 - i) The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing warning and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of all alarm, shutdown, and status conditions associated with the generator set, including all paralleling control functions and the engine ECM on an alphanumeric display on the genset. The following alarm, shutdown, and status conditions are required, as a minimum:
 - (1) Low oil pressure (alarm).
 - (2) Low oil pressure (shutdown).
 - (3) Oil pressure sender failure (alarm).



- (4) Low coolant temperature (alarm).
 - (5) High coolant temperature (alarm).
 - (6) High coolant temperature (shutdown).
 - (7) Engine temperature sender failure (alarm).
 - (8) Low coolant level (alarm or shutdown--selectable).
 - (9) Fail to crank (shutdown).
 - (10) Fail to start/overcrank (shutdown).
 - (11) Overspeed (shutdown).
 - (12) Low DC voltage (alarm).
 - (13) High DC voltage (alarm).
 - (14) Weak battery (alarm).
 - (15) Low fuel-daytank (alarm).
 - (16) High AC voltage (shutdown).
 - (17) Low AC voltage (shutdown).
 - (18) Under frequency (shutdown).
 - (19) Over current (warning).
 - (20) Over current (shutdown).
 - (21) Short circuit (shutdown).
 - (22) Ground fault (alarm).
 - (23) Overload (alarm).
 - (24) Emergency stop (shutdown).
- ii) The generator set control shall annunciate all alarm and shutdown conditions from the engine electronic control.
 - iii) Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- d) Engine Status Monitoring:
- i) The following information shall be available from a digital status panel on the generator set control:
 - (1) Engine oil pressure (psi).
 - (2) Engine coolant temperature (°F).
 - (3) Engine oil temperature (°F).
 - (4) Engine speed (rpm).
 - (5) Number of hours of operation (hours).
 - (6) Number of start attempts.
 - (7) Battery voltage (DC volts).
 - ii) The control system shall also incorporate a data logging and display provision to allow logging of a minimum of the last 20 warning or shutdown indications on the generator set, the time of the last fault of each type, and the number of faults of each type, and total time of operation at various loads as a percent of the standby rating of the generator set.
- e) Engine Control Functions:
- i) The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3



- cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
- ii) The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.
 - iii) The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
 - iv) The control system shall include sender failure monitoring logic for oil pressure, and engine temperature which can discriminate between failed sender or wiring components, and an actual failure condition.
- f) Alternator Control Functions:
- i) The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched, and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from mis-operation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
 - ii) Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds.
 - iii) Controls shall be provided to individually monitor all three phases of the output current for 1, 2, or 3-phase short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). This function shall be provided by equipment which is listed under UL category NRGU.
 - iv) Controls shall be provided to monitor the KW load on the generator set and initiate an alarm condition (overload) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
 - v) An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%.



- Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
- vi) A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25 VDC or more than 32 VDC (24VDC nominal) or less than 8 VDC or more than 16 VDC (12VDC nominal). During engine cranking (starter engaged), the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.
 - vii) The control System shall include a ground fault monitoring relay.
 - g) The generator set shall be provided with a network communication module to allow real time communication with the generator set control by remote devices. The control shall communicate all engine and alternator data; alarm, shutdown, and status conditions; and allow starting and stopping of the generator set via the network in both test and emergency modes.
 - h) Control Interfaces for Remote Monitoring:
 - i) No field connections for control devices shall be made in the AC power output enclosure. Provide the following features in the control system:
 - (1) Form "C" dry contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.
 - (2) One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.
 - (3) A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
 - (4) A fused 20-amp 24VDC power supply circuit shall be provided for customer use. DC power shall be always available from this circuit from the engine starting/control batteries.
 - (5) The control shall be provided with a direct serial communication link for the communication network interface as described elsewhere in this specification and shown on the drawings.

7. Outdoor Enclosure:

- a) The generator set shall be provided with an outdoor enclosure. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank (when used) shall be designed to be lifted into place using spreader bars.
 - i) Enclosure shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100°F. The enclosure shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable and include retainers to hold the door open during service. Enclosure roof shall be designed to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.
 - ii) All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer's standard color using a powder coat paint process, or equal meeting



the performance requirements specified below. All surfaces of all metal parts shall be primed and painted.

- iii) Enclosure material shall be either steel or aluminum. Steel enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels. Aluminum enclosure shall be wind rated for 150 mph conditions. All enclosure hardware and hinges shall be stainless steel.
- iv) A factory-mounted exhaust silencer shall be installed inside the enclosure and insulated as necessary to allow the generator set to operate at rated load in the maximum specified ambient temperature. Exhaust connections to the generator set shall be through seamless flexible connections.
- v) The enclosure shall include the following maintenance provisions:
 - (1) Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves.
 - (2) External radiator fill provision.
- vi) Provide motorized louvers to minimize air flow through the enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
- vii) Inlet ducts shall include rain hoods.
- viii) Provide a mounted and wired electrical distribution panel to serve the generator set and enclosure. The provisions required include:
 - (1) 100-amp distribution panelboard connected to a 120/240VAC utility service by the installer.
 - (2) Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure.
 - (3) Two three-way switches controlling AC lamps mounted in vapor tight and gasketed fixtures.
 - (4) Normal AC service from the panelboard to the engine coolant and alternator heaters, and battery charger.
- ix) The generator set shall be provided with sound-attenuated housing which allows the generator set to operate at full rated load in an ambient temperature of up to 100 deg. F. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 85 dBA at any location 3 feet from the generator set.
- x) The enclosure shall be insulated with non-hygroscopic materials. The enclosure shall have a minimum of 25 dBA of sound attenuation.

26 32 13.16 Gas-Engine-Driven Generator Sets

1. Approved natural gas engine generator manufacturers are Caterpillar Power Systems, Cummins Power Systems, and MTU Onsite Energy.
2. Refer to section 26 32 13, Engine Generators, for additional information.
3. Generator set:
 - a) Ratings:
 - i) The generator set shall operate at 1800 rpm. A/E to determine the Volts AC, phase, wire, and hertz per project.



- ii) The generator set rating: A/E to determine the kW, kVA at 0.8 PF, rating, based on site conditions of: Altitude 59 ft., ambient temperatures up to 104°F.
- iii) The generator set rating shall be based on emergency/standby service.
- b) Performance:
 - i) Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
 - ii) Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
 - iii) The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
 - iv) Motor starting capability minimum kVA shall be determined by the A/E per project.
 - v) The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
 - vi) The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic. Telephone influence factor shall be less than 40.
- c) Construction:
 - i) The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
 - ii) All switches, lamps, and meters in the control system shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate more than 50 volts.
- d) Connections:
 - e) The generator set load connections shall be composed of silver- or tin-plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
 - f) Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
 - g) Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.
- 4. Engine and Engine Equipment:
 - a) The engine shall be natural gas fueled, radiator and fan cooled. Minimum displacement volume and number of cylinders shall be determined by the A/E per project. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Engine accessories and features shall include:
 - i) Complete engine fuel system, including all pressure regulators, strainers, and control valves. The fuel system shall be plumbed to the generator set skid for ease of site



connections to the generator set. For dual fuel systems, changeover from primary to secondary fuel shall be automatic.

- ii) An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
- iii) Skid-mounted radiator and cooling system rated for full load operation in 104°F ambient as measured at the generator air inlet, based on 0.5 in H₂O external static head. Radiator shall be sized based on a core temperature that is 20°F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture. Rotating parts shall be guarded against accidental contact.
- iv) Electric starter(s) capable of three complete cranking cycles without overheating.
- v) Positive displacement, mechanical, full pressure, lubrication oil pump.
- vi) Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
- vii) Replaceable dry element air cleaner with restriction indicator.
- viii) Flexible fuel lines.
- ix) Engine mounted battery charging alternator, 40-ampere minimum, and solid-state voltage regulator.
- x) Coolant heater:
 - (1) Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
 - (2) The coolant heater shall be installed on the engine with high temperature silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using quick disconnect couplers to isolate the heater for replacement of the heater element. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - (3) The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.
 - (4) The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100°F in a 40°F ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.



- xi) Provide vibration isolators, spring/pad type or as recommended by the manufacturer, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
- xii) Starting and Control Batteries shall be calcium/lead antimony type, 24-volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.
- xiii) Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer. The mufflers shall be critical grade. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.
- xiv) Provide a minimum 12-amp battery charger for each generator set battery bank. Generator sets incorporating two battery banks shall be provided with two chargers connected together and operating in parallel, with alarm output(s) connected in parallel. The charger(s) shall include the following capabilities:
 - (1) Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.
 - (2) The charger shall be compliant with UL991 requirements for vibration resistance.
 - (3) The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; EN61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.
 - (4) The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.
 - (5) The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.
 - (6) The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.
 - (7) The charger shall include the following features:
 - (a) Two-line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming.
 - (b) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red).
 - (c) AC input overcurrent, over voltage, and undervoltage protection.
 - (d) DC output overcurrent protection.
 - (e) Alarm output relay.



(f) Corrosion resistant aluminum enclosure.

5. AC Generator:
- a) The AC generator shall be synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed A/E determined temperature (°F).
 - b) The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
 - c) A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
 - d) The sub-transient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.
 - e) The alternator shall be capable of operation with reverse kVAR of 0.15 per unit.
6. Generator set Control: The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

The control shall be mounted on the generator set or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated, and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The generator set mounted control shall include the following features and functions:

- a) Control Switches:
- i) Mode Select Switch: The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - ii) EMERGENCY STOP switch: Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down and be locked out from automatic restarting.
 - iii) RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - iv) PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be



- switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
- b) Generator Set AC Output Metering: The generator set shall be provided with a metering set including the following features and functions:
- i) Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
 - ii) Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be color coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output. Both analog and digital metering are required.
 - iii) The control system shall monitor the total load on the generator set and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
 - iv) The control system shall log total number of operating hours, total kWh, and total control on hours, as well as total values since reset.
- c) Generator Set Alarm and Status Display:
- i) The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
 - (1) The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).
 - (2) The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
 - (3) The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
 - (4) The control shall include an amber common warning indication lamp.
 - ii) The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:
 - (1) Low oil pressure (warning).
 - (2) Low oil pressure (shutdown).
 - (3) Oil pressure sender failure (warning).
 - (4) Low coolant temperature (warning).
 - (5) High coolant temperature (warning).
 - (6) High coolant temperature (shutdown).
 - (7) High oil temperature (warning).



- (8) Engine temperature sender failure (warning).
 - (9) Low coolant level (warning).
 - (10) Fail to crank (shutdown).
 - (11) Fail to start/overcrank (shutdown).
 - (12) Overspeed (shutdown).
 - (13) Low DC voltage (warning).
 - (14) High DC voltage (warning).
 - (15) Weak battery (warning).
 - (16) Low fuel-daytank (warning).
 - (17) High AC voltage (shutdown).
 - (18) Low AC voltage (shutdown).
 - (19) Under frequency (shutdown).
 - (20) Over current (warning).
 - (21) Over current (shutdown).
 - (22) Short circuit (shutdown).
 - (23) Overload (warning).
 - (24) Emergency stop (shutdown).
 - (25) (4) Configurable conditions.
- iii) Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- d) Engine Status Monitoring:
- i) The following information shall be available from a digital status panel on the generator set control:
 - (1) Engine oil pressure (psi).
 - (2) Engine coolant temperature (°F).
 - (3) Engine oil temperature (°F).
 - (4) Engine speed (rpm).
 - (5) Number of hours of operation (hours).
 - (6) Number of start attempts.
 - (7) Battery voltage (DC volts).
 - ii) The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.
- e) Engine Control Functions:
- i) The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
 - ii) The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
 - iii) The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification.



- The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
- iv) The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
 - v) The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which can discriminate between failed sender or wiring components, and an actual failure condition.
- f) Alternator Control Functions:
- i) The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched, and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from mis-operation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
 - ii) Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 Article 445. The protection for this function shall be 3rd party certified to very performance.
 - iii) Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 Article 445. The protection for this function shall be 3rd party certified to very performance.
 - iv) Controls shall be provided to monitor the KW load on the generator set and initiate an alarm condition (overload) when total load on the generator set exceeds the generator set rating for more than 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
 - v) A line to neutral sensing AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when



- voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
- vi) When required by the National Electrical Code or indicated on project drawings, the control system shall include a ground fault monitoring relay. The relay shall be adjustable from 3.8-1200 amps and include adjustable time delay of 0-10.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set and provide relay that will function correctly in system as installed.
 - vii) The generator set control shall include a 120VAC-controlled heater.
 - g) Other Control Functions:
 - i) The generator set shall be provided with a network communication module to allow compliant communication with the generator set control by remote devices. The control shall communicate all engine and alternator data and allow the starting and stopping of the generator set via the network in both test and emergency modes.
 - ii) A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.
 - h) Control Interfaces for Remote Monitoring:
 - i) The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, and (4) load shed command.
 - ii) A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
 - iii) A fused 10-amp 24VDC power supply circuit shall be provided for customer use. DC power shall be always available from this circuit from the engine starting/control batteries.
 - iv) The control shall be provided with a direct serial communication link for the communication network interface as described elsewhere in this specification and shown on the drawings.
7. Other equipment to be provided with the generator set:
- a) Outdoor Weather Protective Enclosure:
 - i) The generator set shall be provided with an outdoor enclosure, with the entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank (when used) shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100 °F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into



the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

- ii) All sheet metal shall be primed for corrosion protection and finish paint with the manufacturer's standard color using a two-step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
 - (1) Primer thickness, 0.5-2.0 mils. Topcoat thickness, 0.8-1.2 mils.
 - (2) Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
 - (3) Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
 - (4) Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
 - (5) Salt Spray, per ASTM B117-90, 1,000+ hours.
 - (6) Humidity, per ASTM D2247-92, 1,000+ hours.
 - (7) Water Soak, per ASTM D2247-92, 1,000+ hours.
- iii) Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.
- iv) Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels. All hardware and hinges shall be stainless steel.
- v) A factory-mounted exhaust silencer shall be installed inside the enclosure. The exhaust shall exit the enclosure through a rain collar and terminate with a rain cap. Exhaust connections to the generator set shall be through seamless flexible connections.
- vi) The enclosure shall include the following maintenance provisions:
 - (1) Flexible coolant and lubricating oil drain lines, which extend to the exterior of the enclosure, with internal drain valves.
 - (2) External radiator fill provision.
- vii) Provide an external emergency stop switch that is protected from accidental actuation.
- viii) Provide motorized louvers to minimize air flow through the enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
- ix) Inlet ducts shall include rain hoods.
- x) Provide a factory mounted and wired electrical distribution panel to serve the generator set and enclosure. The provisions required include:
 - (1) 100-amp distribution panelboard connected to a 120/240VAC utility service by the installer.
 - (2) Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure.
 - (3) Two three-way switches controlling three AC lamps mounted in vapor tight and gasketed fixtures.
 - (4) Factory-wired normal AC service from the panelboard to the engine coolant and alternator heaters, and battery charger.



- xi) The generator set shall be provided with sound-attenuated housing which allows the generator set to operate at full rated load in an ambient temperature of up to 100 °F. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 85 dBA at any location 3 feet from the generator set.
- xii) The enclosure shall be insulated with non-hydroscopic materials. The enclosure shall have a minimum of 25 dBA of sound attenuation.

26 41 00 Facility Lightning Protection

1. Each building shall be considered individually as to the necessity for lightning protection as it may fall within the cone of protection provided by other structures. If such an installation is deemed necessary, an Underwriter Label Master System shall be specified.
2. Steel frame buildings shall be provided with a low resistance grounding system whether or not lightning protection is provided.
3. 13.2KV lightning arresters shall be rated for 15KV. 2.4 KV lightning arresters shall be rated for 5KV.

26 51 00 Interior Lighting

1. The interior lighting design for new buildings shall be in accordance with the requirements and limitations of the 2018 International Energy Conservation Code. The following values are extrapolated from Table C405.3.2, which stipulates allowable power density allowances by building type:
 - a) Atrium (Less than 40 ft. in height) 0.03 W/sf. per foot in total height
 - b) Atrium (Greater than 40 ft. in height) $0.40 + 0.02$ W/sf. per foot in total height
 - c) Cafeteria Dining 0.79 W/sf.
 - d) Classrooms 0.96 W/sf.
 - e) Corridor 0.66 W/sf.
 - f) Dormitory 0.61 W/sf.
 - g) Electrical Room 0.43 W/sf.
 - h) Exercise Center 0.65 W/sf.
 - i) Gymnasium 0.68 W/sf.
 - j) Healthcare-clinic 0.82 W/sf.
 - k) Laboratory (Classroom) 1.20 W/sf.
 - l) Laboratory (Non-Classroom) 1.45 W/sf.
 - m) Library 0.78 W/sf.
 - n) Mechanical Room 0.43 W/sf.
 - o) Museum 1.06 W/sf.
 - p) Office (Enclosed) 0.93 W/sf.
 - q) Office (Open) 0.81 W/sf.
 - r) Parking Garage 0.15 W/sf.
 - s) Performing Arts Theater 1.18 W/sf.
 - t) Police Station 0.80 W/sf.
 - u) Religious Buildings 0.94 W/sf.
 - v) Restrooms 0.85 W/sf.



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- w) Retail 0.90 W/sf.
 - x) Stairwell 0.58 W/sf.
 - y) Vivarium 2.50 W/sf.
2. The overall lighting power density for the building must be specified in plans, and only under exceptional circumstances will variances allowing a higher level be permitted.
3. Illuminance Levels:
- a) All lighting applications and light levels shall follow the guidance of the most recent Illuminating Engineering Society Lighting Handbook or applicable Design Guide or recommended practice.
 - b) The illuminance levels specified shall be maintained in accordance with all applicable energy codes and power budgets listed within.
 - c) Task lighting shall be used where necessary to increase specific area illuminance levels or where it can be used to reduce ambient illuminance level requirements.

26 51 19 LED Interior Lighting

1. Interior Lighting Fixtures:
- a) Fixtures used for general interior lighting applications must have an integral LED light source. All other light sources must be approved for use by Planning, Design, and Construction prior to submittal for use.
 - b) Calculations for any luminaires proposed for use must use the following baseline information unless otherwise noted.
 - i) Light loss factor: 0.9%
 - ii) Ceiling cavity reflectance: 80%.
 - iii) Wall reflectance: 50%.
 - iv) Floor cavity reflectance: 20%.
 - c) All sources proposed for use must utilize .ies file sources.
 - d) Specialty and custom-made light fixtures require Facilities review and approval.
 - e) All Manufacturers proposed for use must have at least ten (10) years' experience in development and manufacture of LED Light Sources suitable for architectural use as a general lighting instrument.
2. Lamps and Light Sources:
- a) All light sources shall be LED.
 - i) Efficacy: LED sources shall have a minimum efficacy of 110 lumens per watt, initial.
 - ii) Life and Testing: LED sources shall have Lumen Maintenance per IES TM-21 & LM-80 testing & measuring methods and shall have a minimum expected life of 60,000hrs @ L70.
 - iii) Color: 3500K Correlated Color Temperature.
 - iv) Consistency: 90+ CRI Color Rendering Index with a consistency from fixture-to-fixture of no more than three (3) Macadam's Ellipse.
 - v) Where 'Screw-in' replacement style LED lamps are used to replace conventional light sources, must have integral, dimmable drivers, and must be listed for the specific use, such as 'enclosed' or 'exterior'.



- b) Where replacement is necessary for Conventional source lamps used for general lighting applications must have an efficacy of no less than the lumens per watt specified below:
 - i) Fluorescent: 80 lumens/watt.
 - ii) HID: 110 lumens/watt.
 - iii) Incandescent: $8 + (0.06 \times \text{lamp wattage})$ lumens/watt.
 - c) Fluorescent type lighting, where used shall be at 277 or 208 volts.
 - d) Incandescent lighting may only be used with prior approval and is not encouraged.
 - e) The use of straight two-foot fluorescent lamps is discouraged, U tube lamps or longer lamps.
3. Drivers and Ballasts:
- a) Drivers for use with all LED sources must be capable of 0-10V dimming control, suitable to reach low-end dim levels of 10% unless called out otherwise within specifications for the control system.
 - b) Drivers specifications must be listed on any, and all, submittals for all luminaires proposed for use.
 - c) Electronic or hybrid electronic ballasts shall be used instead of core-coil ballasts. In buildings where the quality of the power supply is of critical concern, electronic ballasts shall be specified. Ballasts shall be of the multi-voltage type (120-277 volts).
4. The Planning, Design and Construction Department, along with the University Architect, has developed a product design guide with standard product solutions to direct installers and design professionals in selection of new luminaires. These fixture standards are in Appendix C – Luminaire Standards.

26 52 13.16 Exit Signs

1. Internally illuminated exit signs shall not exceed 3 Watts per side.
2. Exit signs to be on emergency lighting panel. A/E to verify with University Facilities for approval to use battery backup exit signs. These should only be used when a generator is not available.
3. Exit signs and emergency lighting shall meet UL924, NFPA 101 Life Safety Code, NEC, OSHA, Local and State Codes.

26 56 00 Exterior Lighting

1. The exterior lighting design for new buildings shall be in accordance with the requirements and limitations of the 2018 International Energy Conservation Code.
2. Sufficient area lighting shall be provided to provide safe transit under all conditions. Excessive contrast should be avoided, and glare should be minimized.
3. Exterior lighting should be in conformance with the University's Plan for the Public Realm; a copy of the lighting appendix Section 11 will be furnished to consultants upon request. Average target footcandle levels are:



Primary vehicular	0.9 fc
Secondary vehicular	0.7 fc
Pedestrian paths	0.5 fc
Sports fields (when not in use)	0.5 – 1 fc
Facades to be lit (requires University Architect Approval)	1 fc vertical

Where specific light levels are not called out above, or are deemed insufficient for a specific location, as judged by the University Architect and Facilities, then all designs shall follow the guidance of the most recent Illuminating Engineering Society Lighting Handbook or applicable Design Guide or Recommended Practice.

4. LED fixtures should comply with LM-79 testing requirements. LM-79 “Electrical and Photometric Measurements of Solid-State Lighting Products” provides an IES-approved method describing standard procedures and conditions required for performing reproducible measurements of LED products. The characteristics measured are total flux, luminous intensity distributions, electrical power, efficacy, and color characteristics (chromaticity, CCT, CRI).
5. Color appearance and consistency: CRI of 80+ and correlated color temperature of 3000k.
6. Exterior lighting shall be 277-volt except where **prohibited** by building voltage availability.
7. Exterior lighting fixtures shall be designed for the most efficient illumination of the area of intent and shall not cast or distribute any light trespass or direct glare on adjacent property. Where the University owns and maintains neighboring properties, the University Architect may permit light trespass when it does not affect any living quarters.
8. LED fixtures are required for use in all exterior applications. Where replacement or **exclusive** use of other sources need to be considered as exceptions only, these require review and explicit acceptance by the University Architect’s office prior to purchase.
9. Mercury Vapor lamps may not be used in any application.
10. All Exterior luminaires shall protect against both particulates (including insects) and liquids and shall be an Ingress Protection standard per the IEC 60529 with a minimum of 5 for particulates and a minimum of 5 for liquids, or IP55. In the case where a luminaire may incur direct power washing and/or may rest in no more than one (1) meter, the rating shall be at least IP66.
11. Exterior lighting shall be automatically controlled by photocell-controlled contactors rated for the connected load with bypass switch or BAS.



XVII. DIVISION 27 – COMMUNICATIONS

27 05 28 Pathways for Communication Systems

1. This Section pertains to installation of electrical boxes, conduit, raceway, floor poke-throughs, cabletrays, ground bus and miscellaneous accessories for telecommunications and data cable. Refer to Appendix B for typical room layout, manufacturer's data and installation guide for specified products, and conduit riser diagram example.
2. The following systems are **prohibited** from being installed in or through telecommunication and data rooms:
 - a) Ductwork.
 - b) Domestic water, drainage, and hydronic piping.
 - c) Fire protection sprinkler piping.
3. Design of telecommunications pathways, closets, conduit, cable trays, risers etc. will be coordinated with the University's Project Manager and the University's IT Project Manager. Cable tray locations will be marked up on contract drawings by the University's IT Project Manager, to be implemented in final Construction Documents by A/E.
4. Comply with ANSI/TIA/EIA-569-A Standard (latest edition), "Commercial Building Standard for Telecommunications Pathways and Spaces."
 - a) Typical Telecommunication Room shall be provided in the Basement or on lowest floor of the building with the following:
 - i) Minimum inside dimensions of the telecommunication and data room is 96 inches wide and 120 inches deep.
 - ii) Provide a swing outdoor with storage function lock, door closer and latch guard. The door shall be secured with an electronic card access.
 - iii) Communications room should be outfitted with 3/4 in fire rated plywood on all walls from 6 inches above finish floor to a height 8-foot 6-inch.
 - iv) One (1) convenience outlet near the entrance door.
 - v) Three (3) 20-Amp dedicated 120-volt quad outlets with dedicated #10 wire, neutrals, and grounds on Emergency Power.
 - vi) Provide year-round cooling for the telecommunication room, refer to part 6 under Section K, Temperature Control Requirements of General. Drexel IT will provide the heat loads. The dedicated HVAC equipment should be on Emergency Power equipment. Refer to Section 23 81 26 for approved HVAC equipment.
 - vii) Provide a minimum of two (2) 4-inch EMT conduits between this room and the suspended ceiling of each floor above (total of two per floor). Total number of conduits to be coordinated with the University's IT Project Manager based on cable load.
 - viii) Provide uniform lighting for the space. Light fixtures shall be on a separate circuit, preferably on emergency power. The illumination level shall be a minimum of 500 Lux (50 fc at 3 ft.).
 - ix) Condensate pumps or Building Automation System (BAS) components located in the room shall be on a separate circuit.



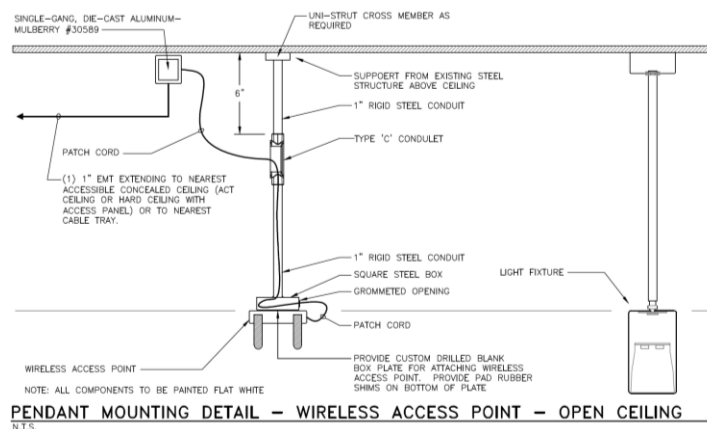
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- x) Floors shall be either sealed concrete (preferred) or VCT tiles as per Section 09 62 00.
 - xi) Provide one (1) fire extinguisher located near the entrance door; refer to Section 21 00 00 for requirements.
 - xii) Refer to Section 21 00 00 for fire sprinkler system requirements.
5. The installing contractor shall be responsible for the installation of electrical boxes, conduit, raceway, floor poke-throughs, cable tray, and miscellaneous accessories. Cable installation and termination of equipment shall be the responsibility of the University.
6. Non-acceptable Products:
- a) Conductor-less flexible armored sheathing ("Greenfield") shall not be permitted for use in installation of telecommunications and data cable pathways.
7. Required Products:
- a) Boxes:
 - i) Recessed mount telecommunications and data outlet box: 4 inches square by 2.125-inch-deep galvanized steel box.
 - ii) Surface mounted telecommunications and data outlet box: single-gang, deep steel box; Mulberry #30589 (no substitution).
 - iii) Recessed mount CATV outlet box: 4 inches square by 2.125 inches deep galvanized steel box.
 - iv) Surface mounted CATV outlet box: two-gang, deep steel box; Mulberry #30599 (no substitution).
 - b) Covers:
 - i) Recessed mount telecommunications and data outlet box: 4 inches square trim ring with center single device opening.
 - ii) Recessed mount CATV outlet box: 4 inches square trim ring with dual device opening.
 - iii) Surface mounted outlet box covers shall be provided and installed by others.
 - c) Other Materials:
 - i) All recessed and surface mounted boxes shall be furnished with a single length of 1 inch diameter EMT fixed to the top of the box (typical) and extending a minimum of 6 inches above the nearest accessible concealed ceiling level (ACT ceiling or hard ceiling with access panel) or in exposed ceiling areas to the nearest cable tray. EMT pipe to have NO more than 180 degrees of bend with 12-inch minimum radius.
 - ii) Both open ends of the EMT shall be furnished with a 1-inch diameter set screw connector and threaded plastic bushing.
 - iii) Each length of EMT shall be furnished with a pull string extending at least 18-inches beyond each open end of EMT.
 - iv) EMT serving wireless units shall be routed from outlet box to nearest accessible ceiling.
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- d) Raceway:
- i) Dual-channel raceway shall be Wiremold DS4000 Designer Series raceway; Color: Dark Gray (DG). Wiremold DS4000 URL for specifications: <http://www.legrand.us/wiremold/raceway/steel-raceway/multi-channel-raceway/ds4000-designer-series-large-raceway/ds4000-designer-series-large-raceway.aspx#res>.
 - ii) Provide a single channel NEMA device plate (Wiremold, Model DS4047C-DG) for each data location.
 - iii) Wiremold with three (3) or more IT ports shall use 1-1/2-inch diameter EMT. Refer to item 7.c) for additional information.
- e) Floor Poke-throughs:
- i) Whenever power, data, and AV are required: floor poke-throughs shall be Legrand Wiremold Model 8AT. For the IT data portion, IT will need one of the three center sections (not the middle one) with the 8DEC mounting plate. In addition, an 8DIV divider plate will need to be installed between the data compartment and the other two center compartments, which should be used for AV. An 1125CHA Bottom housing assembly to attach the conduit pathway for the IT cabling. <http://www.legrand.us/wiremold/poke-thru-devices/recessed-poke-thru-devices/evolution-8at-poke-thru-device/8at.aspx#res>.
 - ii) When power and data are required: Floor poke-throughs shall be Legrand Wiremold Model RC4ATCAL. For the IT data portion, IT will need one of the three center sections (not the middle one) with the 8DEC mounting plate. In addition, an 8DIV divider plate will need to be installed between the data compartment and the other two center compartments, which should be used for AV. An 1125CHA Bottom housing assembly to attach the conduit pathway for the IT cabling.
 - iii) In leased locations, ALL floor box conduits for IT to be extended into the University leased space typically the ceiling area of same floor where the box is being installed. Same rules in section 27 05 28 part 7.c).i) apply.
- f) Grounding and Bonding:
- i) Acceptable manufacturer: Storm Copper Components, Co. or approved equal.
 - ii) Copper ground bar with multiple holes, UL recognized standoff insulators, stainless steel mounting brackets, stainless steel assembly bolts and lock washers.
 - iii) Size: 0.25 inch thick by 4 inch tall by 24-to-40-inch length.
 - iv) Bonding conductors to be routed with a minimum of bends.
- g) Cabletray:
- i) Basis of Design to be Cablofil.
 - (1) Color for cabletray and accessories to be EZ.
 - (2) Part numbers for cabletray and associated accessories:
 - (a) CF 105 300: 4 inch deep by 12-inch-wide basket tray.
 - (b) EDRN: Splice Fast Splice.
 - (c) SWK: Splice Washer Kit.
 - (d) AS: Trapeze Hang Clip.
 - (e) Cable Dropout.
 - ii) Acceptable substitute to be Copper B-Line.
 - (1) Color of cabletray and accessories to be Gray.
 - (2) Part numbers for cabletray and associated accessories:
 - (a) FT4X12X10: 4.38 inch deep by 12-inch-wide basket tray.



- (b) FTSTLC: Splice Fast Splice.
 - (c) SPL KIT: Splice Washer Kit.
 - (d) SUPT2: Trapeze Hang Clip.
 - (e) 90 Degree Kit: Cabletray elbow.
 - (f) Cable Dropout.
- h) Floor box – Use on slab:
- i) When power, data, and AV are required: Floor box shall be Legrand Wiremold Model RFB-4 or the RFB4-SS (not the CI). The RFB4, has three different sized compartments (two are 16.4 cu in, one is 32.3 cu in, and the other is 50 cu in). Given the depth needed for the termination hardware, voice/data (IT) will need to be in one of the larger compartments and will need the RFB-GFI device bracket. IT requires a 1-inch conduit from the compartment to the area above the ACT. AV requires, at a minimum, a 1-1/4-inch conduit from the other larger compartment. The two smaller compartments can be used for power.
<http://www.legrand.us/wiremold/floor-boxes/concrete-floor-boxes/rfb4-four-compartment-single-or-multiservice-floor-box/rfb4-four-compartment-single-or-multi-service-recessed-floor-box.aspx#spec>.
 - ii) In leased locations, ALL floor box conduits for IT to be extended into the University leased space typically the ceiling area of same floor where the box is being installed. Same rules in section 27 05 28 part 7.c).i) apply.
8. Installation: For recessed boxes, both the box and trim ring shall be mounted directly behind the rear face of gypsum wall board panels.
- a) Install trim rings prior to the application of gypsum wall board.
 - b) Only the trim ring opening shall be seen or shall slightly protrude into the gypsum wallboard cut opening, but not beyond the front face.
9. Installation for wireless device pathway in open ceiling areas, see detail below.



10. Wireless for MEP system communications:
- a) A/E to coordinate with Facilities Management Department and IT for approval prior to designing a wireless system.
 - b) Stay out of all the unlicensed 2.4, 5, and 60 GHz WiFi frequencies. See the exact frequency ranges for each in https://en.wikipedia.org/wiki/List_of_WLAN_channels.



- c) WiFi products should be in the 5 GHz frequency only and with the understanding that the lifecycle replacement of all gear to be at least every 3-5 years to keep up with changing WiFi standards.
- d) A/E and contractor will be required to coordinate with Drexel IT to qualify the product based on location and deployment size. For example, Drexel IT strongly suggests staying out of dense WiFi areas particularly if your deployment was dense as well (i.e. dorms).
- e) Look for products using Zigbee, Zwave or even BLE protocols. Zigbee overlaps with the 5GHz frequencies, but it is a standard protocol and operates at lower power levels.

27 05 48 Vibration and Seismic Controls for Communications Systems

1. A/E to determine if vibration and seismic controls are required for the project.
2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

27 40 00 Audio-Video Communications

1. University Instructional Media Services (IMS) installs A/V system components in all classrooms located in Main, Randell, Curtis Hall, Paul Peck Problems Solving and Research, Hagerty Library, and some classrooms in the LeBow College of Business.
2. An outside Contractor is responsible for installing A/V system components in all rooms located in Papadakis Integrated Sciences Building, One Drexel Plaza (Garden Level) and LeBow College of Business.
3. Basic A/V system components specifications for each classroom can be found on the IMS website at <http://www.drexel.edu/ims/>. Select "Classroom Information" and then choose the room to view the equipment.
4. The Standard Audio/Visual Package for Classrooms consists of the following:
 - a) Projector: Epson 1710C or 1715C. (Used majority of the time but could be changed out.)
 - b) Projector Mount: Manufacturer is Bretford, mounting pole BRETPM UN14.
 - i) Ceiling at 13 ft.: Provide an adjustable Bretford pole, which is attached directly to the ceiling. The projector is required to hang down even with the top of the screen. In small classrooms, the screens are usually 6 ft. wide and mounted at a height of about 7 ft. to 8 ft. from the floor. Screen surface is matte white. Provide an A/C 120 VAC outlet box (via bx cable) to a location near the projector.
 - ii) Ceiling at 7 ft. to 8 ft.: Adjustable pole is not required. Provide a Bretford 24" x 12" plate in the ceiling (where a tile would go), to which we attach a short Bretford projector mount (fixed at 12" in length), and then attach the projector to that. Provide an A/C 120 VAC outlet box in the standard cutout in the ceiling plate.
 - c) Projector powered with 120 VAC Outlet located in ceiling near projector mount.
 - d) Speakers: TIC-ASP-120B Architectural Series 120 WATT with wall mounts at front of the classroom typical.
 - e) Wireless equipment shall be reviewed and approved by Drexel IT prior to installation.



5. A freestanding rack (front of the room) should contain:
 - a) Sony FM Stereo Receiver STR-DE 197: 120 VAC.
 - b) Sony DVD/VHS player SLV-D370P: 120 VAC.
 - c) Rack powered with 120 VAC outlet located in wall near rack, location at front of the classroom typical.
 - d) Rack will contain connections for amplifier, DVD player, and laptop. Amps and DVDs vary greatly. Amps are usually 100 watts.

NOTE: Video and control cables and speaker wire will be routed through plastic, surface-mounted plastic hinged raceway, color white, in installations in existing rooms. Cables and speaker wire are often partially hidden behind drop ceilings.



XVIII. DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

28 05 48 Vibration and Seismic Controls for Electronic Safety and Security

1. A/E to determine if vibration and seismic controls are required for the project.
2. Refer to Section 23 05 48 for required vibration control and seismic restraints for all equipment, where applicable, with wind load requirements for all equipment in outdoor locations. Additionally, included are provisions for flood control as stated herein.

28 16 13 Access Control Interface to Intrusion Detection

Incorporate, by reference, Divisions 8 and 26 into Division 28.

1. General:
 - a) Notice of Confidentiality:
 - i) Security system design plans, specifications, and other documentary material are confidential information and shall remain secure and confidential. Drawings, manuals, and programming notes shall be provided to the system owner upon completion of the project and shall not be left in system enclosures.
 - b) Purpose:
 - i) Establish design criteria, define activities, identify stakeholders, and assign responsibilities as they relate to the installation of electronic access control, intrusion detection systems, and CCTV for University buildings and campuses.
 - c) Overview:
 - i) The electronic safety and security systems for University's buildings and facilities are managed and maintained by the University Public Safety Operations department. The primary function of these security systems is to protect the campus population and assets. The Drexel Public Safety Department (DPS) will monitor and respond to all approved security alarms that are a part of the campus security system.
 - d) Electronic Security Supported at University:
 - i) Card Access Control: This system (Software House CCure) replaces typical mechanical key-controlled door locks with a door locking system that uses an access card (Dragon Card) as the access credential.
 - ii) Emergency Delay Exit Door: The emergency delay exit door system operates as a fire code compliant emergency exit door but will not open until a fifteen (15) second delay period has expired after an exit attempt has been initiated. Local siren sounds immediately to alert local staff of attempt to exit, and police receive messages with location and specific alarm information. A local fire alarm triggers the immediate release of the door(s). Local controls or programmable time schedules can be used to override this security function. Typical installations include back, or side code required exits to labs, exterior building emergency exit doors and stairwell doors. These systems may also be used with card readers in interior egress applications; however, these interior applications should be provided on a limited basis only to secure areas accessed through egress doors.
 - iii) Intrusion Detection System: This system monitors offices, classrooms, etc. for unauthorized entrance or intruders. This system can consist of motion sensors, door



- status sensors, glass break sensors and one or more control keypads. The keypad is used to arm/disarm system by entering a numeric code on the keypad. Alarm signals are transmitted to DPS with location and specific alarm information.
- iv) Asset Protection System: This system is designed to monitor various computer equipment, projectors, lab equipment etc. for unauthorized removal.
 - v) Duress Button: These buttons, also known as panic buttons, are installed in locations where potential personal safety or security threats exist. Depressing the button sends a silent priority alarm signal to DPS with location and specific alarm information. The panic button is usually located in the knee space underneath a desk or service counter. Once activated the alarm must be reset by DPS.
 - vi) Police Help Call Box: The typical system is a distinct blue box or pole with a red call button, “Emergency” signage and a blue locator lamp. Depressing the call button puts the individual in direct voice contact with a DPS dispatcher along with specific location information. These can be interior or exterior installations.
 - vii) Security Closet Design: One (1) 20-Amp duplex receptacle on emergency power, one (1) gigabit network station, one (1) light fixture at a minimum, and one (1) 3/4-inch rated plywood on one (1) wall from 6 inches above finish floor to a height 8-foot 6 inch. Air conditioning is not required unless otherwise specified.
 - viii) All wiring in closet shall be individually labeled within panels or enclosures and within 12” of all field terminations. All wiring shall be labeled alike on both ends. Labels shall be computer generated and fastened to wiring with transparent heat shrink material. Handwritten labels are not acceptable.
 - ix) All keys to enclosures shall be turned over to University Public Safety upon completion of the project. Keys shall not be left in panel lock or on top of secured panel.
- e) Quality Assurance:
- i) Only approved security contractors may perform work on University systems. The University is presently entered into a contract agreement with Johnson Controls Integrated Systems (JCI) as the sole source provider for security system service and installations.
 - ii) JCI shall work directly for DPS Operations for all projects.
- f) Door Schedules:
- i) Door and door hardware schedules must be provided to the DPS for review prior to the acceptance of any design standards. The purpose of the schedule review is to ensure that the products are compatible with electronic access control and meet University requirements.
2. Products:
- a) General:
 - i) All products and components must be new and approved by the University prior to installation.
 - b) Building Access Control System (BACS):
 - i) System Description:
 - (1) All electronic access-controlled doors shall comply with current jurisdictional Fire code or University Life Safety guidelines, whichever is more stringent.



- (2) Perimeter access-controlled doors shall be provided back up power supplied by the building's backup power supply system. This should include power to the security panel and any associated lock power supply units.
- (3) All wiring shall individually be labeled within all panels or enclosures and within 12" of all field terminations. All Cables shall be labeled alike on both ends. All labels shall be computer generated and fastened to conductors with transparent heat shrink material. Handwritten labels shall not be acceptable.
- (4) Provide Software House iStarUltra panels, HID Signo Series readers and alarm input and output devices connected to the DPS CCURE security management system.
 - (a) All keys to enclosures shall be turned over to the system owner upon completion of project. Keys shall not be left on top of or otherwise secured to panel boxes.
- (5) Card Reader Controlled Doors:
 - (a) Card Reader controlled doors shall include:
 - (i) HID Signo Series Card Reader.
 - (ii) Software House RM-4 Reader Module in enclosure (if required).
 - (iii) Magnetic position switches for each door leaf.
 - (iv) Local audible sounder.
 - (b) Emergency Exit Doors shall include:
 - (i) Magnetic position switches for each door leaf.
 - (ii) Local audible sounder.
 - (iii) Fixed IP Camera (University Standard).
 - (c) Roof Doors and Roof Access Hatches shall include:
 - (i) HID Signo Series Card Reader.
 - (ii) Software House RM-4 Reader Module in enclosure (if required).
 - (iii) Magnetic position switches for each door leaf.
 - (iv) Fixed IP Camera (University Standard)
 - (d) Security and Information Technology Closets shall include:
 - (i) HID Signo Series Card Reader.
 - (ii) Software House RM-4 Reader Module in enclosure (if required).
 - (iii) Magnetic position switches for each door leaf.
- (6) Proximity Card Readers:
 - (a) Wall Mount and Special Function: HID Signo Series RP40 (NO EXCEPTIONS).
 - (b) Mullion Mount: HID Signo Series RP15 (NO EXCEPTIONS).
 - (c) Card Reader with Keypad Option: HID Signo Series (Must receive written approval by DPS prior to acceptance of Keypad devices).
- (7) Request to Exit
 - (a) Doors equipped with electrified locksets or panic (crash) bars shall have integrated REX switches.
 - (b) REX motion sensors shall only be used when integrated REX is not feasible.
- (8) Door Position Switches:
 - (a) Concealed Magnetic Door Position Switch: Provide Sentrol 1078 series or approved equivalent.



- (b) Surface Mount Door and Hatch: Provide Sentrol 2500 Series or approved equivalent.
- (c) Overhead Door Position Switch: Provide Sentrol 2300 Series or approved equivalent.
- (d) Provide armored cable from surface mount and overhead switches to the associated junction box to secure and conceal the wire.
- (9) Delayed Egress Device Controller:
 - (a) Von Duprin Series 98-99 with CX (Chexit) accessory pack.
 - (b) Delayed egress magnetic locks may only be used with approval from University Public Safety.
- (10) Electric Locking Mechanisms:
 - (a) Magnetic locks may not be utilized without prior written approval from University Public Safety.
 - (b) Stanley “Preferred” Branded electronic panic devices shall not be used. (NO EXCEPTIONS).
 - (c) DPS preferred electronic lock manufacturers:
 - (i) Electrified Exit Device:
 - 1. Von Duprin (Ingersoll Rand).
 - 2. Corbin Russwin (Assa Abloy).
 - 3. Sargent (Assa Abloy).
 - (ii) Electric Strikes:
 - 1. Von Duprin (Series to be specified depending upon application).
 - 2. HES (Assa Abloy) (Series to be specified depending upon application).
- ii) Intrusion Detection:
 - (1) Motion Detection:
 - (a) Provide dual technology (microwave and infrared) to prevent false alarms. Specific models depend on application and mounting requirements.
 - (b) One motion detector per zone, do not wire in series.
 - (2) Glass Break Detector:
 - (a) Sentrol Shatter Pro II or equivalent.
 - (b) If a different model is approved. A compatible glass break tester for the device being installed must be provided.
 - (3) Duress Buttons:
 - (a) USP HUB momentary hold up series.
 - (b) Duress button locations must be reviewed and approved by DPS.
 - (c) Provide 20-foot service loop in ceiling when mounting to non-fixed furniture.
 - (4) Call Boxes:
 - (a) All call boxes shall be equipped with constantly lit blue light and a flashing blue light when activated.
 - (b) Call tower: WEBS-MT/R OP4, ETP-MTE-ARM or ETP-MT-R. A/E to coordinate with Drexel Public Safety for which model to specify for the project.
 - (i) All call towers shall be equipped with CCTV armature. The color shall be the custom Drexel blue.



- (c) Wall Mount Station: Talk-A-Phone WEBS-WM.
- (d) Flush or Vestibule mount: VOIP-500.
- (5) Closed Circuit Television:
 - (a) Mounting locations and field of view will be specified by DPS.
 - (b) Fixed Cameras: Samsung Wisenet Q Series or Axis Q Series (Model to be specified depending upon application).
 - (c) Pan Tilt Zoom (PTZ): Samsung Wisenet or Axis Q Series (Model to be specified depending upon application).
 - (d) CCTV Settings:
 - (i) Minimum Resolution: 5 Megapixel (1920 x 1080).
 - (ii) Video Compression Formats: H.265, H.264, and MJPEG.
 - (iii) Minimum Frame Rate: At least 60fps (Max).
 - (iv) Day/Night Vision Auto adjust required.

28 46 00 Fire Detection and Alarm

1. The following is a list of **prohibited** installations and required University approval for their installation:
 - a) Fire alarm system brands other than Notifier or Fire Control Instruments (FCI).
2. Fire alarm systems shall be addressable, by FCI or Notifier.
3. All fire alarm systems shall be connected to the Campus Security Office utilizing a Silent Knight 5104B Digital Communicator equipped with a Silent Knight Model 5230 Remote Annunciator mounted on the communicator enclosure.
4. Programmable fire alarms shall be provided with all documentation, instructions, hardware, and software keys to permit Owner programming.
5. Fire alarm panels shall be provided with spare devices and panel cards as required by the Owner.
6. All terminals in panels and devices shall be identified by connecting wire, wire color and number.
7. All fire alarm pull stations shall be metal.
8. Cable and conduit shall enter fire alarm panel from side or bottom. Top entry is **prohibited**.
9. All fire alarm system power-limited signal wiring shall be installed in metal conduit.
 - a) All exposed metal conduit to be EMT, IMC, or Rigid.
 - b) All concealed metal conduit to be MC, EMT, IMC, or Rigid.
10. All fire alarm system power-limited signal wiring shall be installed in separate conduits from AC power wiring (including AC power feeds to fire alarm and BAS devices). AC power wiring feeding fire alarm panel and other related power supplies must be protected by surge suppressing device.



11. All closets/rooms containing heat generating fire alarm equipment (NAC panel) are to be ventilated.
12. Contractor is to provide the following:
 - a) Label all field devices, i.e. detectors and modules, with a printed device address.
 - b) Printed instructions on how to disable and reset the different sections of the fire alarm system.
 - c) Function buttons in the panel for:
 - (1) Disable horns.
 - (2) Disable strobes.
 - (3) Disable elevator recall (primary).
 - (4) Disable elevator recall (alternate).
 - (5) Disable sprinkler system (waterflows and pressure switches).
13. Conduit compression connectors and couplings are to be insulated steel.
14. Digitally addressable combination smoke and carbon monoxide detectors are required outside the entry of every sleeping quarter in residential housing and fraternities. Detectors and locations are to [follow](#) the 2013 ACT 121, Carbon Monoxide Alarm Standards Act – Enactment, as adopted by the Commonwealth of Pennsylvania.
15. A/E is responsible for designing the fire alarm system for all new construction and renovation projects. The Contractor is only responsible for designing the fire alarm system when the contract is based on a Design Build agreement.
16. The University’s preferred fire alarm vendor is BFPE International. Contact [Tom Tunstill](#), at [443-652-8713](tel:443-652-8713) or ttunstill@bfpe.com.



XIX. DIVISION 32 – EXTERIOR IMPROVEMENTS

32 05 23 Cement and Concrete for Exterior Improvements

1. Concrete is to be maintained wet for at least four (4) days using a wet curing blanket. Material shall meet ASTN C171-97 and AASHTO M171-00. Wet curing blanket shall be placed as soon as the concrete has hardened enough to prevent surface damage. Immediately repair any holes or tears during curing period.
2. Approved manufacturer: McTech / UltraCure NCF.

32 33 00 Site Furnishings

1. Movable Umbrellas:
 - a) Manufacturer: Shadescape Americas.
 - b) Model: Filius.
 - c) Size: Diameter 3 meters.
 - d) Color: To be approved by PD&C.
 - e) Other: Mobile Installation Option Order No. DMZ210, Full frame pedestal with placement hinge and upper tube of DMZ150.
 - i) Creese Upper Courtyard: Canopy - Navy Blue / 314414. Edge Binding - Navy Blue/91.
 - f) Website: <http://may.shadescapescapamericas.com/collections/market-umbrellas/products/filius-market-umbrella>.

32 33 23 Site Trash and Litter Receptables

1. Location and spacing to be reviewed by PD&C.
 - a) Medium Size Receptacles: To be installed close to buildings and where smaller receptacles are desired.
 - i) Manufacturer: Landscapeforms.
 - ii) Model: Metro40 Collect.
 - iii) Colors and Finishes: "Titanium" metal-polyester powder coat surround. "Black" polyethylene basket.
 - iv) Trash: 23-gallon, side opening. Surface mounted.
 - v) Recycling: 30-gallon capacity. Top opening, 5" diameter. Custom white lettering to read, "aluminum glass paper plastic". Standard recycling logo, white. Surface mounted.
 - vi) Website: <http://www.landscapeforms.com/en-US/product/Pages/Metro40-Collect-Litter.aspx>
 - b) Large Size Receptacles: To be installed in more open areas, along streets, and where larger receptacles are desired.
 - i) Manufacturer: Landscapeforms.
 - ii) Model: Chase Park, 36-gallon capacity.
 - iii) Colors and Finishes: "Titanium" metal-polyester powder coat.
 - iv) Trash: Side opening for trash. Surface mounted.



- v) Recycling: Top opening, 5” diameter. Custom white lettering to read, “aluminum glass paper plastic”. Standard recycling logo, white. Surface mounted.
- vi) Website: <http://www.landscapeforms.com/en-US/product/Pages/Chase-Park-Litter.aspx>
- c) Ash Urns:
 - i) Manufacturer: Landscapeforms.
 - ii) Model: Free standing Grenadier Ash Urns.
 - iii) Colors and Finishes: “Titanium” metal-polyester powder coat.

32 33 43 Site Seating and Tables

1. Movable Table and Chairs:
 - a) Manufacturer: Fermob.
 - b) Color: To be approved by PD&C.
 - c) Chair Model: Luxembourg.
 - i) Website: <https://www.fermob.com/en/Products/The-furniture/Dining/Seats/Chairs/Chair-Luxembourg>.
 - d) Table Model: Bistro.
 - i) Website: <https://www.fermob.com/en/Products/The-furniture/Dining/Tables/Standard-tables/OE-96-cm-Table-Bistro>
 - e) Size: Varies. Available in 60 cm; 77 cm; 96 cm; and 117 cm diameters.

32 84 00 Planting Irrigation

1. The University has developed a centralized irrigation system which links every controller for all buildings via the internet, enabling the University to control each system from a central location.
2. All new buildings, additions, or system additions shall be integrated into the new system.
3. All irrigation heads, valves, and controllers shall be Rain Bird brand.
4. Heads and valves will vary depending on the installation, but the controller shall be Rain Bird ESP-LX Modular Series or the next upgraded/updated controller as outlined by University Facilities prior to installation.
5. All irrigation installations, modifications and upgrades must be reviewed with and approved by University Facilities before [implementation](#).
6. As-built drawings must be supplied for all irrigation work performed at the University.



XX. DIVISION 33 – UTILITIES

33 05 00 Common Work Results for Utilities

1. Prime Professional to specify clean lump free sand for refill around buried trenches, conduits, pipes, etc. Sand to be 12 inches all around. Sand from job site is **prohibited**.
2. Trench should have a caution ribbon between the fill sand and finish covering above each pipe.
3. University and Prime Professional to witness pressure test before covering. Pressure test is to be repeated after finish covering trench.



XXI. DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT

41 22 00 Cranes and Hoists

1. Prime Contractor shall provide a site plan showing the location of the crane, delivery trucks, etc. for review and coordination by the University. Upon review the University will request a meeting with the Prime Contractor, crane operator, and University Staff, Police, Public Safety to walk through the logistics of the plan.
2. Prime Contractor is not to perform any crane picks prior to coordinating with the University.
3. When equipment weight is at or greater than 1-ton the building must be closed during the crane lift. Contractor is responsible for creating and installing the appropriate signage at exist doors. Locations are to be reviewed with the Project Manager and [EH&RS](#).



XXII. APPENDIX A

Laboratory Design Standard [2024](#)



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TABLE OF CONTENTS
Section Number and Title

Page No.

I. GENERAL	1
A. Introduction.....	1
II. GENERAL REQUIREMENTS FOR DREXEL UNIVERSITY LABORATORIES	2
A. Scope.....	2
B. Building Requirements	2
C. Building Design Issues	3
D. Laboratory Design Issues.....	3
E. Mechanical Considerations.....	5
III. VENTILATION	6
A. Scope.....	6
B. General Ventilation Considerations.....	6
C. Negative Pressurization	7
D. Supply Air Arrangements	7
E. Biological Safety Cabinet and Fume Hood Location	7
F. Fume Hood and Local Exhaust Ventilation Selection / Types	8
G. Fume Hood Labeling	9
H. Biological Safety Cabinet, Fume Hood and Local Exhaust System Construction and Installation	10
I. Fume Hood Power and Electrical	11
J. Sashes	12
K. Ducting	12
L. Exhaust	12
M. Noise.....	13
N. Specialty, Controlled Climate, and Cold Rooms.....	13
O. Laboratory Hood Commissioning	14
P. Testing, Adjusting, and Balancing.....	14
IV. EMERGENCY EYEWASH AND SAFETY SHOWER EQUIPMENT	14
A. Scope.....	14
B. General Location	15
C. Eyewash Requirements.....	15
D. Deluge Shower Requirements	16
E. Testing	17
F. Approved Equipment.....	17
V. COMPRESSED GAS CYLINDERS	17
A. Scope.....	17
B. Design Features for the Storage of Compressed Gas Cylinders – General	17
C. Design Features for the Storage of Compressed Gas Cylinders – Toxic and Highly Toxic Gases	18
VI. FLAMMABLE LIQUID STORAGE CABINETS	19
A. Scope.....	19
B. Design.....	19
C. Construction.....	20
D. Location	20



I. GENERAL

A. Introduction

1. Purpose:
 - a) Drexel University and Drexel University College of Medicine have a continuing need to modernize and update their facilities. The resulting construction projects often have significant health and safety requirements due to regulatory oversight. Since these requirements can impact the design of a project, the Drexel University Department of Environmental Health and Radiation Safety (EH&RS) has prepared this Laboratory Design Standard to aid the campus community with planning and design issues. EH&RS believes that this Standard, in conjuncture with EH&S's plan review and consultation, improves design efficiency and minimizes changes.
2. Application:
 - a) The Laboratory Design Standard is a resource document for use by faculty, staff, and design professionals for use during the planning and early design stages of a project. The Standard applies to construction and renovation projects for all Drexel University and Drexel University college of Medicine facilities, including leased properties.
 - b) The Designer must be mindful that laboratory design is a highly specialized field. A successful design requires adequate research, programmatic development and due diligence. Codes and guidelines referred to in this (or any other) section of the Building Systems Standards and Design Guide are not to be assumed comprehensive. It is the responsibility of the Designer to properly investigate the specific requirements of the lab to ensure compliance with all local, state, and national codes and regulations.
3. Format of Guide:
 - a) The Laboratory Design Standard is formatted to address laboratory design issues pertinent to General Laboratories in Section 1. Within the sections, specific design criteria are provided.
4. References:
 - a) References include regulations (e.g. [City of Philadelphia Building Codes](#), OSHA, etc.), consensus standards (e.g. ANSI/ASHRAE), and good practices. Good practices stem from industry standards and/or the knowledge and judgment of Drexel University's EH&RS professionals.
 - b) [The University requires the A/E to design laboratories based on the following industry documentation, current editions:](#)
 - i) [American Association for Accreditation of Laboratory Animal Care \(AAALAC\) – Guide for the Care and Use of Laboratory Animals.](#)
 - ii) [Center for Diseases Control and Prevention \(CDC\) – Biosafety in Microbiological and Biomedical Laboratories \(BMBL\).](#)
 - iii) [National Institutes of Health \(NIH\) – Design Requirements Manual \(DRM\).](#)
 - iv) [World Health Organization \(WHO\) – Laboratory Biosafety Manual.](#)



5. Limitations of the Guide:
 - a) The Drexel Laboratory Design Standard is not “all inclusive.” It does not cover regulatory issues nor does it cover all design situations. It is important to note that use practices must be considered during the design process, as they can directly influence how the laboratory will be designed (e.g., how hazardous materials are used impacts how they are stored, which is a design issue). In all cases, [EH&RS](#) should be consulted on questions regarding health, safety, and environment.

6. Environmental Health and [Radiation](#) Safety Contacts:
 - a) Martin Bell – Director: (215) 895-5892
 - b) Joseph Nihill – Industrial Hygienist: (215) 895-1624
 - c) Jeffrey Nemetz – Industrial Hygienist: (215) 895-5913
 - d) [Jon Chase – Radiation Safety Officer](#): (215) 895-5891

II. GENERAL REQUIREMENTS FOR DREXEL UNIVERSITY LABORATORIES

A. Scope

1. The primary objective in laboratory design standard is to provide a safe environment for laboratory personnel to conduct their work. A secondary objective is to allow for the maximum flexibility for safe research use. Undergraduate teaching laboratories require other specific design considerations. Therefore, all health and safety hazards must be anticipated and carefully evaluated so that protective measures can be incorporated into the design. No matter how well designed a laboratory is, improper usage of its facilities will always defeat the engineered safety features. Proper education of the facility users is essential.

2. The general requirements listed in this section illustrate some of the basic health and safety elements to include in all new and remodeled laboratories at Drexel University and Drexel University College of Medicine facilities, and leased properties. Variations from these guidelines need approval from Drexel Environmental Health and [Radiation](#) Safety ([EH&RS](#)). The subsections of Section 1.0 provide specific guidance on additional critical features of a general laboratory (e.g. fume hoods, hazardous materials storage, and compressed gases.)

B. Building Requirements

1. Designer Qualifications – The designer must have the appropriate professional license in his/her area of expertise.

2. Building Occupancy Classification – Occupancy classification is to be based upon an assessment of a projected chemical inventory of the building. The classification must be reviewed by [EH&RS](#) and Fire and Life Safety.

3. Environmental Permits – Project managers must consult with Drexel Environmental Health and Safety to identify permitting and pollution abatement engineering requirements for the building. This should be done well before key resource allocation decisions are made.



4. Any building, or portions thereof, in which hazardous materials are stored, shall be constructed in accordance with the City of Philadelphia's Building Codes, [current editions](#).

C. Building Design Issues

1. Provide separate office spaces for laboratory employees. The research personnel writing areas must be located outside the laboratory.
2. Public access to laboratory personnel in office rooms with separate corridor access is highly desirable.

D. Laboratory Design Issues

1. The laboratory shall be completely separated from outside areas (i.e., must be bound by four walls). The writing areas for research personnel must be located outside the laboratory environment. All laboratory walls are to be constructed from floor to deck above and sealed airtight at all connection/ penetration points.
2. The laboratory shall have means of securing specifically regulated materials, such as DEA (Drug Enforcement Administration) controlled substances and CDC (Center for Diseases Control) select agents and radioactive materials (i.e., lockable doors, lockable cabinets, etc.).
3. Each door from the hallway into a laboratory must have a view panel and be at least 36 inches wide.
4. If the laboratory has windows that open, they must be fitted with insect screens.
5. The floor must be non-pervious, one piece, and with covings to the wall. This can be achieved by use of glue, heat welded vinyl flooring, epoxy coated concrete slab, etc. **Flooring for offices within the laboratory shall not be carpeted.** The nature of the chemicals being stored and used in the lab shall be considered. A/E shall review flooring in section 09 62 00 and consult with [EH&RS](#) for chemical resistance review and final approval.
6. Floors in storage areas for hazardous materials shall be of liquid tight construction.
7. Floor drains shall be **prohibited** in laboratories and hazardous material storage areas, unless approved by [EH&RS](#). Drains dedicated to safety showers are allowed.
8. Each laboratory must contain a sink for hand washing.
9. Laboratory sinks shall have lips that protect sink drains from spills.
10. Chemical storage shelves shall not be placed above laboratory sinks.
11. Sufficient space or facilities (e.g., storage cabinets with partitions) shall be provided so that incompatible materials can be physically separated and stored. This will be based on the chemical inventory and use projection provided by the Principal Investigator to the project



manager and the Department of Environmental Health and [Radiation Safety](#). If the project scope cannot provide sufficient storage the user must develop a written management control plan to include as part of their local Chemical Hygiene Plan.

12. All furniture must be sturdy and non-porous. Fabric covered chairs are strictly **prohibited**. All work surfaces (e.g., bench tops and counters) must be impervious to the chemicals used. The countertop should incorporate a lip to help prevent run-off onto the floor.
13. Vented cabinets with electrical receptacles and sound insulation should be provided for the placement of individual vacuum pumps, where their use is anticipated. A one- to two- inch hole for the vacuum line hose from the cabinet to the bench top should be provided.
14. The lab shall have a minimum aisle clearance of at least 24 inches. Main aisles used for emergency egress must have a clearance width of at least 36 inches.
15. A pathway clearance of 36 inches must be maintained at the face of the access/ exit door.
16. Designated storage space should be provided for lab carts. Location must not reduce width of corridors or aisles to less than code-required widths. Lab carts should be secured when not in use.
17. Furniture design should comply with basic ergonomic specifications referenced by OSHA.
18. Laboratory shelving should NOT be installed at heights and distances which require workers to reach 30 centimeters above shoulder height and extend arms greater than 30 centimeters while holding objects 16 kg or less when standing on the floor or on a 12” step stool.
19. The space between adjacent workstations and laboratory benches should be 5 ft or greater to provide ease of access. In a teaching laboratory, the desired spacing is 6 ft. Bench spacing shall be considered and included in specifications and plans.
20. The laboratory doors shall be automatically self-closing. Such self-closing doors are to be able to be opened with a minimum of effort as to allow access and egress for physically challenged individuals.
21. Doors in D-H-occupancy laboratories shall have doors which swing in the direction of egress. Doors serving B-occupancy shall swing in the direction of egress if the occupant load is 50 or more. Where possible, all B-occupancy lab doors should swing out.
22. Laboratory areas shall be provided adequate natural or artificial illumination to ensure sufficient visibility for operational safety. Lighting must be even across the room, with a maintained light level for work surfaces in accordance with IES standards.
23. All laboratories and hazardous material storage rooms must have at least one light not controlled by an occupancy sensor. This light must be on an emergency circuit. The occupancy sensors are to be wired so that it can be bypassed with a conventional light switch. LED light fixtures are preferred.



24. Laboratories with lasers and/or high voltage equipment must have an emergency power-off switch installed near the laboratory exit.
25. Laboratories with lasers must have a “Laser In Use” at the entrances to the laboratory. The sign must be connected to a light switch inside the laboratory.
26. The laboratory shall be designed so that it can be easily cleaned. Bench tops must be a seamless one-piece design to prevent contamination. Laminate bench tops are not suitable. Penetrations for electrical, plumbing, and other considerations must be completely and permanently sealed. If the bench abuts a wall, it must be coved or have a backsplash against the wall. Walls should be painted with washable, hard non-porous paints.
27. Spaces between benches, cabinets, and equipment must be accessible for cleaning and allow for servicing of equipment. Metal cabinets are preferred unless specified otherwise and approved by EH&S.
28. Fire rated walls and doors to be implemented per NFPA 45.
29. Laboratory entrance doors to be secured with Card Access Control.
30. Wall phone:
 - a) Location near entry doors should be mounted at 44 inches on center (for ADA compatibility).
 - b) Must accommodate a phone with the following dimensions (12-inch width, 9-inch height, 6-inch depth).

E. Mechanical Considerations

1. GFCI protection shall be provided to all electrical receptacles.
2. The lab should be fitted with an adequate number of electrical outlets, which can accommodate electrical current requirements with an additional 20-40% capacity.
3. Electrical panels should be located outside the lab, but not in rated corridors. Electrical panels must be installed to maintain 36 inches of clearance in all directions.
4. An emergency shutoff valve for natural gas must be installed outside the lab adjacent to the laboratory entrance door.
5. Flexible connections should be used for connecting gas and other plumbed utilities to any freestanding device, including but not limited to biosafety cabinets, incubators, and liquid nitrogen freezers. Flexible connections should be appropriate for the pressure requirements and should be constructed of material compatible with the transport gas. A shutoff valve should be located within sight of the connection and clearly marked.



III. VENTILATION

A. Scope

1. The requirements of this Standard apply to all Drexel University and Drexel University College of Medicine facilities, and leased properties.

B. General Ventilation Considerations

1. The room should have mechanically generated supply air and exhaust air. All lab rooms shall be exhausted 100% to the outside. There shall be no return of fume hood and laboratory exhaust back into the building.
2. Mechanical climate control should be provided.
3. Cabinetry or other structures or equipment must not block or reduce effectiveness of supply or exhaust air.
4. Laboratories shall have a minimum of eight (8) to ten (10) air changes/hour during occupied times and 6 air changes/hour during unoccupied times. The control to determine occupied versus unoccupied must be determined by occupancy sensors not time. Variations to this requirement may be necessary due to the type of research work in the laboratory. Variances must be approved by the [EH&RS](#) office.
5. Laboratories must be maintained under negative pressure in relation to the corridor or other less hazardous areas. Clean rooms and tissue culture rooms requiring positive pressure must have entry vestibules provided with door-closing mechanisms so that both doors are not open at the same time.
6. Where appropriate, general ventilation systems should be designed, such that, in the event of an accident, they can be shut down.
7. The air velocity volume in each duct should be sufficient to prevent condensation or liquid or condensable solids on the walls of the ducts.
8. Fume hoods shall not be the sole means of room air exhaust. General room exhaust outlets shall be provided where necessary to maintain minimum air change rates and temperature control.
9. Operable windows are **prohibited** in new lab buildings and shall not be used on modifications to existing buildings.
10. Local exhaust ventilation (e.g., “snorkels” or “elephant trunks”), other than fume hoods, shall be designed to adequately control exposures to hazardous chemicals. An exhausted manifold or manifolds with connections to local exhaust may be provided as needed to collect potentially hazardous exhausts from gas chromatographs, vacuum pumps, excimer lasers, or other equipment which can produce potentially hazardous air pollutants. The contaminant source



needs to be enclosed as much as possible, consistent with operational needs, to maximize control effectiveness and minimize air handling difficulties and costs.

11. Hoods shall be labeled to show which fan or ventilation systems are connected to it.
12. No laboratory ventilation system ductwork shall be internally insulated. Sound baffles or external acoustical insulation at the source should be used for noise control.
13. Air exhausted from laboratory work areas shall not pass un-ducted through other areas.

C. Negative Pressurization

1. Airflow shall be from low hazard to high hazard areas.
2. An adequate supply of makeup air (90% of exhaust) should be provided to the lab.
3. An air lock or vestibule may be necessary in certain high-hazard laboratories to minimize the volume of supply air required for negative pressurization control. These doors should be provided with interlocks so that both doors cannot open at the same time.
4. A corridor should not be used as a plenum.

D. Supply Air Arrangements

1. Room air currents at the fume hood shall not exceed 20% of the average face velocity to ensure fume hood containment.
2. Make-up air should be introduced at opposite end of the laboratory room from the fume hood(s) and flow paths for room HVAC systems shall be kept away from hood locations to the extent practical.
3. Make-up air shall be introduced in such a way that negative pressurization is maintained in all laboratory spaces and does not create a disruptive air pattern.
4. Cabinetry or other structures or equipment should not block or reduce effectiveness of supply or exhaust air.
5. Supply system air should meet the technical requirements of the laboratory work and the requirements of the latest version of ASHRAE, Standard 62, Ventilation for Acceptable Indoor Air Quality.

E. Biological Safety Cabinet and Fume Hood Location

1. Fume hoods and Biological Safety Cabinets shall be located away from activities or facilities, which produce air currents or turbulence. Locate away from high traffic areas, air supply diffusers, doors, and operable windows.



2. Fume hoods should not be located adjacent to a single means of access to an exit. Recommend that hoods be located more than 10 feet from any door or doorway.
3. Fume hood openings should not be located opposite workstations where personnel will spend much of their working day, such as desks or microscope benches.

F. Fume Hood and Local Exhaust Ventilation Selection / Types

1. Constant Volume (CV) Hoods:
 - a) These hoods permit a stable air balance between the ventilation systems and exhaust by incorporating a bypass feature. If bypass is 100%, this allows a constant volume of air to be exhausted through the hood regardless of sash position.
2. Variable Air Volume (VAV) fume hoods:
 - a) These hoods maintain constant face velocities by varying exhaust volumes in response to changes in sash position. Because only the amount of air needed to maintain the specified face velocity is pulled from the room, significant energy savings are possible when the sash is closed. However, since these hoods cost more than up front and more maintenance, effective sash management (e.g., pull sash closed when not using hood) is necessary. **This type of system is the preferred system by EH&RS.**
3. Supply or auxiliary air hoods:
 - a) These hoods are not permitted unless an exception is granted by [EH&RS](#).
4. Ductless fume hoods are not permitted unless an exception is granted by [EH&RS](#).
5. Perchloric/Hot Acid Hoods:
 - a) Heated perchloric acid shall only be used in a laboratory hood specifically designed for its use and identified as "For Perchloric Acid Operations." (Exception: Hoods not specifically designed for use with perchloric acid shall be permitted to be used where the vapors are trapped and scrubbed before they are released into the hood.)
 - b) Perchloric acid hoods and exhaust duct work shall be constructed of materials that are acid resistant, nonreactive, and impervious to perchloric acid.
 - c) The exhaust fan should be acid resistant and spark resistant. The exhaust fan motor should not be located within the ductwork. Drive belts should not be located within the ductwork. Ductwork for perchloric acid hoods and exhaust systems shall take the shortest and straightest path to the outside of the building and shall not be manifolded with other exhaust systems. Horizontal runs shall be as short as possible, with no sharp turns or bends. The ductwork shall provide a positive drainage slope back into the hood. Duct shall consist of sealed sections. Flexible connectors shall not be used.
 - d) Sealants, gaskets, and lubricants used with perchloric acid hoods, ductwork, and exhaust systems shall be acid resistant and nonreactive with perchloric acid.
 - e) A water spray system shall be provided for washing down the hood interior behind the baffle and the entire exhaust system. The hood work surface shall be watertight with a minimum depression of 13 mm (1/2 inch) at the front and sides. An integral trough shall be provided at the rear of the hood to collect wash-down water.



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- f) Spray wash-down nozzles shall be installed in the ducts no more than 5 ft. apart. The ductwork shall provide a positive drainage slope back into the hood. Ductwork shall consist of sealed sections, and no flexible connectors shall be used.
 - g) The hood surface should have an all-welded construction and have accessible rounded corners for cleaning ease.
 - h) The hood baffle shall be removable for inspection and cleaning.
 - i) Each perchloric acid hood must have an individually designated duct and exhaust system.
6. Radioactive Material Use:
- a) Fume hoods intended for use with radioactive isotopes must be constructed of stainless steel or other materials that will not be corroded by the chemicals used in the hood.
 - b) The interior of all radioisotope hoods must have coved corners to facilitate decontamination.
 - c) The hood exhaust may require filtration by HEPA or Charcoal HEPA filters. Where such is the likelihood, the hood must have a bag-out plenum for mounting such filters and fan capacity for proper operation of the hood with the filter installed. The most appropriate location for the plenum is near the exhaust port of the fume hood (i.e., proximal to the hood).
 - d) The cabinet on which the hood is installed shall be adequate to support shielding for the radioactive materials to be used therein.
 - e) In general, glove boxes with HEPA filtered exhausts shall be provided for operations involving unsealed radioactive material that emit alpha particles. Consult with the Radiation Safety for specifics.
 - f) American with Disabilities Act (ADA) Hoods:
 - i) Must consult with Drexel University's ADA Compliance Office regarding the number lab hoods to install in facilities, which are accessible to and usable by individuals with disabilities – recommend minimally one ADA hood per laboratory floor. These hoods must provide appropriate work surface heights, knee clearances, reach to controls, etc. to individuals in wheelchairs.
 - g) Glove Boxes:
 - i) Glove boxes (positive and negative) must meet the type, design and construction of requirements ANSI/AIHA Z9.5-2003, 5.14.
 - h) Walk-in Fume Hoods:
 - i) These hoods must meet the type, design and construction requirements of ANSI/AIHA Z9.5-2003, 5.13.
 - i) Special Purpose Hoods:
 - i) These hoods include enclosures for operations for which other types of hoods are not suitable (e.g., enclosures for analytical balances, histology processing machines, special mixing stations, evaporation racks). These hoods must be designed per ANSI Z9.5 and the Industrial Ventilation manual.

G. Fume Hood Labeling

- 1. All hoods must be labeled with the following:
 - a) Fan Number as designated by Facilities Management.
 - b) Room and fume hood number.



2. Laboratory hoods and special local exhaust ventilation systems (SLEV) should be labeled to indicate intended use (e.g., “Perchloric Acid Hood”).

H. Biological Safety Cabinet, Fume Hood and Local Exhaust System Construction and Installation

1. New hoods can be mounted above a chemical storage cabinet, provided that the cabinet meets the City of Philadelphia Fire Code requirements for construction.
2. Type 316 stainless steel should be used for all parts of the fume hood system ventilation duct as long as compatibility is maintained.
3. Fume hood interior surfaces shall be constructed of corrosion resistant, non-porous, non-combustible materials such as type 316 stainless steel, and should be smooth and impermeable, with rounded corners. These materials shall have a flame spread index of 25 or less when tested in accordance with NFPA method 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
4. Hood inserts are only permitted for radioactive iodination procedures specifically approved by the Drexel Radiation Safety Officer.
5. Laboratory hoods shall be provided with a means of containing minor spills.
6. There must be a horizontal bottom airfoil inlet at the front of the hood.
7. Adjustable baffles with horizontal slots must be present in the fume hood interior at the back and top.
8. Before a new fume hood is put into operation, an adequate supply of make-up air must be provided to the lab.
9. Face Velocity – Laboratory fume hoods shall provide an average face velocity within the range of 80 - 120 feet per minute (fpm). No one test velocity reading should vary by more than 20% of the average. Face velocity uniformity shall be achieved by installing a venturi valve inside the ductwork. The preferred face velocity at a sash height of 18 inches is 100 fpm. **The preferred valve is manufactured by Phoenix Controls.**
10. An LED airflow indicator shall be provided and located so that it is visible from the front of the fume hood and local exhaust unit. The airflow indicator shall be connected to the building automated system or other designated system. **The preferred monitor is Phoenix Controls.**
11. Baffles shall be constructed so that they may not be adjusted to restrict the volume of air exhausted through the laboratory hood.
12. Fans should run continuously without local control from hood location and independently of any time clocks.



13. For new installations or modifications of existing installations, controls for Laboratory hood services (eg., gas, air, and water) should be located external to the hood and within easy reach.
14. Shutoff valves for services, including gas, air, vacuum, and electricity shall be outside of the hood enclosure in a location where they will be readily accessible in the event of fire in the hood. The location of such a shut-off shall be legibly lettered in a related location on the exterior of the hood.
15. Laboratory hoods shall not have an on/off switch located in the laboratory. Exhaust fans shall run continuously without direct local control from laboratories.
16. Hard ducted biological safety cabinets shall be thimble connected to the exhaust system.
17. Sink cups in the fume hoods are **prohibited**, unless authorized by [EH&RS](#).
18. Local exhaust systems must be approved by [EH&RS](#) prior to installation.

I. Fume Hood Power and Electrical

1. Chemical fume hood exhaust fans and airflow monitoring devices shall be connected to an emergency power system in the event of a power failure.
2. Emergency power circuits should be available for fan service so that fans will automatically restart upon restoration after a power outage and supply at least half of the normal airflow.
3. Momentary or extended losses of power shall not change or affect any of the control system's set points, calibration settings, or emergency status. After power returns, the system shall continue operation, exactly as before, without the need for any manual intervention. Alarms shall require manual reset, should they indicate a potentially hazardous condition.
4. Fume hood ventilating controls should be arranged so that shutting off the ventilation of one fume hood will not reduce the exhaust capacity or create an imbalance between exhaust and supply for any other hood connected to the same system.
5. In installations where services and controls are within the hood, additional electrical disconnects shall be located within 15m (50ft) of the hood and shall be accessible and clearly marked. (Exception: If electrical receptacles are located external to the hood, no additional electrical disconnect shall be required).
6. Hood lighting shall be provided by UL-listed fixtures external to the hood or, if located within the hood interior, the fixtures shall meet the requirements of NFPA 70, (National Electrical Code).
7. Light fixtures should be of the fluorescent type, and replaceable from outside the hood. Light fixtures must be displaced or covered by a transparent impact resistant vapor tight shield to prevent vapor contact.



8. The valves, electrical outlets and switches for utilities serving hoods should be placed at readily accessible locations outside the hood. All shutoff valves should be clearly labeled. Plumbing (e.g., vacuum lines) should exit the sides of the fume hood and not the bench top.

J. Sashes

1. Hoods shall have transparent movable sashes constructed of shatter-resistance, flame resistant material and capable of closing the entire front face.
2. Vertical-rising sashes are the only sash style permitted at the University. Horizontal sashes are **prohibited** unless authorized by [EH&RS](#) must be attained.
3. A force of five pounds shall be sufficient to move vertically and/or horizontally moving doors and sashes.
4. Chemical fume hoods shall have a self-closing sash.

K. Ducting

1. Hood exhausts should be manifolded together except for:
 - a) Perchloric/hot acid hoods.
 - b) Hoods with wash-down equipment.
 - c) Hoods that could deposit highly hazardous residues on the ductwork.
 - d) Exhaust requiring HEPA filtration or other special air cleaning.
 - e) Situations where the mixing of exhausted materials may result in a fire, explosion, or chemical reaction hazard in the duct system.
2. Manifolded fume hood exhaust ducts shall be joined inside a fire rated shaft or mechanical room, or outside of the building at the roofline.
3. Horizontal ducts must slope at least 1 inch per 10 feet downward in direction of airflow to a suitable drain or sump.
4. Ducts exhausting air from fume hoods should be constructed entirely of noncombustible material. Gaskets should be resistant to degradation by the chemicals involved and fire resistant.
5. Automatic fire dampers shall not be used in laboratory hood exhaust systems. Fire detection and alarm systems shall not be interlocked to automatically shut down laboratory hood exhaust fans.

L. Exhaust

1. New exhaust fans shall be oriented in a vertical up direction
2. Hood exhaust stacks shall extend at least 10 feet above the adjacent rooflines and air intakes. Discharge shall be directed vertically upward.



3. Hood exhausts shall be located on the roof as far away from air intakes as possible to preclude re-circulation of laboratory hood emissions within a building.
4. Discharge from exhaust stacks must have a velocity of at least 3,000 fpm. Achieving this velocity should not be done by the installation of a cone type reducer. The duct may be reduced, but the duct beyond the reduction should be of sufficient length to allow the air movement to return to a linear pattern.
5. Rain caps that divert the exhaust toward the roof are **prohibited**.
6. Laboratory ventilation exhaust fans shall be spark-proof and constructed of materials or coated with corrosion resistant materials for the chemicals being transported. [Fans are to be direct drive type with VFDs.](#)
7. Vibration isolators shall be used to mount fans. Flexible connection sections to ductwork, such as neoprene coated glass fiber cloth, shall be used between the fan and its intake duct when such material is compatible with hood chemical use factors.
8. Each exhaust fan assembly shall be individually matched (cfm, static pressure, brake horsepower, etc.) to each laboratory ventilation system.
9. Exhaust fans shall be located outside the building at the point of final discharge. Each fan shall be the last element of the system so that the ductwork through the building is under negative pressure.
10. Fans shall be installed so they are readily accessible for maintenance and inspection without entering the plenum.

M. Noise

1. System design must provide for control of exhaust system noise (combination of fan-generated noise and air-generated noise) in the laboratory. Systems must be designed to achieve an acceptable Sound Pressure Level (SPL) frequency spectrum (room criterion) as described in the [ASHRAE HVAC Applications Handbook, current edition](#).

N. Specialty, Controlled Climate, and Cold Rooms

1. The issue of ventilation in cold rooms during periods of occupancy or for storage of hazardous materials must be addressed. EH&S should be consulted to review arrangements for providing fresh and exhaust air during periods of occupancy and for storage of hazardous materials or compressed gases.
2. Specialty rooms, designed for human occupancy must have latches that can be operated from the inside to allow for escape.



3. Latches and frames shall be designed to allow actuation under all design conditions, such as freezing. Magnetic latches are recommended.
4. Doors of walk-in specialty rooms must have viewing windows and external light switches.

O. Laboratory Hood Commissioning

1. Proper operation of fume hoods must be demonstrated by the contractor installing the fume hood prior to project closeout. The recommended containment performance test is ANSI/ASHRAE 110. The contractor must utilize the University's contracted vendor.
2. Laboratory hood commissioning to be witnessed by a representative of [EH&RS](#) or Drexel Facilities.

P. Testing, Adjusting, and Balancing

1. Testing, Adjusting and Balancing (TAB) contractor must provide a floor plan showing diffuser and register layouts and designations used on balancing report, in accordance with NEBB requirements.
2. TAB to be in accordance with ANSI/ASHRAE Standard 111.
3. A/E to add the following statement in the fume hood specification section:
 - a) Laboratory fume hoods shall achieve an average face velocity of 100 feet per minute (fpm) at a sash height of 18 inches. No one-test velocity reading within the test grid structure should vary by more than +/-20% (80-120 fpm) of the average. If reading is +/- 20% Drexel [EH&RS](#) will deem the face velocity test a failure and require a retest. Face velocity uniformity shall be achieved by installing a venturi valve inside the ductwork. Refer to section 23 36 00.1 for venturi valve specification.

IV. EMERGENCY EYEWASH AND SAFETY SHOWER EQUIPMENT

A. Scope

1. The Standard applies to all Drexel University and Drexel University college of Medicine facilities, including leased properties. This Standard presents the minimum performance requirements for eyewash and shower equipment for the emergency treatment of the eyes or body of a person exposed to injurious materials. It covers the following types of equipment: emergency showers, eyewash equipment, and combination shower and eyewash or eye/face wash.
 - a) All eyewash and deluge showers must comply with ANSI Z 358.1.
 - b) A plumbed eyewash shall be provided for all work areas where, during normal operations or foreseeable emergencies, the eyes of an employee may come into contact with a substance which can cause corrosion, severe irritation, or is toxic by skin absorption. Drench hoses, sink faucets, or showers are not acceptable eyewash facilities.



- c) A plumbed eyewash shall be provided at all work areas where formaldehyde solutions in concentrations greater than or equal to 0.1% are handled.
- d) An emergency shower shall be provided for all work areas where, during normal operations or foreseeable emergencies, areas of the body may come into contact with a substance which is corrosive, severely irritating to the skin or is toxic by skin absorption.
- e) A deluge shower shall be provided at all work areas where formaldehyde solutions in concentrations greater than or equal to 1% are handled.

B. General Location

1. Emergency eyewash facilities and deluge showers shall be in unobstructed and accessible locations that require no more than 10 seconds or 25 feet for the injured person to reach along an unobstructed pathway (i.e., no doors without panic bars or which don't swing open when pushed). If both eyewash and shower are needed, they shall be located so that both can be used at the same time by one person.
2. American with Disabilities Act (ADA) Emergency Eyewash/Showers:
 - a) Install an emergency eyewash/shower so that a disabled person can access it within 10 seconds of an ADA fume hood (minimally one ADA hood per laboratory floor). These emergency eyewash/showers must provide appropriate accessibility (e.g., activation of controls and height of eyecups) to individuals in wheelchairs.
3. Signage:
 - a) Emergency eyewash and shower locations shall be identified with a highly visible sign. The areas around the eyewash or shower shall be well lighted and highly visible.
 - b) Whenever possible, the floor immediately beneath the eyewash and emergency shower, and to a radius of between about 12-30 inches, shall be a distinctive pattern and color to facilitate promoting a clear path of access.
4. Prohibitions Around Equipment:
 - a) No obstructions, protrusions, or sharp objects shall be located within 16 inches from the center of the spray pattern of the emergency shower facility.
 - b) Electrical apparatus, telephones, thermostats, or power outlets should not be located within 18 inches of either side of the emergency shower or emergency eyewash facility (i.e., a 36-inch clearance zone).

C. Eyewash Requirements

1. Flushing Rates
 - a) A means shall be provided to ensure that a controlled flow of flushing fluid is provided to both eyes simultaneously.
 - b) Eyewash equipment shall be capable of delivering to the eyes not less than 0.4 gallons per minute of flushing fluid for 15 minutes.



2. Eyewash Positioning
 - a) The eyewash unit shall be positioned with the water nozzles 33-45 inches from the floor and 6 inches minimum from the wall or nearest obstruction. The unit must be located at an operable sink.
3. Equipment Activation
 - a) The valve shall be designed so that the flushing fluid remains on without requiring the use of the operator's hands. The valve shall be designed to remain activated until intentionally shut off.
4. Eyewash Equipment Protection
 - a) Nozzles shall be protected from airborne contaminants. The removal of the nozzle protection shall not require a separate motion by the operator when activating the unit.

D. Deluge Shower Requirements

1. Deluge Shower Positioning
 - a) The emergency shower location must have a level surface beneath the shower head. The floor shall be slip-resistant and privacy curtain shall be provided.
 - b) Emergency shower heads shall be designed so that a flushing fluid column is provided that is not less than 82 inches and not more than 96 inches in height from the surface on which the user stands.
 - c) The shower head should not be mounted flush or recessed within any constructed surfaces or partitions and the center of the spray pattern shall be located at least 16 inches from any obstruction.
 - d) The spray pattern shall have a minimum diameter of 20 inches at 60 inches above the surface on which the user stands
2. Flushing Rates
 - a) Emergency shower heads shall be capable of delivering a minimum of 75.7 liters per minute (20 gpm) of flushing fluid.
 - b) The shower should be attached to a flushing fluid supply from a 1-inch minimum iron pipe size (IPS).
3. Equipment Activation
 - a) The valve shall be designed so that the flushing fluid remains on without requiring the use of the operator's hands. The valve shall be designed to remain activated until intentionally shut off.
 - b) The manual actuator, triangle pull, shall be located not more than 69 inches above the surface on which the user stands. The manual actuator shall be free from obstruction for 18 to 24 inches in all directions. The actuator shall not be mounted flush or recessed within any constructed surfaces or partitions.
4. Design for Maintenance/Use.
 - a) The water supply to showers and/or shower/eyewash combination units should be controlled by a ball-type shutoff valve which is visible and accessible to shower testing personnel in the event of leaking or failed shower head valves.



- b) Any floor drain which may be in service during safety shower use shall be installed with a temporary plug which remains closed except when the shower is in use, or if protected from spills by a covered sump or berm system.

E. Testing

1. Proper operation of the equipment must be demonstrated by the contractor installing the emergency eyewash or shower equipment prior to project closeout and facility occupation. Tags to allow monthly testing records to be kept shall be affixed to the showers and eyewash fountains.

F. Approved Equipment

1. All emergency showers and eyewash facilities shall meet the requirements of ANSI Z358.1 and shall be installed in accordance with ANSI Z358.1.

V. COMPRESSED GAS CYLINDERS

A. Scope

1. The Standard applies to all Drexel University and Drexel College Medicine facilities, including leased properties. It covers all unfired pressure vessels (i.e., storage tanks; compressed gas cylinders) that have been designed to operate at pressures above 15 psig. including the storage and use of compressed gas cylinders and cryogenic fluids.

B. Design Features for the Storage of Compressed Gas Cylinders – General

1. Location/Design
 - a) Laboratory design shall include a storage area for cylinders of compressed gases where:
 - i) The cylinders are protected from external heat sources such as flame impingement, intense radiant heat, electric arc, or high temperature steam lines.
 - ii) The cylinders are in a well-protected, well ventilated, dry location, at least 20 feet from highly combustible materials.
 - iii) The cylinders are stored in a ventilated area under negative pressurization.
2. Adequate space shall be made available for the segregation of gases by hazard class. Flammable gases shall not be stored with oxidizing agents. Separate storage for full or empty cylinders is preferred. Such enclosures shall serve no other purpose.
3. Design features which are **prohibited**:
 - a) Unventilated enclosures such as closets, lockers, cold-rooms, and cupboards.
4. Liquefied fuel-gas cylinders shall be stored in an upright position so that the safety relief device is always in direct contact with the vapor space in the cylinder.



5. The heating of flammable gas storage areas shall be indirectly heated, such as by air, steam, hot water, etc.
6. Gas cabinets shall be required for flammable, toxic and highly toxic gases.
7. Storage areas must be secure at all times against unauthorized access.
8. A secure central cylinder collection point must be provided. The collection must accommodate segregation of gases by hazard class and empty cylinder storage.
9. Cylinder Restraint Systems:
 - a) Laboratory design shall include restraints for the storage of cylinders greater than 26 inches tall; the restraint system shall include at least 2 restraints (made of non-combustible materials), which are located at one-third and two-thirds the height of the cylinder.
 - b) The purchase and installation of compressed gas cylinder securing systems must be approved by EH&S.
 - c) Gas cylinder securing systems should be anchored to a permanent building member or fixture.

C. Design Features for the Storage of Compressed Gas Cylinders – Toxic and Highly Toxic Gases

1. Storage Systems:
 - a) Storage systems for toxic and highly toxic compressed gas cylinders must be in accordance with the City of Philadelphia's Fire Code, [current edition](#). Laboratory design shall include one of the following storage systems:
 - i) Ventilated gas cabinets/exhausted enclosures/laboratory fume hoods.
or
 - ii) Separate ventilated gas storage rooms without other occupancy or use.
2. When gas cabinets or exhausted enclosures are provided, they shall be:
 - a) Located in a room or area which has independent exhaust ventilation.
 - b) Under negative pressure in relation to the surrounding area.
 - c) A unit that has self-closing limited access parts or noncombustible windows to provide access to equipment controls, with an average face velocity of at least 200 fpm and with a minimum of 150 fpm at any part of the access port or window; and with design criterion of 200 fpm at the cylinder neck when the average face velocity is >200 fpm.
 - d) Connected to an exhaust system.
 - e) A unit that has self-closing doors and be constructed of at least 0.097-inch (12 gauge) steel.
 - f) Internally sprinklered.
 - g) Contain no more than 3 cylinders per gas cabinet, except where cylinder contents are 1 pound net or less, in which case gas cabinets may contain up to 100 cylinders;
 - h) Fitted with sensors connected to alarms to notify in the event of a leak, or exhaust system failure.



3. When separate gas storage rooms are provided, they shall:
 - a) Operate at a negative pressure in relation to the surrounding area.
 - b) Direct the exhaust ventilation to a dedicated exhaust system.
 - c) Fitted with sensors connected to alarms to notify in the event of a leak or exhaust system failure.
4. Emergency Power:
 - a) Emergency power shall be provided for exhaust ventilation, gas-detection systems, emergency alarm systems, and temperature control systems.
5. Detection System:
 - a) The detection system shall initiate a local alarm and transmit a signal to a constantly attended location. Activation of the monitoring system shall automatically close the shut-off valve on toxic and highly toxic gas supply lines to the system being monitored.
 - b) An approved supervised smoke detection system shall be provided in rooms or areas where highly toxic compressed gases are stored indoors.
6. Security:
 - a) Storage areas shall be secured against unauthorized entry.
 - b) Wall cylinder bracket is the preferred method to secure gas cylinders in the laboratories.

VI. FLAMMABLE LIQUID STORAGE CABINETS

A. Scope

1. Flammable liquid storage cabinets are intended for the storage of flammable and combustible liquids. This Standard applies to all Drexel University and Drexel University College of Medicine facilities, including leased properties. It covers the design, construction, and installation of Flammable Liquid Storage Cabinets; the Standard does not address the proper use of Flammable Liquid Storage Cabinets.

B. Design

1. Approval/Submittal:
 - a) Flammable Liquid Storage Cabinets must be UL listed and must meet the City of Philadelphia's Fire Code requirements and NFPA 30 (Flammable and Combustible liquids code), [current editions](#).
2. Cabinet Capability:
 - a) Where flammable liquid storage cabinets are required, they shall be designed such that they do not exceed 120 gallons for the combined total quantity of all liquids (i.e., Classes 1, 2, and 3).



3. Labeling:
 - a) Flammable Liquid Storage Cabinets shall be conspicuously labeled in red letters on contrasting background "FLAMMABLE - KEEP FIRE AWAY."
 - b) When flammable or combustible liquids present multiple hazards, the laboratory design shall address the storage requirements for each hazard.

C. Construction

1. Materials
 - a) New Flammable Liquid Storage Cabinets must be constructed of steel.
 - b) Flammable Liquid Storage Cabinets shall be constructed as follows:
 - i) Minimum wall thickness of 0.044 inches (18 gauge).
 - ii) Double walled construction with a minimum air gap of 1-1/2-inches between the walls including the door, top, bottom, and sides.
 - iii) Tight-fitting joints welded or riveted.
 - iv) Liquid-tight bottom with a door sill of at least 2 inches.
 - v) Three-point latch on doors. Storage cabinets with sliding drawers are **prohibited**.
2. Doors:
 - a) Cabinet doors shall be self-closing, self-latching, and swing open.
3. Venting:
 - a) Flammable Liquid Storage Cabinets are not required to be vented except for odor control of malodorous materials. Vent openings shall be sealed with the bungs supplied with the cabinet or with bungs specified by the manufacturer of the cabinet. If vented, it shall be vented outdoors to an approved location or through a flame arrester to a fume hood exhaust system. Construction of the venting duct should be equal to the rating of the cabinet.

D. Location

1. Flammable Liquid Storage Cabinets shall NOT be located near exit doorways, stairways, or in a location that would impede egress.
2. Flammable Liquid Storage Cabinets must NOT be wall mounted.
3. Laboratory design must ensure that Flammable Liquid Storage Cabinets are NOT located near an open flame or other ignition source.



XXIII. APPENDIX B

Telecommunications and Data System Components

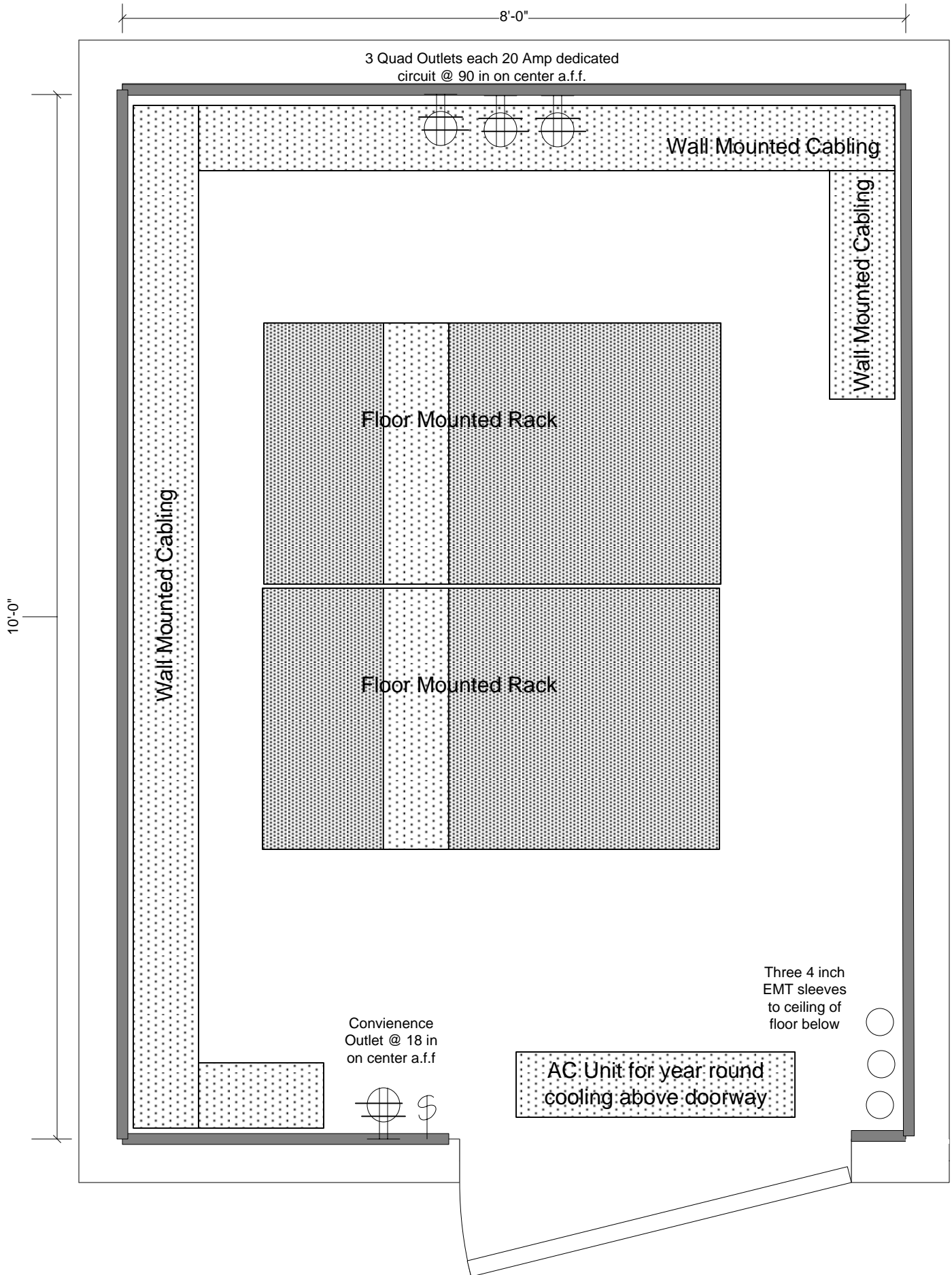


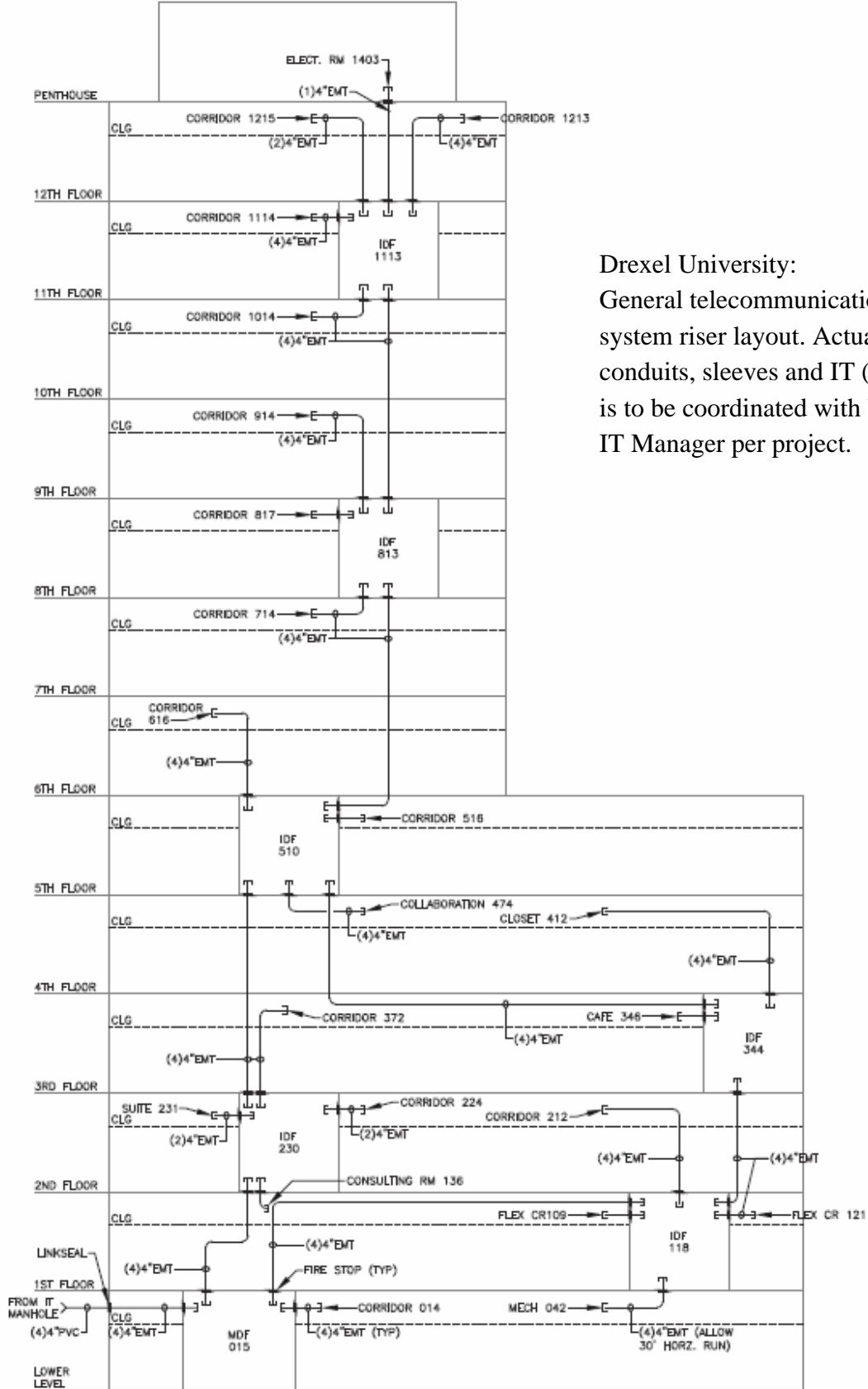
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Light Switch

Dedicated 20 Amp Quad Receptacle

3/4 in Fire Rate Plywood starting 6 in a.f.f. to 8'6" all walls





Drexel University:
 General telecommunication and data system riser layout. Actual number of conduits, sleeves and IT (IDF) rooms is to be coordinated with University IT Manager per project.

TELECOMMUNICATIONS CONDUIT RISER DIAGRAM

N.T.S.

NOTES:

1. REQUIRED JUNCTION BOXES ARE NOT SHOWN. PROVIDE ACCESSIBLE JUNCTION/PULL BOXES SO THAT THERE ARE NO MORE THAN (2) 90 DEGREE BENDS IN ANY SINGLE RUN.
2. REFERENCE DRAWINGS FOR ADDITIONAL HORIZONTAL CONDUIT RUNS AND CABLE TRAY LAYOUT.



Wiremold

DS4000[®] Series Steel Raceway

Innovative Raceway Profile Provides Increased Wiring Capacity Available Factory Prewired



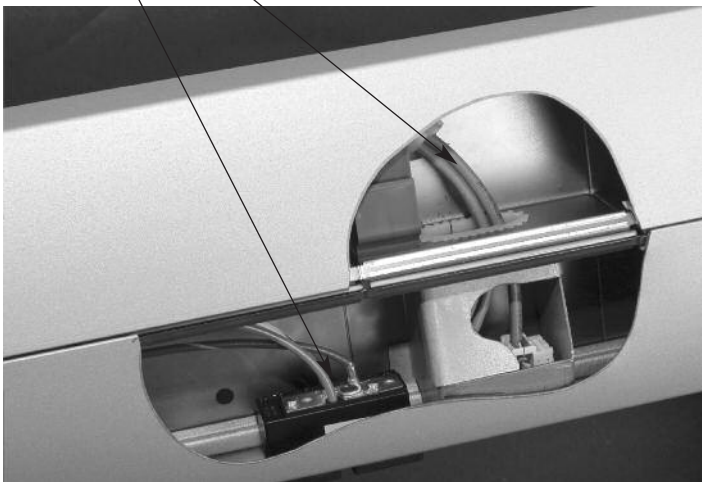
Wiremold introduces the next generation in innovative surface raceway systems. The new DS4000[®] Series Raceway provides an aesthetically and functionally superior alternative to existing raceway profiles. DS4000 Series Raceway is a dual service steel raceway, with twin covers and a built-in divider that provides full isolation of services. Because of the innovative features and fittings, this raceway saves on installation time, costs less to specify, and provides 1/3 more wiring capacity than conventional box-style raceway profiles.

With its increased capacity and unique downward-facing activation capabilities, DS4000 Series Raceway is an ideal solution for any commercial, institutional, or industrial application requiring a high capacity metal raceway.



DS4000[™] Raceway in a contemporary office environment.

Power Data



Sectioned view illustrating internal crossover capability, allowing adjacent downward facing power and data activations. Raceway profile meets or exceeds EIA/TIA bend radius requirements.



DS4000[™] Series Raceway prewired with streamlined downward facing power and data activations.



Now compatible with A/V devices.

FEATURES & BENEFITS

4000 Designer Series™ Raceway represents a significant advancement in both the design and functionality of surface-mounted raceway systems. Design improvements not only make the raceway easier to install and wire, they result in a more functional, higher capacity system with a more appealing streamlined appearance. Unique adaptable fittings, multiple activation options, upgraded color options and a host of design improvements all contribute to the overall benefits and advantages of this innovative product. Listed below are the full range of improvements that have been incorporated into this industry-leading raceway system.

SYSTEM

- **Innovative profile.** Accommodates greater wiring capacity and has a more aesthetic appearance than conventional box-shaped profiles. Design allows for more efficient use of raceway capacity and provides 1/3 more wiring capacity than conventional raceways including Wiremold 4000 Series™ Raceway.
- **Adaptable fittings.** Reduces the number of SKUs required for inventory making DS4000™ Series Raceway easier to specify, order, and inventory.
- **Ease of installation.** DS4000™ Raceway systems can be installed by a single installer, reducing installation costs and maximizing installer resources. Innovative fittings and features also save time and money on future adds and changes.
- **No-saw cut base design.** Raceway base and Adjust-to-Fit™ couplings eliminate precise cuts required during installation, saving installation time. Raceway base is scored so that it can be easily cut with tin snips when required.
- **Overlapping fittings and faceplates.** Simpler, cleaner, and more attractive installation. No visible screws. Also allows raceway covers to be cut to larger tolerances.
- **Field-configurable.** Installers can easily adapt and modify installations to accommodate unforeseen obstacles. Saves installation time and reduces cost overruns from ordering additional parts not originally specified.
- **Dual cover raceway.** True separation of services allows data and power installers to access their respective channels individually.
- **Full capacity channels.** Power and data can be fed through either raceway channel, with special cross-over fittings available to maximize raceway capacity and maintain separation of services.
- **Room to grow.** Generous bend radius and increased raceway capacity support newer and larger capacity Cat 6a cables. Raceway accommodates increased power and data requirements in installations.
- **Meets or exceeds industry standards.** Conforms to UL, NEC, and NEMA standards and EIA/TIA recommendations.
- **Greater range of standard colors.** DS4000™ Steel Raceway is available in an updated palette of colors including Designer Ivory, Designer Gray, Matte Black, and Metallic Bronze. Custom colors are also available.
- **Patents pending.**

BASE

- **Easy to cut.** Base sections are scored at four-inch [102mm] intervals and can be easily cut with tin snips (when required). Specialized cutting tools or saws are not needed.
- **Easy to mount.** Base sections have mounting holes at four inches [102mm] intervals. Installer can utilize them with both 16" or 24" [406mm or 610mm] framing. Combined with included Adjust-to-Fit™ couplings, this ensures that mounting holes line up with wall studs.
- **One-piece base and divider.** Divider has pre-scored knockouts for cabling crossovers. One-piece design reduces installation time.

- **Hardware included.** Each ten-foot [3.04m] section of base includes wire clips (8 clips, 4 pre-installed) and a pair of Adjust-to-Fit™ couplings. Adjust-to-Fit™ couplings are also included with all raceway fittings.

FITTINGS

- **Streamlined fittings.** Innovative design eliminates large, bulky fittings that detract from raceway appearance.
- **Easy to install.** Adjust-to-Fit™ couplings (included) provide up to four inches [102mm] of lateral adjustment, eliminating the need for precision cuts and reducing waste caused by measuring errors.
- **Full-range of obstacle avoidance fittings.** Bypass large and small obstacles, as well as small offsets in supporting walls. Small obstacle avoidance fitting also can be used as a transition fitting to other Wiremold® metal raceway systems. Eliminates all barriers to installation.
- **Transition fittings.** Transition fittings connect DS4000™ Series Raceway to existing Wiremold 4000 Series Raceway installations or make transition to other Wiremold raceway systems (500 Series™, 700 Series™, 2400 Series™).
- **Cable bend radius control.** No need to order special fittings to meet bend radius compliance standards. All fittings include cable bend radius control and meet the specifications for Fiber Optic and UTP/STP cabling and exceed the TIA 569 requirements for communications pathways.
- **Tamper-proof.** Tamper-resistant fasteners are available to fully secure the raceway installation. Ideal for security systems, alarms or other security-sensitive installations.

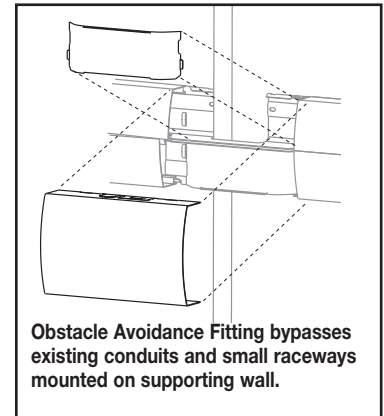
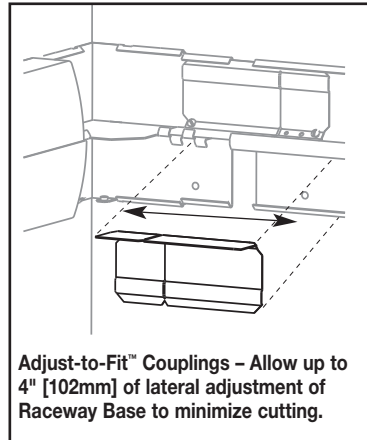
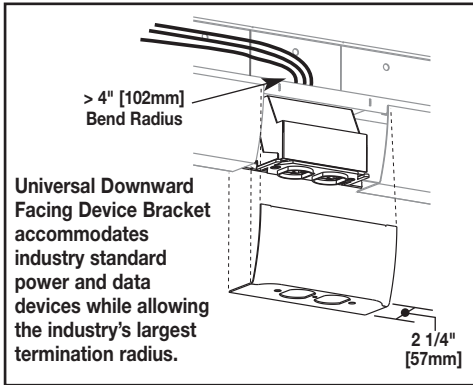
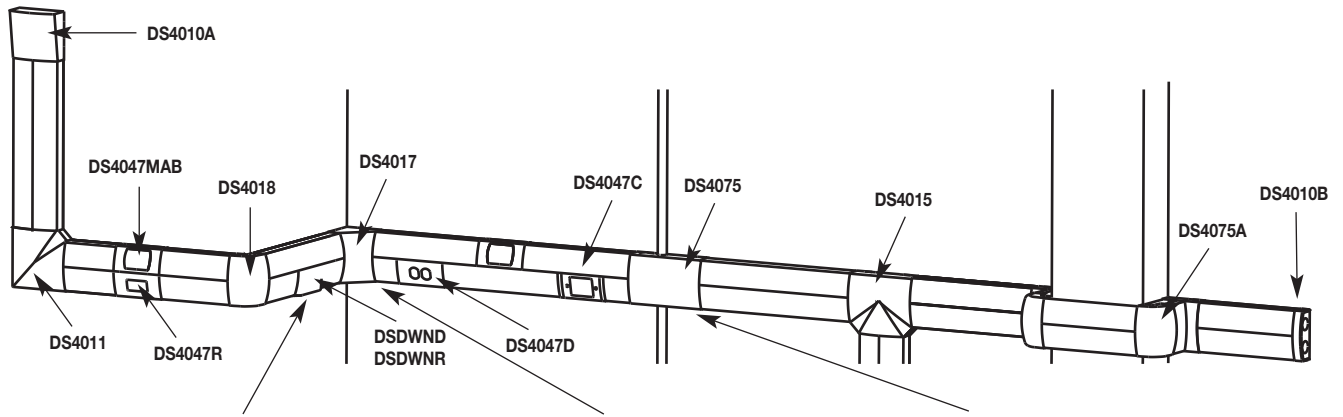
ACTIVATIONS

- **Unique downward-facing activations.** Large bend radius for data cables and activations, streamlines the raceway appearance, and provides increased protection for both activations and cabling. Only raceway system that offers this feature.
- **Innovative downward-facing and/or side-channel activation features.** Raceway can be loaded with either downward-facing or conventional activations, or a combination of both as needed.
- **Cross-over feature.** Allows better utilization of raceway wiring capacity while maintaining separation of services.
- **Activations accept industry-standard devices and device plates.** Compatible with a full-range of wiring, data, and communication products.

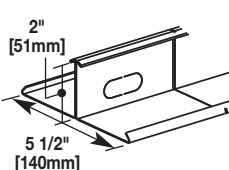
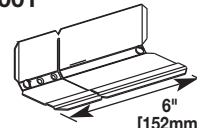
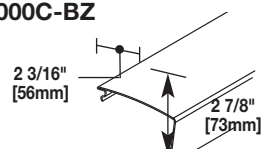
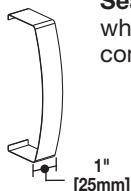
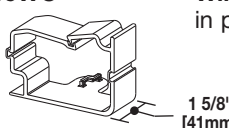
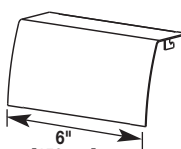
PREWIRED

- **Available prewired.** DS4000™ Series Raceway can be ordered factory prewired saving installation time and money. Jobs are packed to individual job requirements and delivered on schedule to the job site.
- **Streamlined design.** Downward-facing activations provide a clean, streamlined appearance.
- **Visual circuit identification system included.** No need to order additional labels or marking systems.

DS4000 Series Raceway System Layout

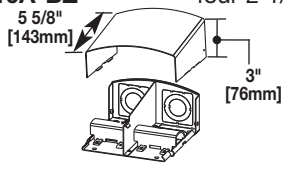
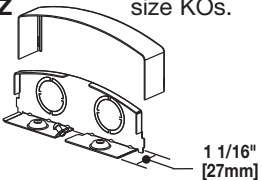
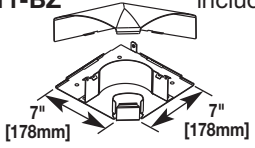
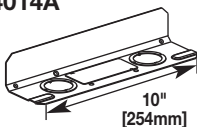
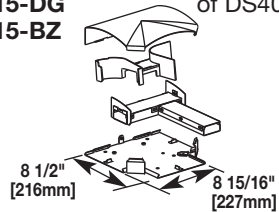
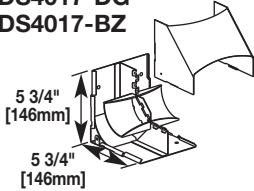
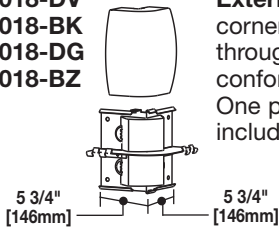
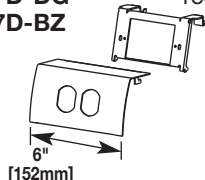
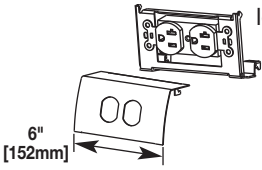
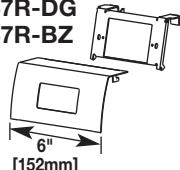
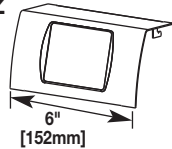
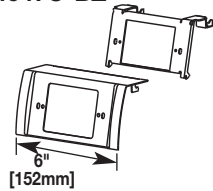


DS4000 Series Raceway Ordering Information

Catalog No./Item	Description/Specifications	Catalog No./Item	Description/Specifications
DS4000B 	Raceway Base – .040" [1.0mm] galvanized steel. Base has two 9/32" [7.1mm] diameter mounting holes on centers of approximately 4" [102mm] and pass through KOs on 8" [203mm] centers throughout. Packed four 10' [3.05m] lengths per carton.	DS4001 	Adjust-to-Fit™ Coupling – For joining lengths of DS4000B together. Sold in pairs.
DS4000C-DV DS4000C-BK DS4000C-DG DS4000C-BZ 	Raceway Cover – .040" [1.0mm] galvanized steel. Packed eight 5' [1.5m] lengths per carton.	DS4006-DV DS4006-BK DS4006-DG DS4006-BZ 	Seam Clip – For covering seams where two sections of DS4000C come together.
DS4000WC 	Wire Clip – For holding conductors in place.	DS4006B-DV DS4006B-BK DS4006B-DG DS4006B-BZ 	Half Seam Clip/Blank Faceplate – For covering seams where two sections of DS4000C Cover come together. Can also be used as a blank faceplate.

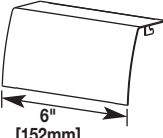
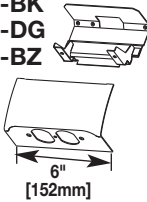
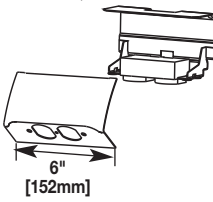


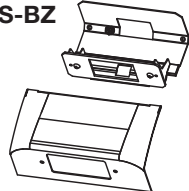
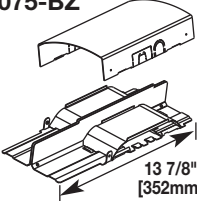
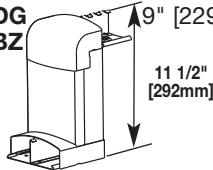
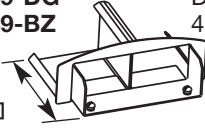
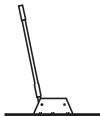



NOTE: "-DV" suffix indicates Designer Ivory color, "-DG" suffix indicates Designer Gray color, "-BK" suffix indicates Matte Black color, and "-BZ" suffix indicates Metallic Bronze color.

DS4000 Series Raceway Ordering Information (continued)

Catalog No./Item	Description/Specifications	Catalog No./Item	Description/Specifications
DS4010A-DV DS4010A-BK DS4010A-DG DS4010A-BZ	Entrance End Fitting – Full-capacity end fitting. Includes four 3/4" and 1 1/4" concentric trade size KOs and four 2 1/8" large capacity KOs.		External Elbow – 90° external corner for new lay-in or pull-through installations. Flexible base conforms to out-of-square corners. One pair of DS4001 Couplings included.
DS4010B-DV DS4010B-BK DS4010B-DG DS4010B-BZ	Blank End Fitting – For closing open end of DS4000B Raceway Base. Has two 3/4" and 1" trade size KOs.		Single Channel Duplex Device Plate – For 15A and 20A duplex receptacles or 106 style data frames.
DS4011-DV DS4011-BK DS4011-DG DS4011-BZ	Flat Elbow – 90° flat corner for new lay-in or pull-through installations. One pair of DS40001 Couplings included.		Single Channel Duplex Device Plate w/One Duplex Installed – Includes one Pass & Seymour 20A duplex receptacle with 6" [152mm] lead wires installed on bracket.
DS4014A	Backfeed Coupling – Extra long coupling allows attachment to wall box or back fed 1" or 1 1/4" trade size conduit.		Single Channel Decorator Device Plate – For 15A and 20A duplex receptacles, or 106 style data frames.
DS4015-DV DS4015-BK DS4015-DG DS4015-BZ	Divided Tee Fitting – For new lay-in or pull-through installations. Two pair of DS4001 Couplings included.		Single Channel MAB Device Plate – For all communication devices, including mini adapter bezels.
DS4017-DV DS4017-BK DS4017-DG DS4017-BZ	Internal Elbow – 90° internal corner for new installations. Flexible base conforms to out-of-square corners. One pair of DS4001 Couplings included.		Single Channel NEMA Device Plate – For Turnlok® and most straight blade devices up to 50 Amps. Use with commercially-available flush plates.
DS4018-DV DS4018-BK DS4018-DG DS4018-BZ			
DS4047D-DV DS4047D-BK DS4047D-DG DS4047D-BZ			

NOTE: “-DV” suffix indicates Designer Ivory color, “-DG” suffix indicates Designer Gray color, “-BK” suffix indicates Matte Black color, and “-BZ” suffix indicates Metallic Bronze color.

DS4000 Series Raceway Ordering Information (continued)

Catalog No./Item	Description/Specifications
DS4006B-DV DS4006B-BK DS4006B-DG DS4006B-BZ	Half Seam Clip/Blank Faceplate – For covering seams where two sections of DS4000C Cover come together. Can also be used as a blank faceplate. 
DSDWND-DV DSDWND-BK DSDWND-DG DSDWND-BZ	Downward Duplex Device Plate – For 15A and 20A duplex receptacles or 106 style data frames. 
DSDWNDQ-DV DSDWNDQ-BK DSDWNDQ-DG DSDWNDQ-BZ	Downward Duplex Device Plate w/One Duplex Installed – Includes one Pass & Seymour 20A duplex receptacle with 6" [152mm] wire leads installed on bracket. 
DSDWNR-DV DSDWNR-BK DSDWNR-DG DSDWNR-BZ	Downward Decorator Device Plate – For 15A and 20A duplex receptacles, GFCI and Surge devices, or 106 style data frames. 
DSDWNX	Crossover Kit – Includes enclosures for power or data crossover. 
DSDWNS-DV DSDWNS-BK DSDWNS-DG DSDWNS-BZ	Downward Ortronics® Series II Device Plate – Accepts one Ortronics® Series II module. 
DS4075-DV DS4075-BK DS4075-DG DS4075-BZ	Small Obstacle/Transition Fitting – For passing over previously installed conduits or raceways up to 2400 Series Raceway, or for transitioning to 500 Series™, 700 Series™ or 2400D Series™ Raceway. 
DS4075A-DV DS4075A-BK DS4075A-DG DS4075A-BZ	Offset Fitting – For use on wall offsets or column depths up to 9" [229mm]. 
DS4089-DV DS4089-BK DS4089-DG DS4089-BZ	Adapter to 4000 Series Raceway – For transitioning in-line from DS4000 Series Raceway to 4000 Series Raceway. 
DSTRK	Tamper-Resistant Kit – Includes 25 screws and bit to secure fitting covers to DS4000B Raceway Base.
640DS	DS4000C Cutter – Portable cover cutter provides clean square cuts for DS4000C Raceway Cover. 
650RT	Fitting Cover Removal Tool – Allows for easy removal of all installed DS4000C Raceway Covers without damaging finish. 
DVWE-S DGWE-S BKWE-S BZWE-S	Spray Paint – Used to touch up large areas. NOTE: Can only be shipped via ground transportation. 
DVWE-P DGWE-P BKWE-P BZWE-P	Touch-Up Paint Pen – Used to touch up small areas. 

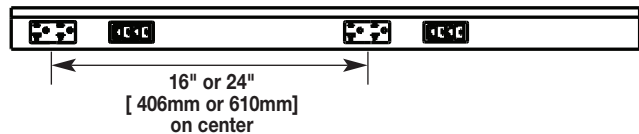
NOTE: “-DV” suffix indicates Designer Ivory color, “-DG” suffix indicates Designer Gray color, “-BK” suffix indicates Matte Black color, and “-BZ” suffix indicates Metallic Bronze color.

DS4000 Series Raceway Prewired Raceway Features

FEATURES	STANDARD	OPTIONS
Communication Devices	Ortronics or Pass & Seymour Activate Connectivity System Devices	Other manufacturers
Electrical Devices	Pass & Seymour	Other manufacturers and some International devices
Base Length	Longest = 10' [2.54m], shortest = 1' [305mm]	—
Installation	Surface mounted	Downward Facing Activations; Front Facing Activations
Finish	Baked enamel finish – Designer colors	Custom colors
Wire Type	THHN stranded	Options per specification
Wiring Splices	Insulation displacement connectors	Continuous wiring or twist-on wire connector
Grounding Conductors	Wire gauge per National Electrical Code (NEC) and shared grounding wires	Oversized and/or separate grounding wires
Device Identification	Gray self-adhesive polyester label with black letters	Self-adhesive engraved nameplate
Neutrals	Shared neutral	Oversized and/or separate neutral wires
Pigtails	12" [305mm] feeds and receptacle leads	Per specification
Conduit Feeds	Raceway drilled at job site	Entrance end cap
Record Drawings	3 sets and 2 copies of marked-up blueprints	Per job requirements
Submittal Services	Detailed submittal	Submittal free

DS4000 Series Raceway Prewired Downward Device Options

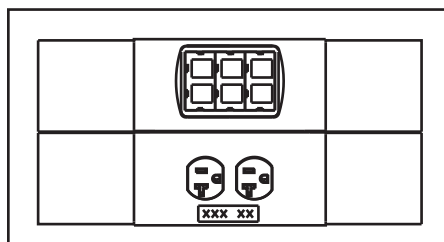
Flush downward facing power and data are available in the following single or multi-circuit 20A configurations:



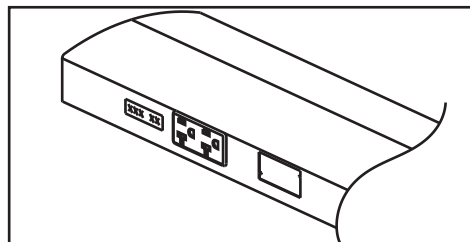
NOTE: Top channel Should be reserved for data to provide highest capacity and bend radius. Standard forward facing faceplates can be intermixed with prewired, but are subject to location restrictions due to the location of downward facing data. Consult factory for recommended locations.

Device and Raceway Labeling Detail for Prewired Applications

- Device labeling is available in the following materials:
 - Gray self-adhesive polyester label with black lettering (standard).
 - Other color self-adhesive polyester labels.
 - Engraved phenolic nameplates with adhesive backing.
- The back of the raceway is labeled with the raceway number and the room or area number(s).



Labeling detail using the front activation plates.



Labeling detail using the downward facing activation plates.

DS4000 Series Raceway Ordering Specifications for Prewired Applications

Two options available when ordering a prewired job:

- 1. Detailed Submittal** The detailed submittal will show exactly how each raceway run will be built including lengths, number and type of receptacles, wiring schematics, circuiting information, etc. The contractor and/or distributor must review, clarify any information not clearly indicated on the drawings or specs, approve, and return to the factory before production can begin.
- 2. Submittal Free** The Prewired Express Building Plan Checklist is filled out by the contractor or distributor and sent along with plans, casework, and specs to the factory. No submittal is required and the project is scheduled for production upon receipt of all necessary information.

DS4000 Series Raceway Wire Fill Capacity Charts

DS4000 Raceway Wire Fill Capacities for Power

WIRE SIZE THHN/THWN	O.D. Inches [mm]		NUMBER OF CONDUCTORS (40% FILL)				
			WITHOUT DEVICES	w/DUPLEX RECT. DEVICES 1.59in. ² [1025mm ²]	w/SURGE/GFCI DEVICES 2.30in. ² [1485mm ²]	w/LARGE SINGLE DEVICES 3.00in. ² [1935mm ²]	40% FILL w/DOWNWARD ACTIVATION/CROSSOVER
14 AWG	0.111	[2.8]	206	141	111	83	46
12 AWG	0.130	[3.3]	150	103	81	60	33
10 AWG	0.164	[4.2]	95	64	51	38	21
8 AWG	0.216	[5.5]	54	37	29	22	12
6 AWG	0.254	[6.5]	39	27	21	15	8

NOTE: For additional information, refer to the Technical Section of the current version of ED439 (Wiremold Product Guide).

DS4000 Raceway Wire Fill Capacities for Communication

CABLE TYPE	CATEGORY/ DESIGNATION	O.D.		40% FILL 1/2 COMPARTMENT	40% FILL w/DOWNWARD ACTIVATION/CROSSOVER
		Inches	[mm]		
UNSHIELDED TWISTED PAIR	4-pair, 24 AWG Cat 3	0.190	[4.8]	70	28
	4-pair, 24 AWG Cat 5e	0.210	[5.3]	57	23
	4-pair, 24 AWG Cat 6	0.250	[6.3]	40	16
	4-pair, 24 AWG Cat 6a*	0.354	[9.0]	20	8
	25-pair, 24 AWG	0.410	[10.4]	15	6
COAXIAL	RG6/U	0.270	[6.9]	35	14
FIBER	ZipCord	0.118 x 0.236	[3 x 6]	72	29
	Round 4 Strand Fiber	0.187	[4.8]	73	29
	Round 6 Strand Fiber	0.256	[6.5]	38	15

*Category 6 Augmented cable for 10 gigabit ethernet – max allowed cable diameter per Addendum 11 to ANSI/TIA-568-B.2.

Prewired DS4000 Cover Wire Fill Capacities with Downward Facing Power & Data Devices

WIRE SIZE THHN/THWN	O.D. Inches [mm]	NO OF CONDUCTORS 40% FILL
14 AWG	0.111 [2.8]	31
12 AWG	0.130 [3.3]	23
10 AWG	0.164 [4.2]	14
8 AWG	0.216 [5.5]	8
6 AWG	0.254 [6.5]	6

NOTE: Prewired downward facing covers are punched in line for a sleek flush look. Power conductors are provided in the lower channel. Additional wires can be added and should not exceed totals above. Communications are to be installed in the top channel – refer to standard cable fill chart for capacities.

DS4000 Raceway Fittings Wire Fill Capacity Chart

WIRE SIZE THHN	O.D. Inches [mm]	DS4010A*		DS4011		DS4015		DS4017**		DS4018**		DS4075		DS4075A**			
		40%	60%	40%	60%	40%	60%	40%	60%	40%	60%	40%	60%	40%	60%		
THHN	14	0.111	[2.8]	125	187	171	256	62	93	160	239	142	213	106	160	142	213
	12	0.130	[3.3]	91	137	125	187	45	68	116	175	104	156	78	116	104	156
	10	0.164	[4.2]	57	86	78	118	28	43	73	110	65	98	49	73	65	98
	8	0.216	[5.5]	33	50	45	68	16	25	42	63	38	57	28	42	38	57
	6	0.254	[6.5]	24	36	33	49	12	18	31	46	27	41	20	31	27	41
UTP	2-pair, 24 AWG	0.150	[4.8]	68	103	94	140	49	74	87	131	78	117	58	87	78	117
	4-pair, 24 AWG Cat 3	0.190	[4.8]	43	64	58	87	31	46	55	82	49	73	36	55	49	73
	4-pair, 24 AWG Cat 5e	0.210	[5.3]	35	52	48	72	25	38	45	67	40	60	30	45	40	60
	4-pair, 24 AWG Cat 6	0.250	[6.3]	25	37	34	51	18	27	32	47	28	42	21	32	28	42
	4-pair, 24 AWG Cat 6a*	0.354	[9.0]	12	18	17	25	9	13	16	24	14	21	10	16	14	21
25-pair, 24 AWG	0.410	[10.4]	12	18	16	24	9	13	15	23	14	20	10	15	14	20	
Coaxial	RG6/U	0.270	[6.9]	21	32	29	43	15	23	27	41	24	36	18	27	24	36
Fiber	ZipCord	0.118 x 0.236	[3 x 6]	44	65	59	89	31	47	56	83	50	74	37	56	50	74
	Round 4 Strand Fiber	0.187	[4.8]	44	66	60	90	32	48	56	85	50	75	38	56	50	75
	Round 6 Strand Fiber	0.256	[6.5]	24	35	32	48	17	26	30	45	27	40	20	30	27	40

* Entrance end fitting fill rate is calculated using backfeed capability and radius inserts. Inserts are removable and fitting can obtain maximum raceway fill from utilizing end fitting knockouts and removing radius control inserts.

**Calculated using radius control inserts. Inserts are factory installed and may be removed in order to obtain full raceway capacity if radius control is not required.

DATACOM CONNECTIVITY OPTIONS

Now you have a wide range of options for providing datacom connectivity into Wiremold/Legrand Pathways. They are:

- **Ortronics® TracJack® and Series II Modular Connectivity Solutions**
- **Pass & Seymour Activate™ Modular Inserts**
- **Open System Communication Modules**

Ortronics® Connectivity

TracJack® Individual Jack System

- Front-loading, snap-in design supports future moves adds and changes
- Inserts for voice, data, audio, and video
- Available Category 3, 5e, 6, USOC 6-position, and other media
- Flat or angled 45° exit configurations
- Choice of 13 colors and color matched to Wiremold Systems
- Universal T568A/B wiring format



Series II Front-Loading, Module System

- Module design features easy snap-in front-loading design
- Linear 110 punch down format for easy termination
- Inserts for voice, data, audio, and video
- Available Category 3, 5e, 6, USOC 6-position, and other media
- Available in flat or angled 45° exit configurations
- Color matched to Wiremold Systems

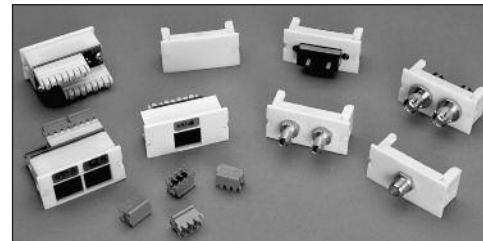


For detailed product selection refer to the **Ortronics Catalog** or visit www.ortronics.com.

Pass & Seymour Legrand Network Wiring

Activate™ Series Front-Loading Inserts

- Modular inserts for voice, data, audio and video applications
- Front-load, snap-in design
- Color and texture matched to Wiremold Systems
- Available Category 3, 5e, 6, as well as 6-position USOC
- Universal T568A/B wiring format



For detailed product selection refer to the **Pass & Seymour Network Wiring Catalog** or visit www.passandseymour.com.

Open Connectivity Solutions

Wiremold Open System Communications Modules

- Accommodate a wide range of manufacturers' communications outlets including keystone jacks, as well as proprietary solutions from Avaya (Systimax) and NORDX
- Modules insert into a wide range of Wiremold Systems
- Pre-punched faceplates accept common communication devices



NOTE: For more information on integrating connectivity into Wiremold Cable Management Systems contact the Wiremold Applications Engineering Team or your local Wiremold Sales Representative.



Wiremold

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ED1444R3 - Updated December 2009 - For latest specs visit www.legrand.us/wiremold

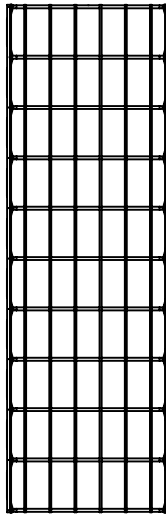


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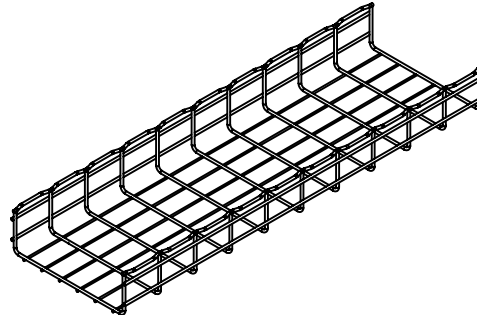
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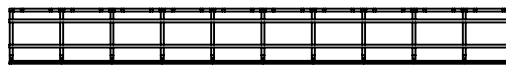
TOP



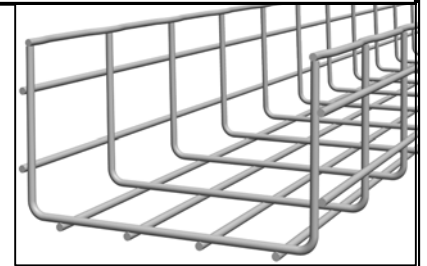
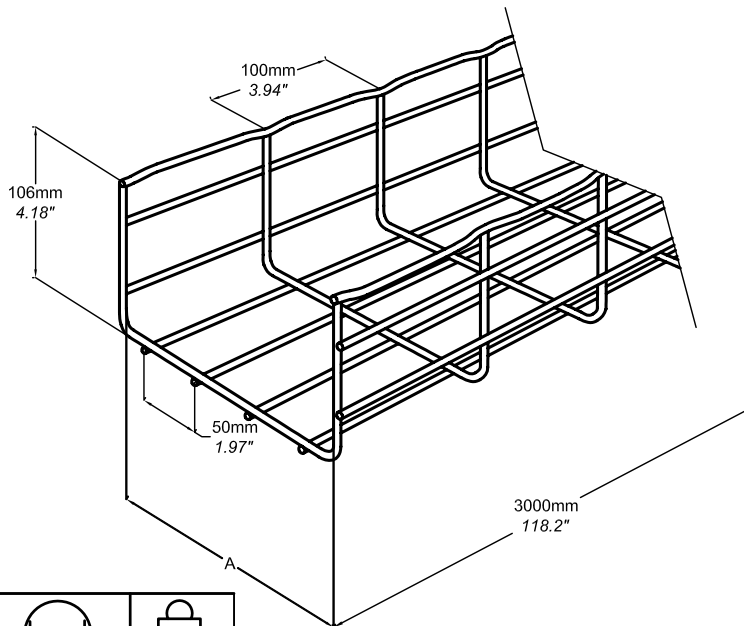
ISOMETRIC



FRONT



SIDE



in	mm
lb	

CF105 100	3.937	100	9.0
CF105 150	5.904	150	10.2
CF105 200	7.872	200	13.4
CF105 300	11.81	300	21.2
CF105 400	15.75	400	22.8
CF105 450	17.71	450	25.9
CF105 500	19.68	500	27.5
CF105 600	23.62	600	30.4

EZ GC 304L 316L

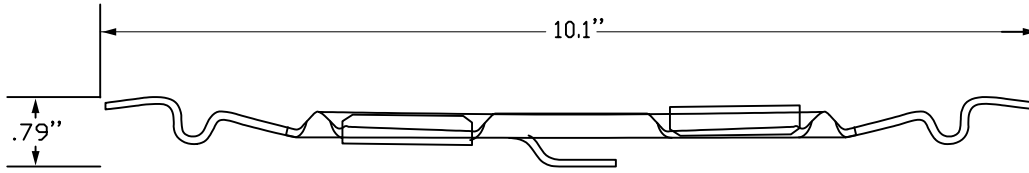
	Material	Finish
EZ	Carbon Steel ASTM A510 Grade 1008	Electroplated Zinc, ASTM B633
GC	Carbon Steel ASTM A510 Grade 1008	Hot-Dip Galvanized ASTM A123
304L	AISI TYPE 304L	Passivated ASTM A 380
316L	AISI TYPE 316L	Passivated ASTM A 380

EDRN FAST SPLICE

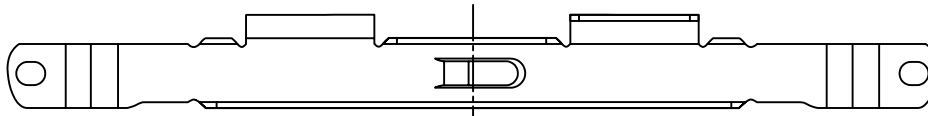
CABLOFIL®

INNOVATORS IN CABLE MANAGEMENT

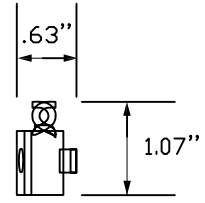
8319 State Route 4
Mascoutah IL 62258
Phone: 800-658-4641
618-566-3230
Fax: 618-566-3250
www.cablofil.com



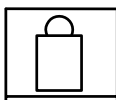
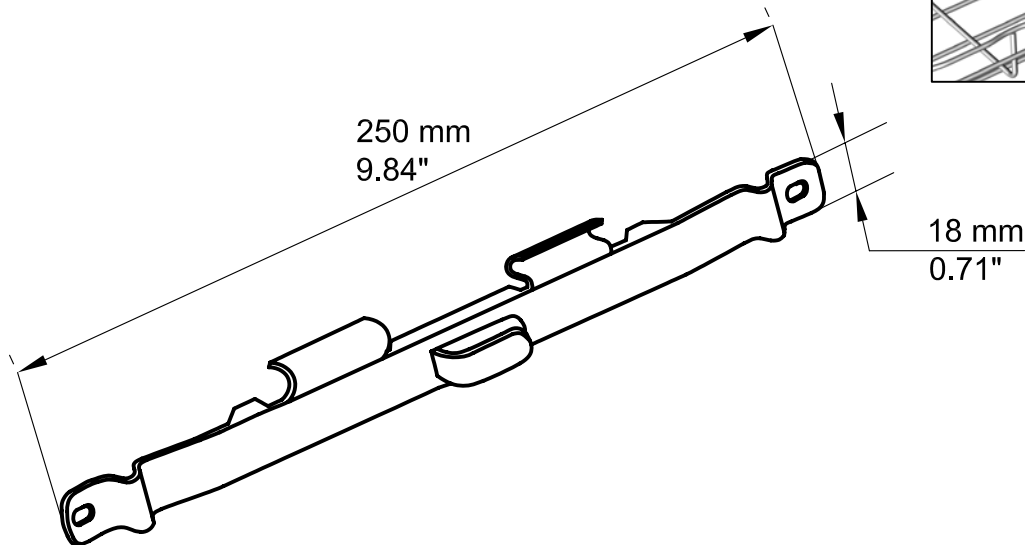
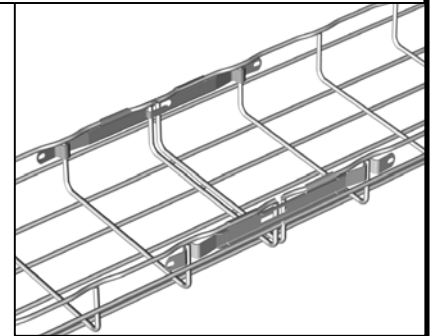
TOP



SIDE



FRONT



lb

EDRN

0.154

EZ

DC

BL

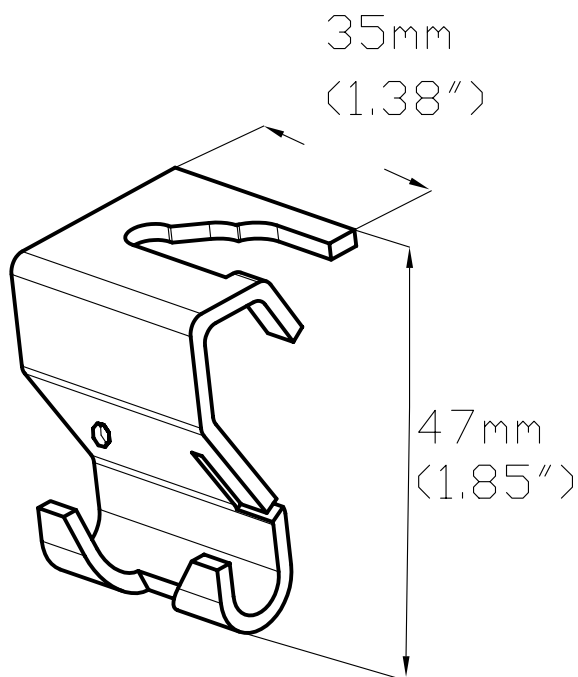
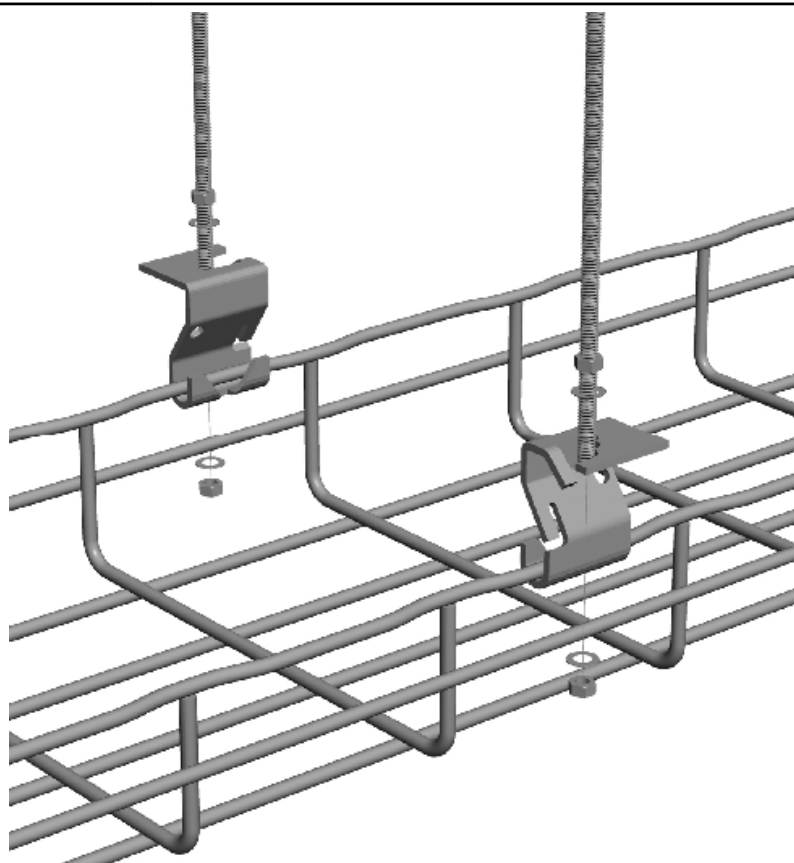
PE

AS TRAPEZE HANGING CLIP

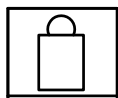
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618-566-3230
Fax: 618-566-3250
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ACCOMMODATES 1/4", 3/8", & 1/2"
THREADED ROD



lb

AS

0.132

PG

GC

316L

BL

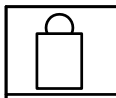
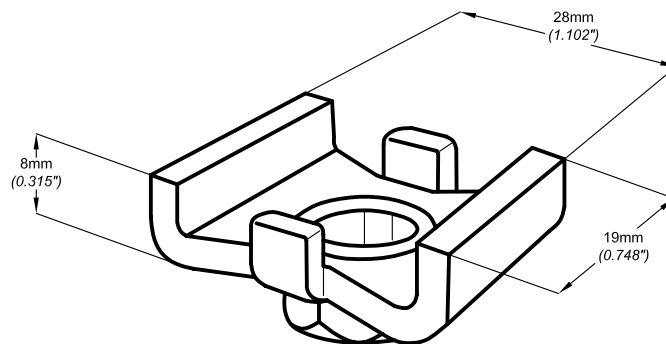
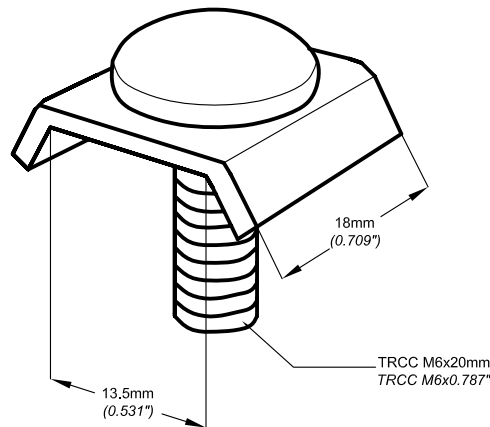
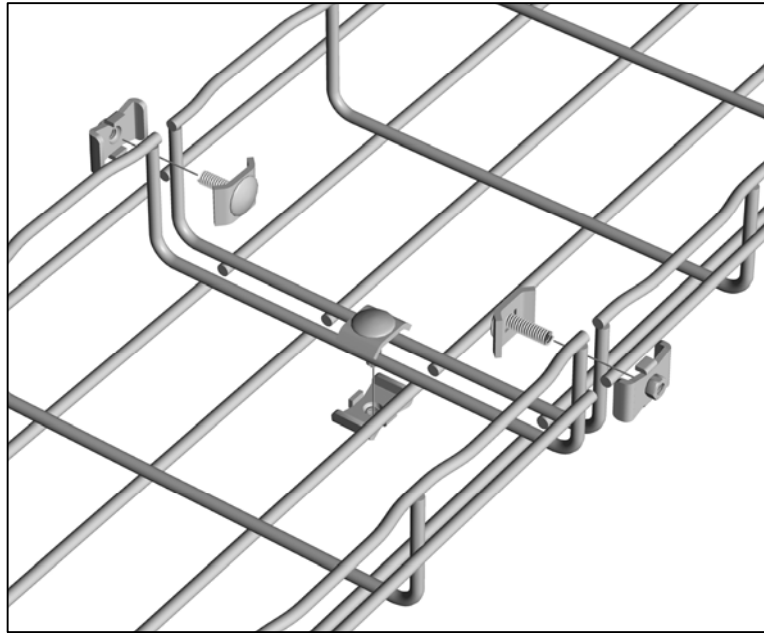
PE

SWK SPLICE WASHER KIT

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INNOVATORS IN CABLE MANAGEMENT

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Fax: 618-566-3250
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lb

SWK

3.6

EZ

DC

GC

316L

BL

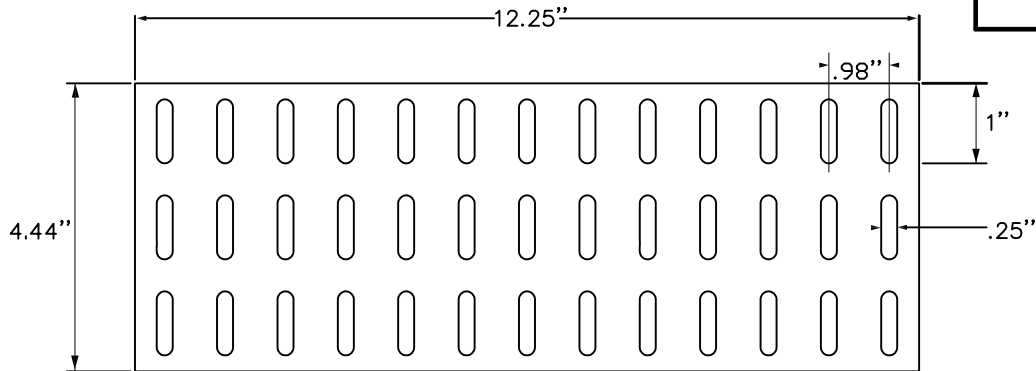
PE

CABLE DROP OUT KIT

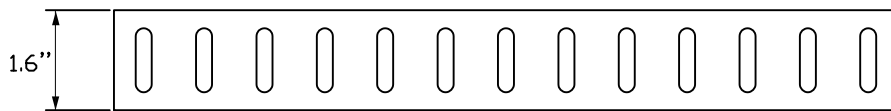
CABLOFIL®

INNOVATORS IN CABLE MANAGEMENT

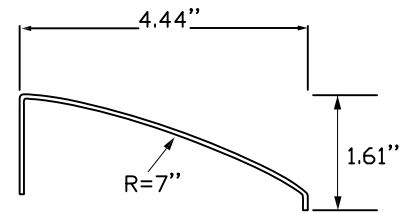
8319 State Route 4
 Mascoutah IL 62258
 Phone: 800-658-4641
 618-566-3230
 Fax: 618-566-3250
www.cablofil.com



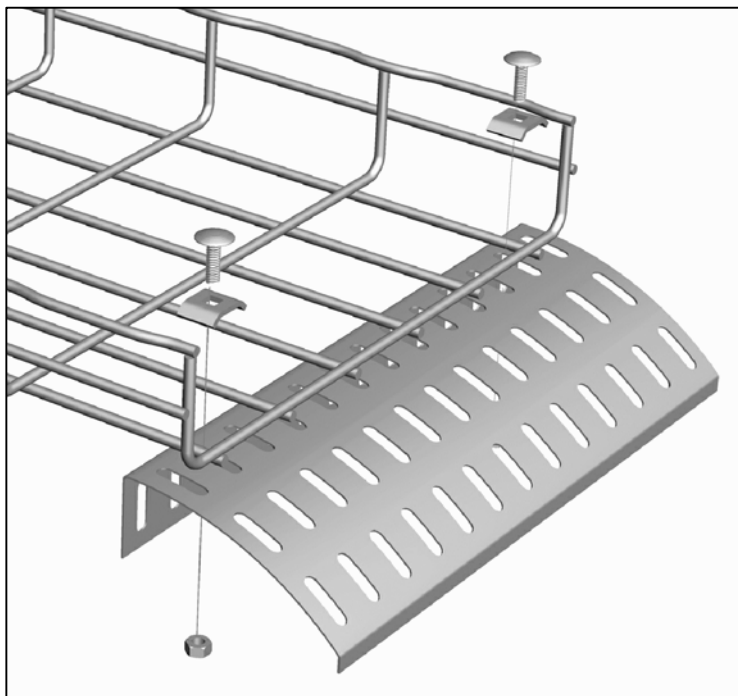
TOP



FRONT

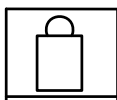


SIDE



NOTE:

(1) KIT CONTAINS (1) DROPOUT,
 (2)EZBN 1/4 AND (2)CE25.



lb

0.9

PG

GC

316L

BL

PE



DROP OUT KIT



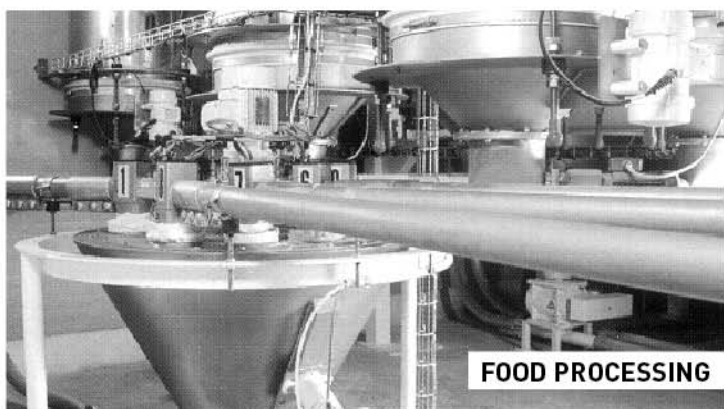
INSTALLATION GUIDE

CABLOFIL[®]

 legrand[®]



EXTERIOR INSTALLATION



FOOD PROCESSING



UNDERFLOOR INSTALLATION



INTERIOR INSTALLATION



INDUSTRIAL PLANT

CABLOFIL WIRE MESH TRAY

Cablofil, the inventor of wire mesh cable tray is a revolutionary cable management system that provides exceptional strength combined with the flexibility to adapt easily to field requirements. Installation is easier since wire mesh requires fewer parts and the FAS system allows splice, bracket and accessory connections without hardware! Manufactured in the heartland of the US, Cablofil is dedicated to providing superior quality product, service and expertise.

INDEX
INSTRUCTIONS

FINISHES	4
HOW TO CUT CABLE TRAY	5
HOW TO SPLICE CABLE TRAY	6
FASLOCK DIRECTIONAL CHANGES	7
T JUNCTIONS: RAD T 90 KIT	8
T JUNCTIONS: EZ T 90 KIT	9
90° BENDS: RAD T 90 KIT	10
90° BENDS: EZ T 90 KIT	11
Y JUNCTIONS	12
90° JUNCTIONS	13
SWEEPS - SWK	14
SWEEPS - FASLOCK	15
REDUCTIONS	16
CHANGING LEVELS	16
BONDING AND GROUNDING	17
LOADING	17
SUPPORT SPACING	17-18

PRODUCTS

TRAY	19
TRAY COVERS	19
SPLICING	19-20
ACCESSORIES	20
WALL MOUNTINGS	21
CEILING MOUNTINGS	21-22
UNDER FLOOR MOUNTINGS	22
OTHER MOUNTING	23

FINISHES

Cablofil wire cable tray and accessories are available in a variety of finishes to meet any industry need, from decorative to extreme environments. Use this chart to help you determine the best finish for your application and its availability.

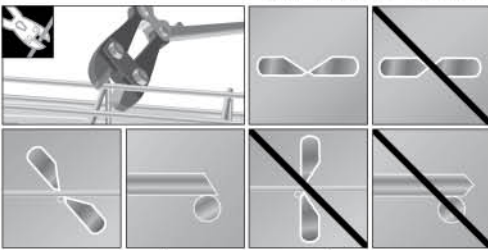
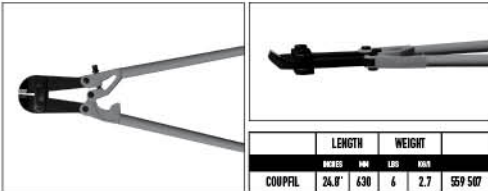
Standard finish is EZ, electroplated zinc. (indoor applications)
 Stock finishes available include (EZ), electroplated zinc, (316L), 316 stainless steel, (GC), Hot dipped galvanized, (BL) Black powder coat paint

SYMBOL	MATERIAL	FINISH & STANDARD	Interior installations	Exterior installations	Petroleum Plants Chemical Plants	Marine/salt, Weak sulphurous environments	Acidic, alkaline environments	Food Production, Wash-down, Clean rooms	Halogen environments
PG	Carbon Steel ASTM A653	Pre-Galvanized: Continuous Galvanization Before Fabrication ASTM A 653	●						
EZ	Carbon Steel ASTM A510 Grade 1008	Electrozinc: Electrozinc plating ASTM B 633	●						
GC	Carbon Steel ASTM A510 Grade 1008	Hot Dipped Galvanized: After Fabrication ASTM A 123		●	●	●	●		
DC	Carbon Steel ASTM A510 Grade 1008	Dacromet: Zinc and Aluminum Protection Equivalent to Hot Dip Galvanization ASTM F 1136		●	●	●	●		
304L	Stainless Steel AISI Type 304L	Stainless Steel 304L: Cleaned and Passivated ASTM A 380		●	●	●	●	●	●
316L	Stainless Steel AISI Type 316L	Stainless Steel 316L: Cleaned and Passivated ASTM A 380		●	●	●	●	●	●
BL	Carbon Steel ASTM A510 Grade 1008	Black Painted: Black Powder Coated ASTM D 3451	●						
PE	Carbon Steel ASTM A510 Grade 1008	Custom Painted: Custom Color Powder Coated ASTM D 3451	●						

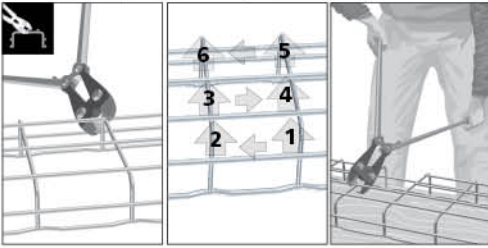
● recommended ● possible

For a more detailed explanation of finish standards and compatibility, visit www.cablofil.com.

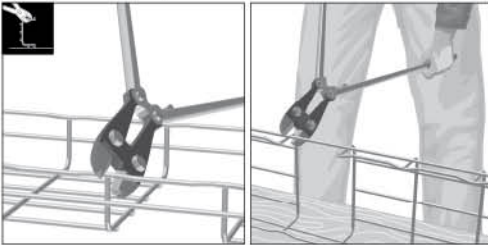
HOW TO CUT CABLOFIL CABLE TRAY



- Always use side action bolt cutters.
- Angle all cuts away from the new end.
- Cut each wire with one clean cut – eliminating any grinding or touch-up.



- Cut the bottom wires first, in order as shown, from the underside of the tray.
- Rest the lower jaw of the cutters against the cradle wire and cut at an angle away from the new end.



- Cut the side wires next, starting with the top wire.
- Make sure the finished cut is safe and ready for installation.

USING A POWER CUTTER TO CUT CABLOFIL CABLE TRAY



cutyfil

	WEIGHT		
	LB	KG	
CUTYFIL	9.5	4.3	559 557
REPLACEMENT BLADES	4	2	559 577
BATTERY	1	5	559 567
CHARGER	2	9	559 558



Cutyfil from Cablofil makes cutting wire cable tray easy. This lightweight power tool features a 330° swivel cutting head to make cuts from any angle. One button control engages and retracts blade for each cut. Cutyfil Kit comes in a padded carrying case with 2 batteries and a charger.



Use the same cutting procedures as outlined on the previous page when using Cutyfil. Remember to always wear safety goggles and follow safe procedures when using power equipment.

HOW TO SPLICE CABLOFIL CABLE TRAY – EDRN

SPLICING GUIDELINES



CF30 – CF54 – CF105 – CF150	2" (50 mm)	12" (300 mm)	18" → 24" (450 → 600 mm)
 EDRN splices needed on side wires	2x EDRN	2x EDRN	2x EDRN
 EDRN splices needed on bottom of tray	-	-	1x OR 2x EDRN

INSTRUCTIONS



HOW TO SPLICE CABLOFIL CABLE TRAY – PRECLICK

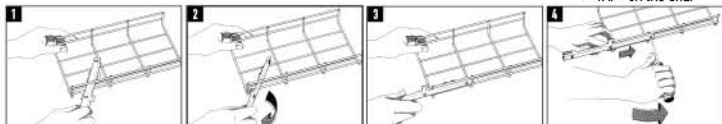
SPLICING GUIDELINES

CF54 – CF105 – CF150	2" → 8" (50 → 200 mm)	12" (300 mm)	18" → 24" (450 → 600 mm)
 PRECLICK splices needed on side wires	2x PRECLICK	2x PRECLICK	2x PRECLICK
 SWK splices needed on bottom of tray	-	1x SWK	2x SWK

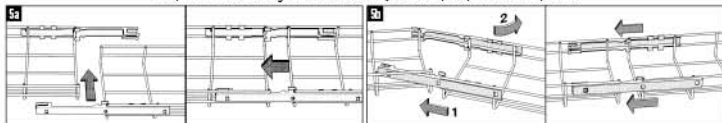
INSTRUCTIONS

Step 1-3: Snap a PRECLICK on each length of Cablofil tray to be joined.

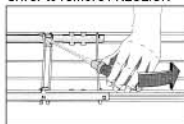
Step 4: Snap in place with a screw driver or a simple "TAP" on the end.



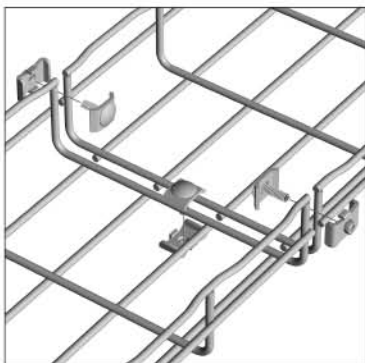
Step 5: Join both lengths of Cablofil tray and snap in place. (two options)



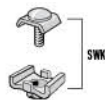
Removing PRECLICK: Use a screw driver to remove PRECLICK





HOW TO SPLICE CABLOFIL CABLE TRAY - SWK

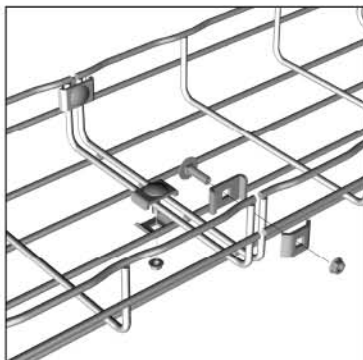


- Use SWK to splice any two sections of Cablofil tray.
- Swaged nut allows clamp to be stationary while nut is tightened.
- Consult chart below for correct number of SWK sets needed for each width of tray.

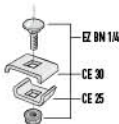


CF30 – CF54 – CF105 – CF150	2" (50 mm)	4" → 8" (100 → 200 mm)	12" → 24" (300 → 600 mm)
 SWK attachment sets needed for side wires	2x SWK	2x SWK	2x SWK
 SWK attachment sets needed for bottom wires	-	1x SWK	2x SWK

HOW TO SPLICE CABLOFIL CABLE TRAY - CE 25, CE 30



- Use CE 25 and CE 30 with EZ BN 1/4 to splice any two sections of Cablofil tray.
- Consult chart below for correct number of Nut/ Bolt/Clamp sets needed for each width of tray.



	CF30 – CF54 – CF105 – CF150	2" (50 mm)	4" → 8" (100 → 200 mm)	12" → 24" (300 → 600 mm)
→ ← CE 25-CE30 attachment sets needed for side wires		2x CE 25, CE 30, EZ BN 1/4	2x CE 25, CE 30, EZ BN 1/4	2x CE 25, CE 30, EZ BN 1/4
↑ CE 25-CE30 attachment sets needed for bottom wires		-	1x CE 25, CE 30, EZ BN 1/4	2x CE 25, CE 30, EZ BN 1/4

DIRECTIONAL CHANGE HARDWARE

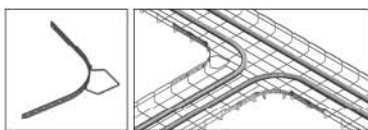
90 DEGREE BENDS

		FASLOCK (SWEEP)	SWK (SWEEP)	RADT90		EZT90		
TRAY WIDTH	QTY. REQUIRED	CUT INSTRUT.	QTY. REQUIRED	CUT INSTRUT.	QTY. REQUIRED	CUT INSTRUT.	QTY. REQUIRED	CUT INSTRUT.
2"	-	-	2	p. 15	-	-	1 kit	p. 11
4"	2	p. 14	2	p. 15	1 kit	p. 10	1 kit	p. 11
6"	3	p. 14	4	p. 15	1 kit	p. 10	1 kit	p. 11
8"	4	p. 14	4	p. 15	1 kit	p. 10	1 kit	p. 11
12"	6	p. 14	6	p. 15	1 kit	p. 10	1 kit	p. 11
18"	9	p. 14	8	p. 15	1 kit	p. 10	1 kit	p. 11
20"	10	p. 14	9	p. 15	1 kit	p. 10	1 kit	p. 11
24"	12	p. 14	11	p. 15	1 kit	p. 10	1 kit	p. 11

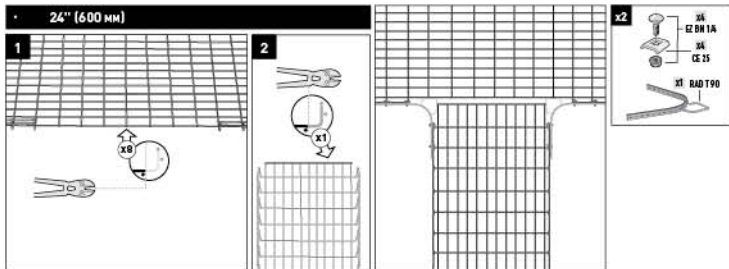
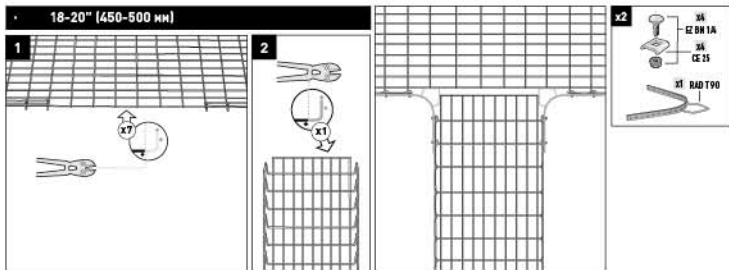
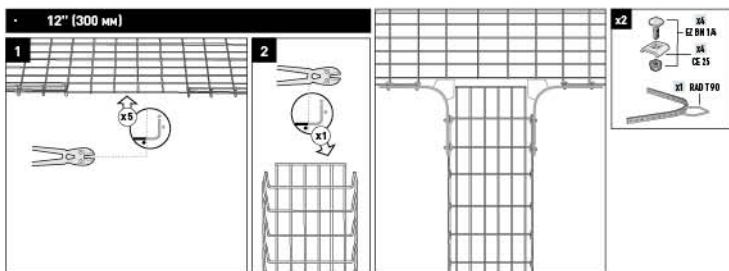
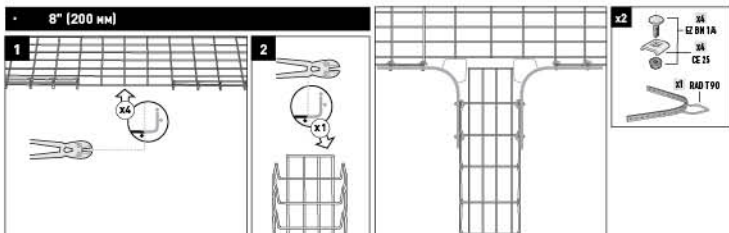
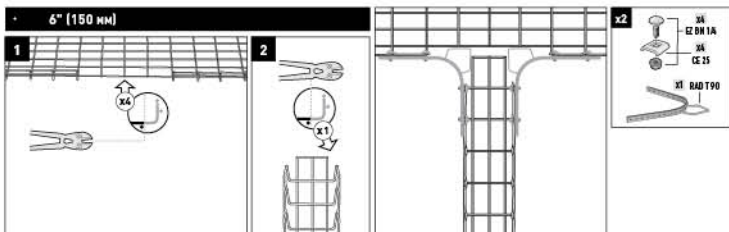
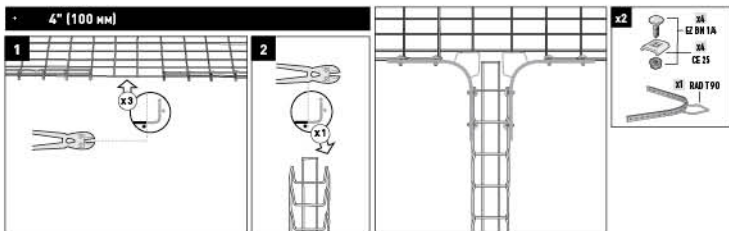
HORIZONTAL TEE

		RADT90		EZT90		Y JUNCTION	
TRAY WIDTH	QTY. REQUIRED	CUT INSTRUT.	QTY. REQUIRED	CUT INSTRUT.	HARDWARE REQUIRED	CUT INSTRUT.	
2"	-	-	1 kit	p. 9	-	-	
4"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
6"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
8"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
12"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
18"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
20"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	
24"	1 kit	p. 8	1 kit	p. 9	p. 12	p. 12	

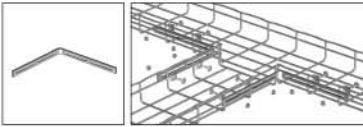
T JUNCTIONS: RAD T 90 KIT



One RAD T 90 KIT will make one T Junction.



T JUNCTIONS: EZ T 90 KIT



One EZ T 90 KIT will make one T Junction.

2" (50 mm)

4" (100 mm)

6" (150 mm)

8" (200 mm)

12" (300 mm)

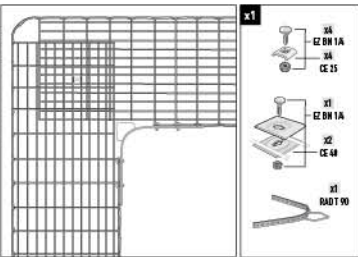
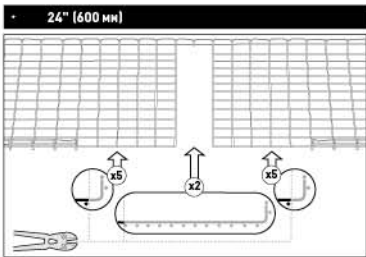
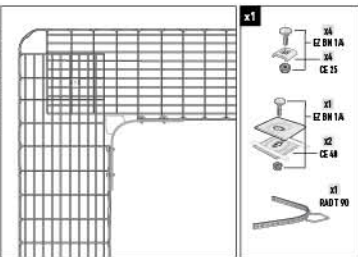
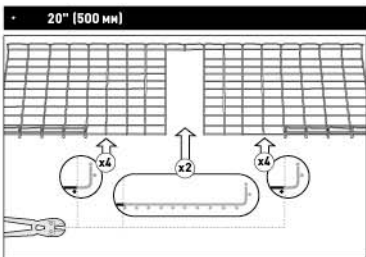
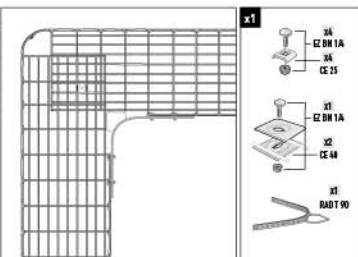
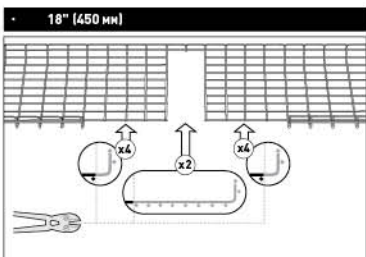
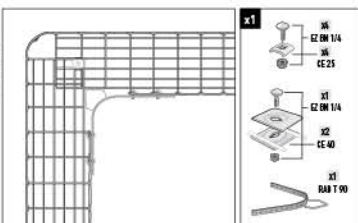
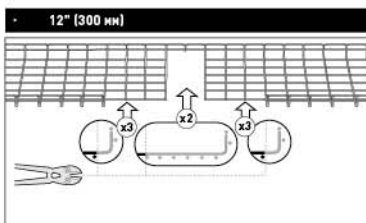
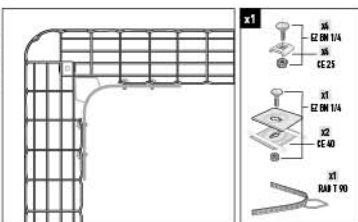
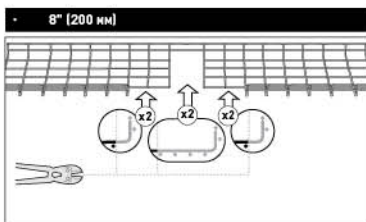
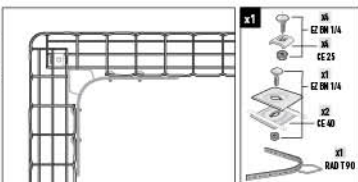
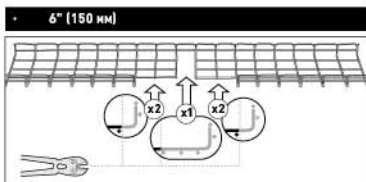
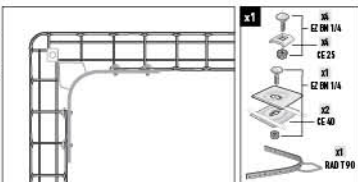
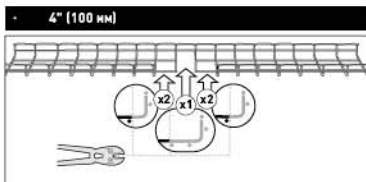
18-20" (450-500 mm)

24" (600 mm)

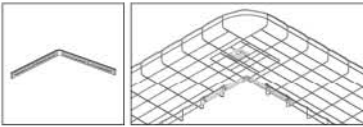
90° BENDS: RAD T 90 KIT



One RAD T 90 KIT will make two 90° Bends.



90° BENDS: EZ T 90 KIT



One EZ T 90 KIT will make two 90° Bends. For complete kit description see page 25.

<p>• 2" (50 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90
<p>• 4" (100 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 6" (150 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 8" (200 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 12" (300 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 18" (450 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 20" (500 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48
<p>• 24" (600 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> 36 EZ DN 1A 36 CE 25 x1 EZ T 90 x1 EZ DN 1A x2 CE 48

Y JUNCTIONS

4" (100 mm)

1

2

x3

See pages 72-73.

6" (150 mm)

1

2

x1

See pages 72-73.

x2

See pages 72-73.

*Use bolt cutters to fabricate this part from EO 275.

8" (200 mm)

1

2

x3

See pages 72-73.

12" - 20" - 24" (300 - 500 - 600 mm)

1

2

x4

See pages 72-73.

18" (450 mm)

1

2

x2

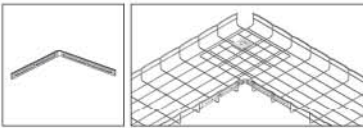
See pages 72-73.

x2

See pages 72-73.

*Use bolt cutters to fabricate this part from EO 275.

90° JUNCTIONS

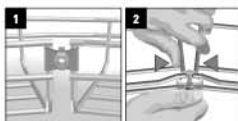
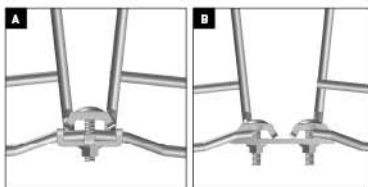


One EZ T 90 KIT will make two 90° Junctions.

<p>• 4" (100 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 6" (150 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 8" (200 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 12" (300 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 18" (450 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 20" (500 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48
<p>• 24" (600 mm)</p>		<p>x1</p> <ul style="list-style-type: none"> • EZ DM 1/4 • CE 25 • EZ T 90 • EZ DM 1/4 • CE 48

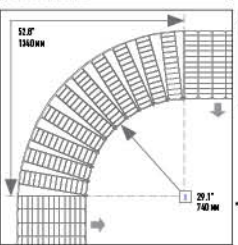
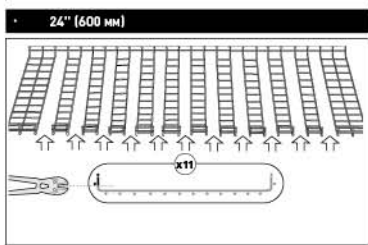
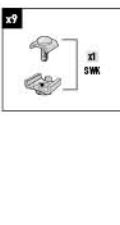
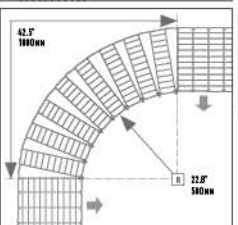
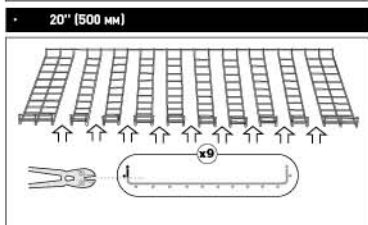
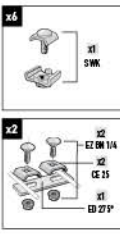
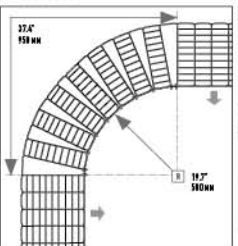
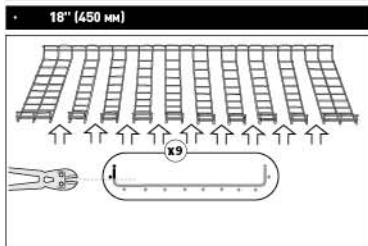
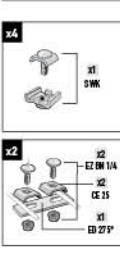
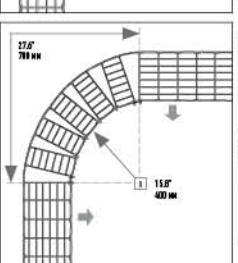
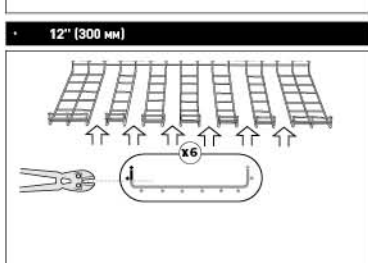
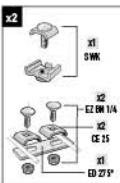
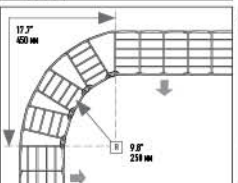
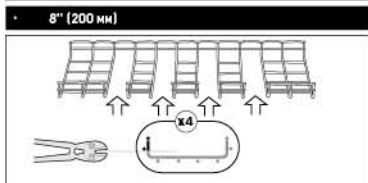
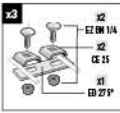
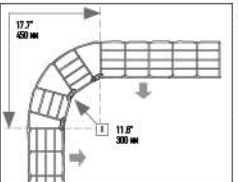
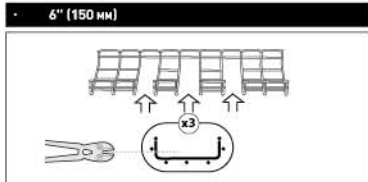
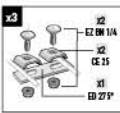
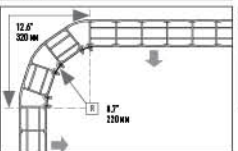
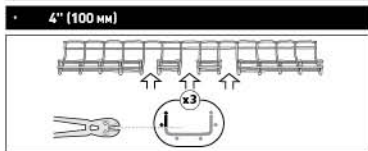
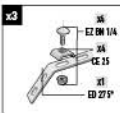
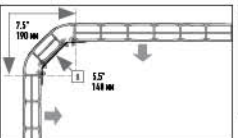
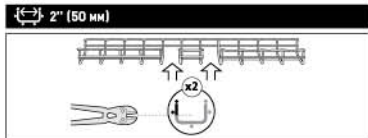
OTHER THAN 90° JUNCTIONS





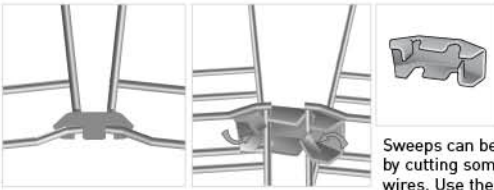
Sweeps can be formed easily on site by cutting some of the side and bottom wires. Use the SWK method to secure desired curve.

Always place bolt heads to inside of tray to prevent frayed wires.



*Use bolt cutters to cut to fit.

SWEEPS: FASLOCK

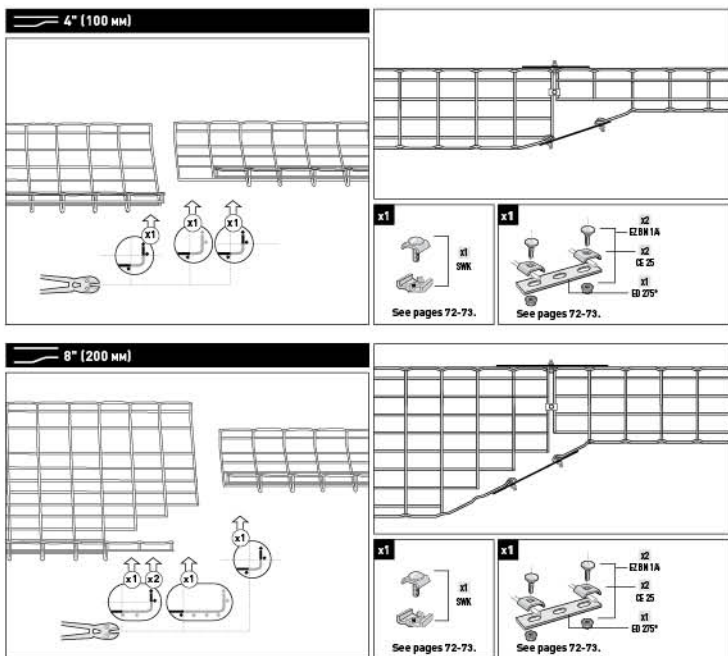


Sweeps can be formed easily on site by cutting some of the side and bottom wires. Use the FASLOCK method to secure desired curve.

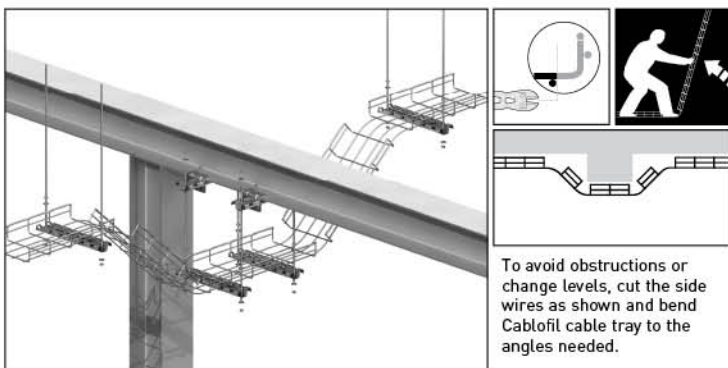
<p>4" (100 mm)</p>	<p>x2</p> <p>FASLOCK S</p>
<p>6" (150 mm)</p>	<p>x3</p> <p>FASLOCK S</p>
<p>8" (200 mm)</p>	<p>x4</p> <p>FASLOCK S</p>
<p>12" (300 mm)</p>	<p>x6</p> <p>FASLOCK S</p>
<p>18" (450 mm)</p>	<p>x8</p> <p>FASLOCK XL</p>
<p>20" (500 mm)</p>	<p>x10</p> <p>FASLOCK XL</p>
<p>24" (600 mm)</p>	<p>x12</p> <p>FASLOCK XL</p>

*Use FASLOCK S for CF54/100, 150, 200, 300, CF105/100, 150, 200. Use FASLOCK XL for all other larger sizes.

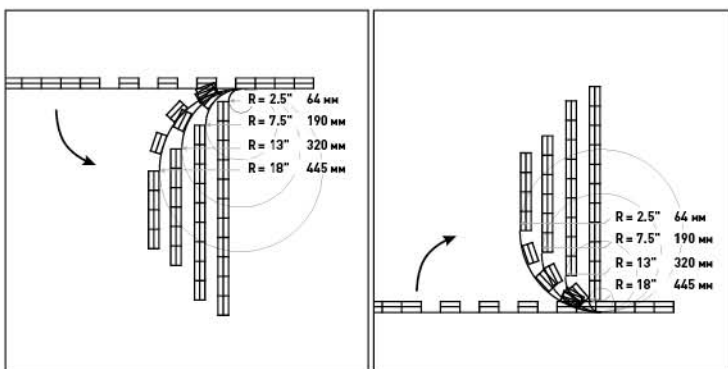
REDUCTIONS



CHANGING LEVELS



CUTTING AND BENDING



BONDING AND GROUNDING

Per NEC 392, the national electrical code section for cable tray, all cable tray systems must be properly BONDED, per section 259.96. To meet this requirement, Cablofil recommends that ULclassified splices are used to joins sections and that the cable tray be bonded to building steel or the facility grounding system every 50'-60'. By bonding the tray every 50'-60', the tray will maintain a low potential to ground which reduces EMI and provides a continuous path for stray currents. Steel trapeze type hangers clamped securely to building steel usually provide a solid bond. Cablofil standard splices (SWK, EDRN, EZBN, EDT, EZT90, RADT90) are designed to have less than 1 milliohm of resistance between connections and provide bonding between sections. These splices have been tested by UL as part of the cable tray grounding system. Painted Cablofil wire mesh tray requires the outer mask of the conductive surface be removed at each end of the tray prior to installing the (SWK) splice. This (SWK) splice provides a UL Classified Bonding continuity between painted tray sections. All cable tray needs to be electrically continuous per NEC 250.96. Standard Cablofil splices provide continuity per 250.96. Cutting and removal of cable tray sections still allow continuity per 250.96 and only affects the rare use of cable tray as the EGC. Use of cable tray as an EGC is rare since UL requires all multiconductor cables to contain an integral EGC and single conductor cables are only used in a few industrial applications.

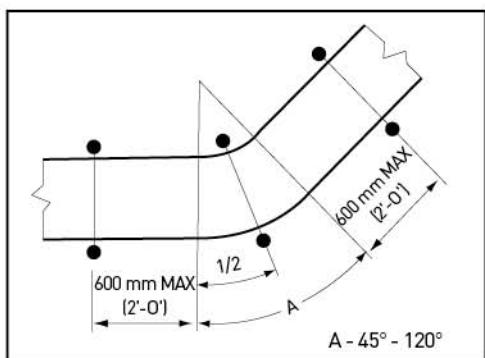
LOADING

Cablofil has been tested to UL, CSA, NEMA VE1 and IEC standards. Cablofil wire mesh tray and supports are designed to support any cable load allowed by the NEC when supports are spaced on 8' spans. Only the heaviest cables (750 kcmil multiconductor power or larger) may require shorter spans. For specific loading go to the interactive load table on www.cablofil.com and choose your exact cable for detailed cable capacity and span requirements.

SUPPORT SPACING

Cablofil comes in 118" lengths and straight sections are designed for 6'-8' support spacing; (building joists or purlins are typically on 6'-7' spacing)

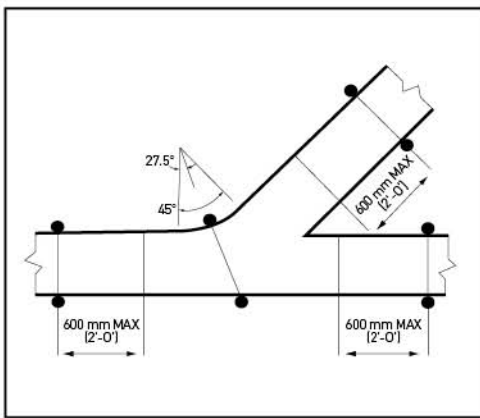
Cablofil has developed the following diagrams as a general guideline for supporting Field Fabricated Wire Mesh Tray. These guidelines will provide assistance in estimating and locating supports for the most common wire mesh tray installations. Supports are required as some of the side wires have been cut and the load capacity has been reduced. In actual installation, shallow and narrow trays may not require as many supports just as deep and wide trays may require additional supports. The installer should keep in mind that unique requirements arise in the field and practical solutions are often simple.



Horizontal Sweep Support

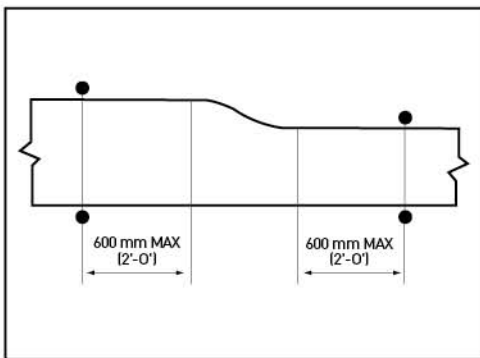
Center support not required on trays less than 12" wide and sweeps less than 45 degrees.

SUPPORT SPACING

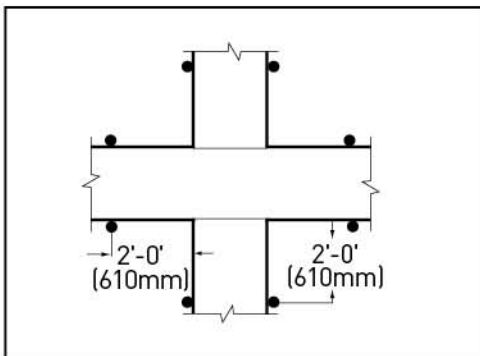


Horizontal Y Support

Center support not required on trays less than 12" wide.

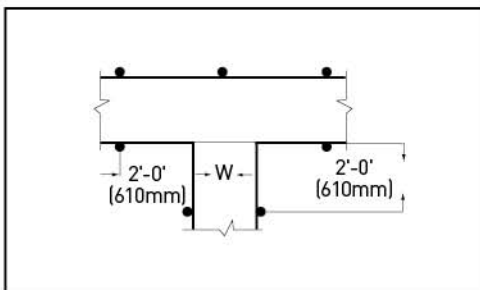


Reduction Support



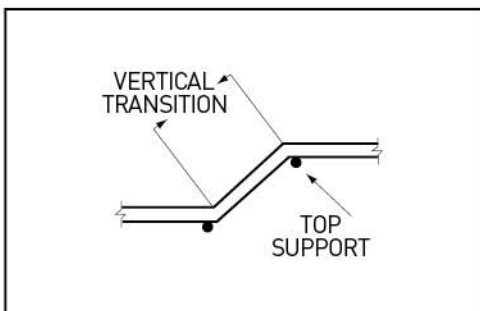
Horizontal Cross Support

On 24' wide items, recommended distance is 1 ft. 6 in. (457mm) from splice connection.



Horizontal Tee Support

Additional support recommended at back of tee (shown) or directly under tee, diagonally positioned, for 4" and 6" deep trays, 18" and wider.



Vertical Transition

Support vertical transition at top support location. Distances of 3 ft. and larger should be supported at each end as illustrated.

TRAY



CF 54

2" DEEP TRAY
2", 4", 6", 8", 12", 18", 20", & 24" WIDE



CF 105

4" DEEP TRAY
4", 6", 8", 12", 18", 20", & 24" WIDE



CF 150

6" DEEP TRAY
12", 18", 20", & 24" WIDE



EasyPack



CFG

G CABLOFIL TRAY



CFG

G MINI



CFL

L CABLOFIL TRAY



TXF35

TELEXRAIL



FCF 54

FASCLIC TRAY

TRAY COVERS



CTXF 35

TELEX RAIL COVER



UC35

TELEX RAIL STANDOFF SUPPORT



CVN

CABLOFIL TRAY COVER



CLIP F02

CABLOFIL COVER CLIP



COT 30/COT 54

DIVIDER STRIP



COT 105/COT 150

DIVIDER STRIP



COT J

DIVIDER COUPLER

SPLICING



EDRN

FAST SPLICE



EDRNT00L

MOUNTING TOOL



PRE-CLICK

SPLICE



EDT

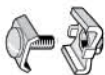
SPLICE PLATE



ED 275

UNIVERSAL SPLICE BAR

SPLICING



SWK
SPLICE WASHER KIT



EZBN 1/4



CE 25 - CE 30
SQUARE SPLICE WASHER



FASLOCK
SPLICE



CE 40
SQUARE SPLICE WASHER



EZT 90 KIT
90° BEND KIT



RAD T 90 KIT
RADIUS TEE 90° KIT

ACCESSORIES



EZBN
1/4"



EZHN
1/4", 3/8", 1/2"



EZFW
1/4", 3/8", 1/2"



THRDR
1/4", 3/8", 1/2"

ACCESSORIES



TRP
THREADED ROD PROTECTOR



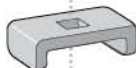
EZCN
1/4", 3/8", 1/2"



SWK



CE 25



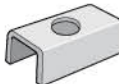
CE 30



CE 40



FASLOCK



ECLI



CA



COUPFIL



CUTYFIL



ED 250/90



ED 275/1100

WALL MOUNTINGS



FAS P
FAS PROFILE



FV
VERTICAL BRACKET



FAS L
BRACKET



FAS C
BRACKET



FAS U
UNIVERSAL BRACKET



EDF
RAIL



CS
STANDARD L BRACKET



CSC
STANDARD C BRACKET



CRP
UNIVERSAL WALL BRACKET

WALL MOUNTINGS



UC 50
CABLE TRAY STANDOFF



CAT 30/41
SNAP-IN WALL
HANGER SUPPORT



C 50
WALL MOUNT ATTACHMENT

CEILING MOUNTINGS



SF 50
CENTER HANGER



SF 100
CENTER HANGER



PAT 30
SUSPENSION SHOE



SAS
SINGLE HANGER
SUSPENSION BRACKET



FAS PCH
CENTER HANGER



FAS P
FAS PROFILE

CEILING MOUNTINGS CONT.



FAS C
BRACKET



AS
TRAPEZE HANGING CLIP



EDF
RAIL



PFREDF
MOUNTING BRACKET



DF
ANGLE MOUNTING BRACKET



ERD 10
BRACE PLATE



PROCS
STANDARD PROFILE



CS
STANDARD L BRACKET



CSC
STANDARD C BRACKET



PS L
PENDANT BRACKET

UNDER FLOOR MOUNTINGS



UFC
UNDER FLOOR SUPPORT CLAMP



UFCN
UNDER FLOOR CLAMP



EDF
RAIL



DF
ANGLE MOUNTING BRACKET



UFS
UNDER FLOOR SUPPORT



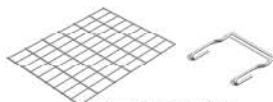
UFS 150
UNDER FLOOR SUPPORT STAND



UC 50
CABLE TRAY STANDOFF



UFCF2
WIRE TRAY SECTIONS

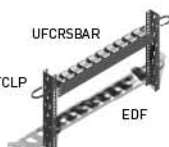


UFS 90° KIT
UFFLAT & UFTXSPRCLP

UFCRSBAR

UFPSTCLP

EDF



UFSUP KIT
UFS SUPPORT KIT



UFS CANTILEVER BRACKET

OTHER MOUNTINGS



FASCLM
FAS CLAMP



ETC
TRAY BEAM SUPPORT



EZBC
THREADED ROD HANGER



C 50
ELECTRICAL BOX
SUPPORT



SBDA
CONDUIT AND BOX SUPPORT



CM50I
INDUSTRIAL BOX MOUNTING BRACKET



CABLEXIT



HB 2
WALL/FLOOR
TERMINATION BRACKET



DROP OUT
CABLE DROP OUT



CCLMP
CABLE CLAMP



MFM
METALLIC MULTIFX PLATE



CABLE LABEL CLIP



EZVC
VELCRO ROLL



CABLO SNAP
CABLE BUNDLER



EZJB 5/16
J-BOLT



FAS ROLLER



HD FAS ROLLER



GRIPPLE
WIRE CABLE
HANGING SUPPORT



FS 41
FASTRUT CONNECTOR



SZMCKIT
SEISMIC BRACING KIT



SZMCCUTR
CABLE CUTTER



SZMCSWAG
HAND SWAGER



GNDSB
GROUNDING LUG



GNDCL
GROUNDING LUG



FLAMESTOPPER™

CABLOFIL[®]

 **legrand[®]**

www.cablofil.com

Phone 800-658-4641

618-566-3230

Fax 618-566-4978

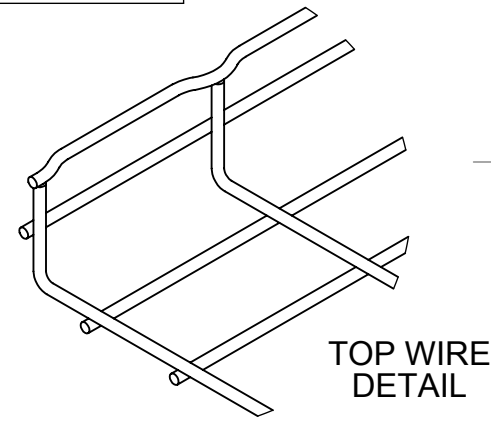
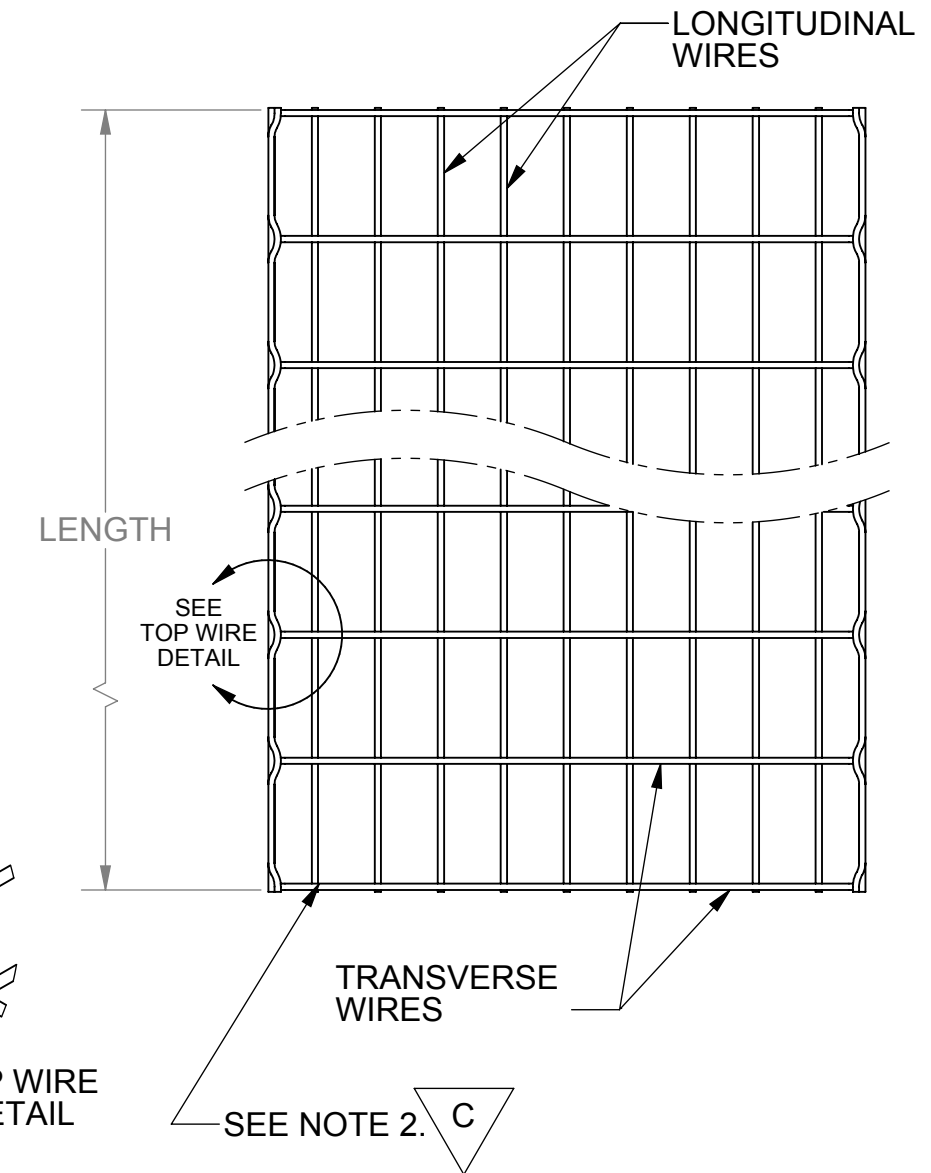
8319 State Route 4

Mascoutah, IL USA 62258

■ THE WORLD'S MOST SPECIFIED CABLE TRAY.

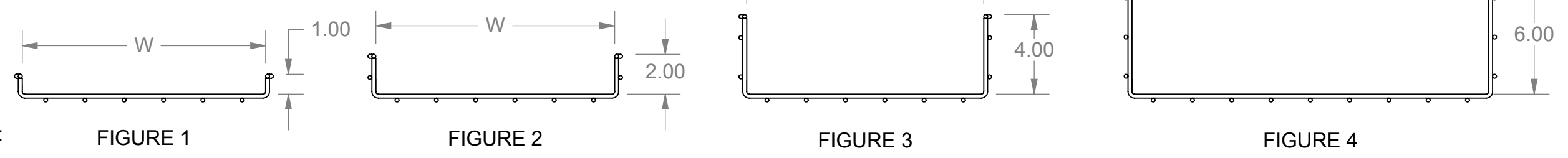
EZ•331•04•08

PART NUMBER	LENGTH (IN)	FIGURE	W (IN)	PART NUMBER	LENGTH (IN)	FIGURE	W (IN)
FT1.5X4X10	118.31"	SEE FIGURE 1	4 3/32"	FT4X4X10	118.31"	SEE FIGURE 3	4 3/32"
FT1.5X6X10			6 1/16"	FT4X6X10			6 1/16"
FT1.5X8X10			8 3/32"	FT4X8X10			8 3/32"
FT1.5X12X10			11 31/32"	FT4X12X10			11 31/32"
FT2X2X10	118.31"	SEE FIGURE 2	2 1/8"	FT4X16X10			15 29/32"
FT2X4X10			4 3/32"	FT4X18X10			17 7/8"
FT2X6X10			6 1/16"	FT4X20X10			19 27/32"
FT2X8X10			8 3/32"	FT4X24X10			23 3/4"
FT2X12X10			11 31/32"	FT4X30X10	29 7/8"		
FT2X16X10			15 29/32"	FT6X8X10	7 7/8"		
FT2X18X10			17 7/8"	FT6X12X10	11 31/32"		
FT2X20X10			19 27/32"	FT6X16X10	15 29/32"		
FT2X24X10			23 3/4"	FT6X18X10	17 7/8"		
FT2X30X10			29 7/8"	FT6X20X10	19 27/32"		
FT2X32X10			31 21/32"	FT6X24X10	23 3/4"		



FT4X12X10

DEPTH	NOM. WIDTH	NOM. LENGTH IN FEET
FT1.5=1.38	2=2"	
FT2=2.38	4=4"	
FT4=4.38	6=6"	
FT6=6.38	8=8"	
	12=12"	
	16=16"	
	18=18"	
	20=20"	
	24=24"	
	30=30"	
	32=32"	

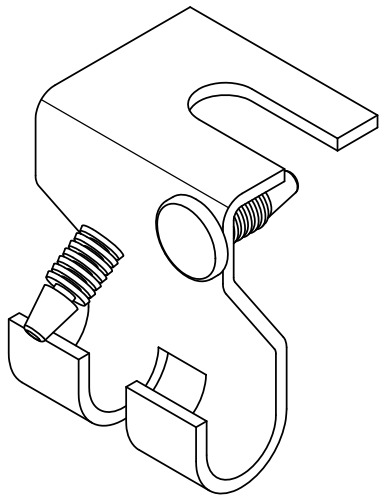


- NOTES:
- B-LINE FINISH SPECIFICATION:
ELECTRODEPOSITED ZINC
PRE GALV
FLAT BLACK
COMPUTER WHITE
GRAY
SS4
 - WIRE BASKET CABLE TRAY SHALL BE MADE OF HIGH STRENGTH STEEL WIRES AND FORMED INTO A STANDARD 2 INCH BY 4 INCH WIRE MESH PATTERN WITH INTERSECTING WIRES WELDED TOGETHER.

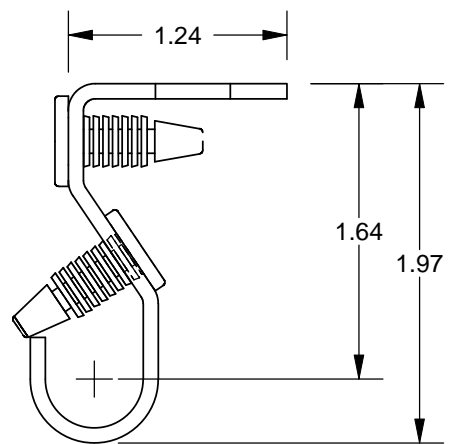
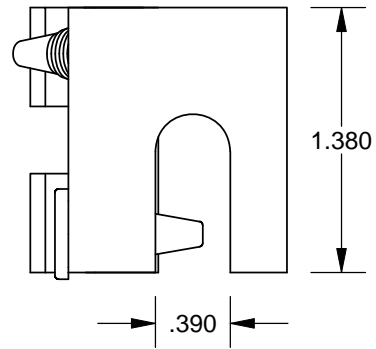
<p>509 W. Monroe Street Highland, IL 62249 Phone (618) 654-2184 FAX (618) 654-5499 www.cooperblinc.com</p>		<p>SUBMITTAL DRAWING</p> <p>TITLE: FLEXTRAY WELDED WIRE MESH CABLE TRAY</p> <p>EQUIPMENT FURNISHED HAS BEEN FABRICATED IN ACCORDANCE WITH THIS DRAWING.</p>		<p>REFERENCE DWG(S):</p>		<p>SUBMITTAL NO: S00015303</p>	
				<p>DATE: 10-03-08</p>		<p>DRAWN BY: DF REV: C</p>	
				<p>MODEL SOURCE FILE: U00015303 REV: 01</p>		<p>SHEET: 1 OF 1</p>	

SNAP GROMMET
IN PLACE TO
RETAIN BASKET

SNAP GROMMET
IN PLACE TO RETAIN
THREADED ROD



TRAPEZE SUPT2



- PART NUMBER: TRAPEZE SUPT2
- TRAPEZE CLIP INSTALLS FAST
- TRAY CAN BE RELEASED FROM SUPPORT TO ALLOW SIDE CABLE LOADING
- ACCEPTS 1/4" AND 3/8" THREADED ROD SIZES
- MATERIAL FINISH:
PRE- GALVANIZED
BLACK POWDER COAT
CUSTOM POWDER COAT

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Highland, IL 62249
Phone (618) 654-2184
FAX (618) 654-5499

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SUBMITTAL DRAWING

TITLE:

TRAPEZE SUPT2

FLEXYTRAY TRAPEZE SUPPORT

EQUIPMENT FURNISHED HAS BEEN FABRICATED IN ACCORDANCE WITH THIS DRAWING.

REFERENCE DWG(S):

SUBMITTAL NO:

S00015639

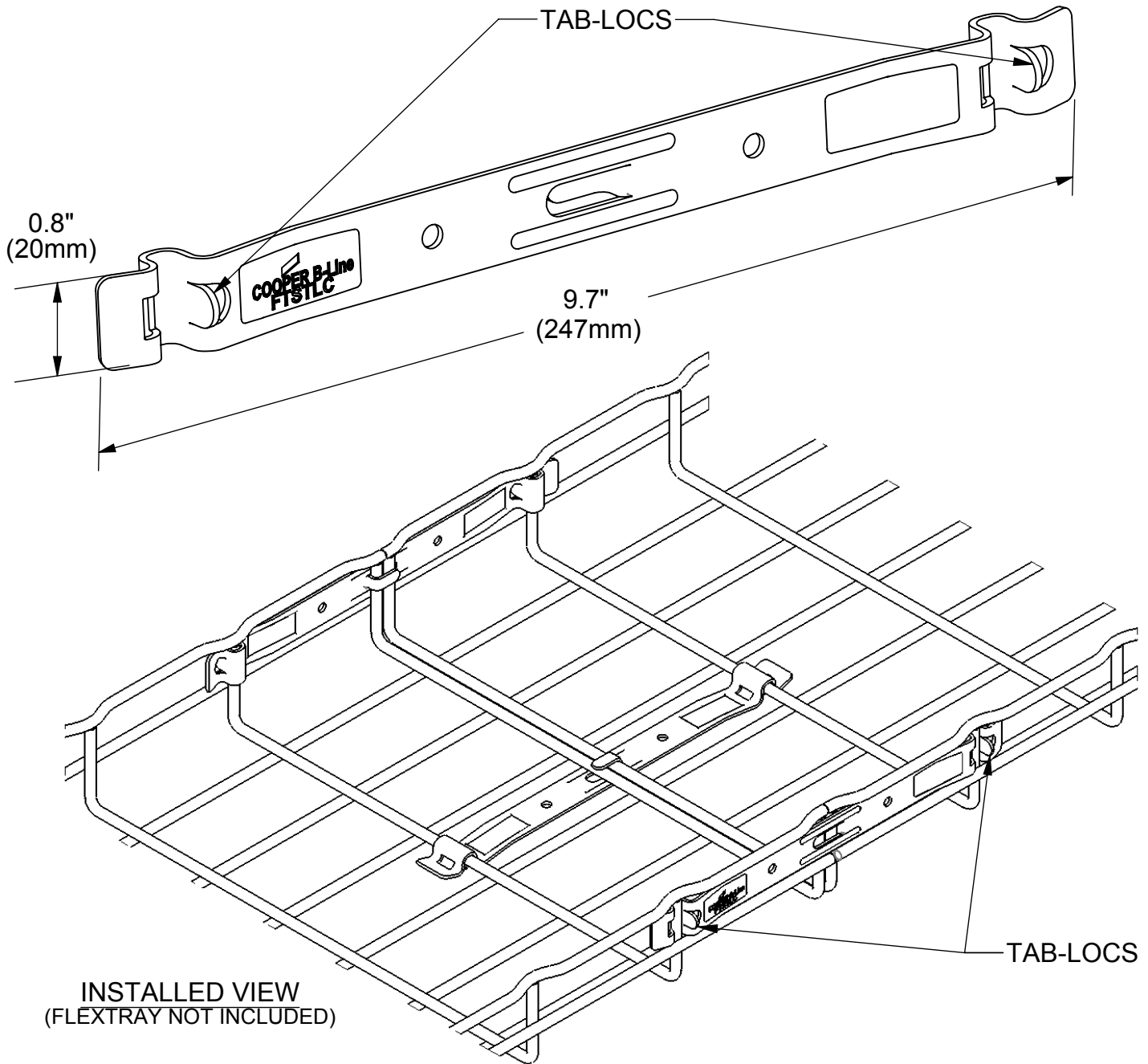
DRAWN BY:	REV.
DF	A

DATE: **08/12/08**


MODEL SOURCE FILE:	REV:	SHEET:
00015639	00	1 OF 1

PART NUMBER: **FTSTLC**

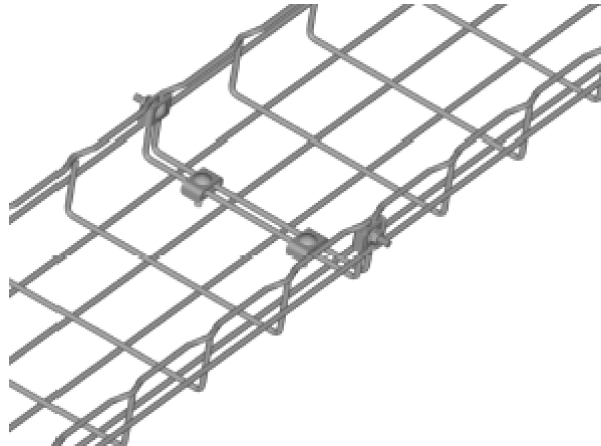
- FINISH: ZINC, STAINLESS STEEL, CUSTOM COLORS
- ZINC FINSH IS UL CLASSIFIED
- TO INSTALL USE PLIERS OR SCREWDRIVER TO CLOSE TAB-LOCS



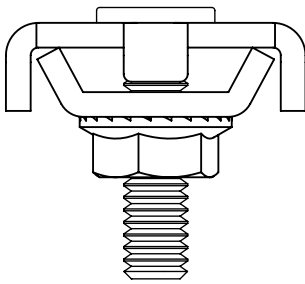
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 509 W. Monroe Street Highland, IL 62249 Phone (618) 654-2184 FAX (618) 654-5499 www.cooperbline.com	SUBMITTAL DRAWING		REFERENCE DWG(S): 00014532 00015303	SUBMITTAL NO: S00014532
	TITLE: FTSTLC FLEXTRAY TAB-LOC CONNECTOR			DRAWN BY: ERN REV: B
				DATE: 06/16/2009
	<small>EQUIPMENT FURNISHED HAS BEEN FABRICATED IN ACCORDANCE WITH THIS DRAWING.</small>		MODEL SOURCE FILE: S00014532	REV: 00 SHEET: 1 OF 1

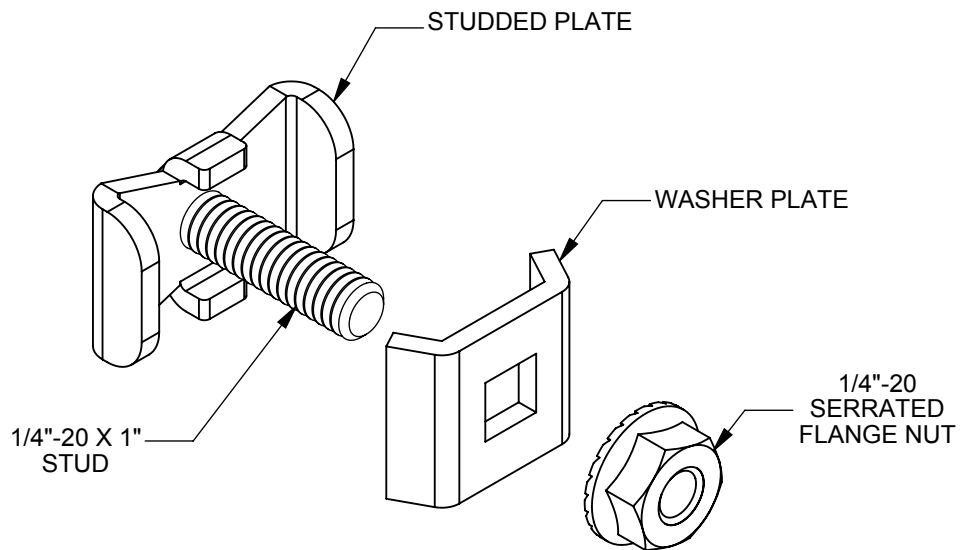
- PART NUMBER: **WASHER SPL KIT.**
- UNIVERSAL BOLTED CONNECTOR.
- MATERIAL FINISH:
ELECTROPLATED ZINC
BLACK ZINC
316 STAINLESS STEEL



INSTALLED VIEW
(BASKET NOT INCLUDED)



TOP VIEW



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SUBMITTAL DRAWING

TITLE:

WASHER SPL KIT
FLEXTRAY WASHER SPLICE KIT

EQUIPMENT FURNISHED HAS BEEN FABRICATED IN ACCORDANCE WITH THIS DRAWING.

REFERENCE DWG(S):

SUBMITTAL NO:

S00015596

DRAWN BY:

DF

REV:

A

DATE:

06/12/08

MODEL SOURCE FILE:

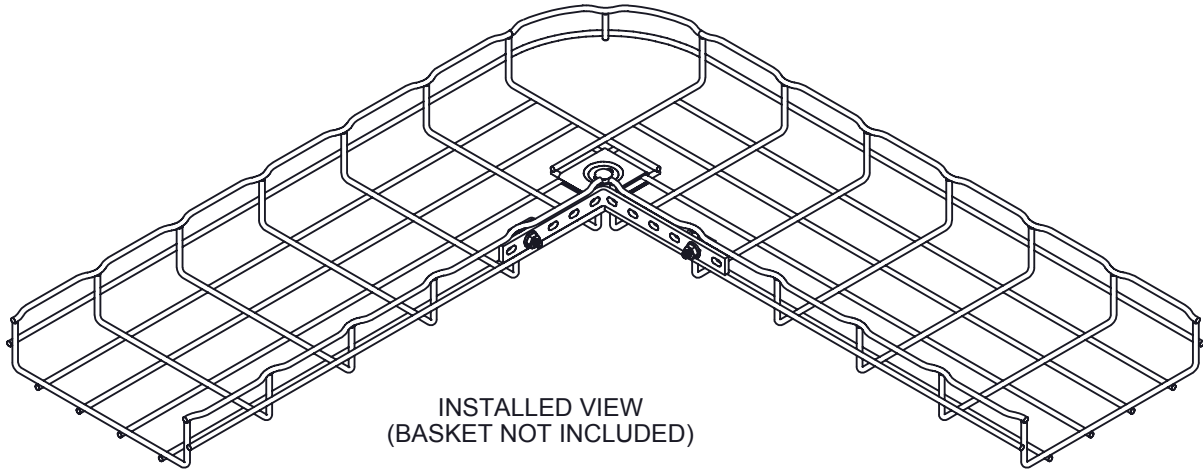
00015596

REV:

00

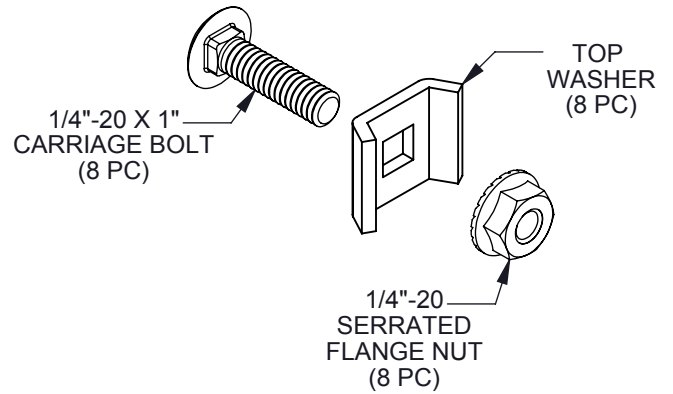
SHEET:

1 OF 1

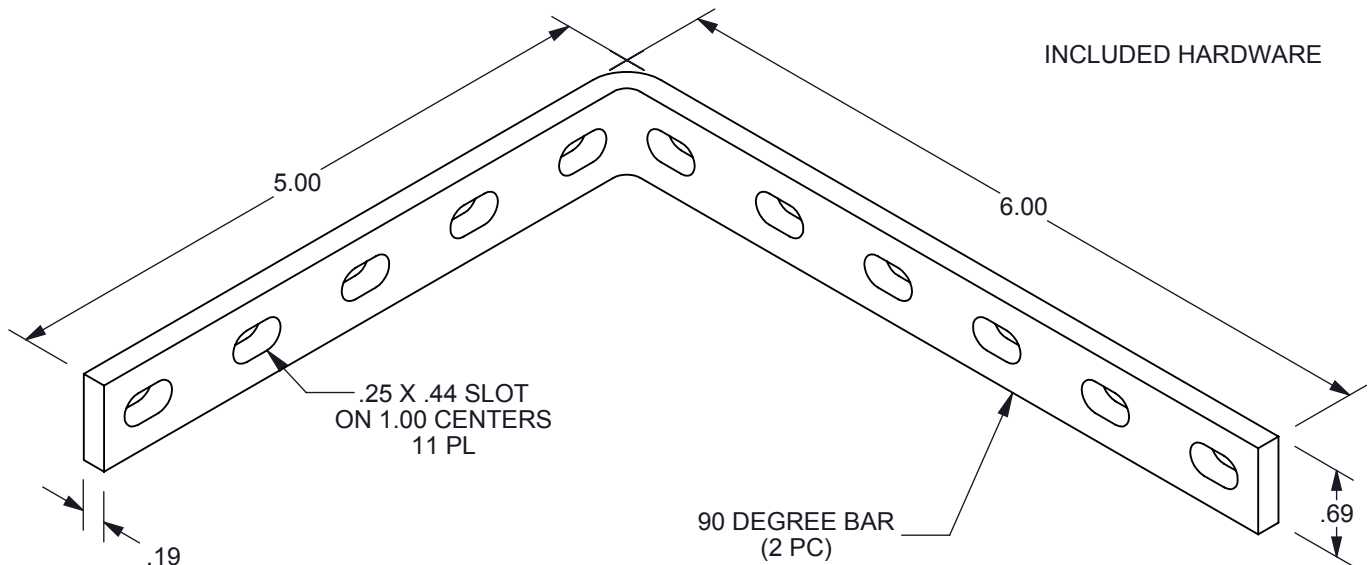


INSTALLED VIEW
(BASKET NOT INCLUDED)

- PART NUMBER: **90 DEGREE KIT**
- FOR FAST ASSEMBLY OF 90 DEGREE TURNS AND TEE FITTINGS
- INCLUDES TWO 90 DEGREE BARS & ATTACHMENT HARDWARE
- MATERIAL FINISH:
ELECTROPLATED ZINC
BLACK POWDER COAT
HOT DIP GALVANIZED
316 STAINLESS STEEL
CUSTOM POWDER COAT




INCLUDED HARDWARE



90 DEGREE BAR
(2 PC)

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 509 W. Monroe Street Highland, IL 62249 Phone (618) 654-2184 FAX (618) 654-5499 www.cooperbline.com	SUBMITTAL DRAWING		REFERENCE DWG(S):	SUBMITTAL NO: S00015606	
	TITLE: 90 DEGREE KIT			DRAWN BY: DF	REV: A
	FLESTRAY 90 DEGREE KIT			DATE: 08/07/08	SHEET: 1 OF 1
	EQUIPMENT FURNISHED HAS BEEN FABRICATED IN ACCORDANCE WITH THIS DRAWING.			MODEL SOURCE FILE:	REV:



XXIV. APPENDIX C

Luminaire Standards



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LUMINAIRE STANDARDS

General Comments

The University prefers to limit the number of manufacturers to ensure ease of maintenance, repair, and warranty issues. Wherever a substitute fixture is suggested for use other than those outlined herein, it will only be accepted if submitted with a per-fixture (unit cost) exact savings, and clearly identifying the reason for its use. In some cases, the University may have negotiated specialized pricing, so therefore at any time, the University may elect to reject any substituted fixtures due to price and/or supply fixtures directly based on the prior buying agreements.

Architectural Recessed Selections

(aka: troffers, grid fixtures, 1x4, 2x2, 2x4, etc.)

Architectural Recessed fixture selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance, LEDs types and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	Features	Typical Areas of Use
<ul style="list-style-type: none"> • Columbia “LCAT” Series Or • HE Williams “AT” Series • LSI “LPEC” Series 	<ul style="list-style-type: none"> • L80>60,000hrs minimum • Made In/Buy America! • 90+CRI • All service accessible from below • Integral sensors 	<ul style="list-style-type: none"> • Classrooms • Offices • Corridors • Conference Rooms • General use for T-grid ceilings • Can be used in hard ceilings with minimal accessories

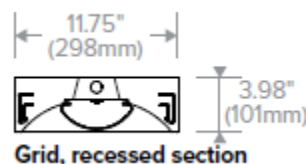
Exclusions: Flat panel style or ‘zero-plenum’ style fixtures that fit within a ceiling grid will not be used in any application throughout the University without special circumstances requiring their use and prior approval of Facilities and University Architect’s office.



LCAT14

1' x 4' LED CONTEMPORARY ARCHITECTURAL TROFFER

KEY DATA	
Lumen Range	2314–8294
Wattage Range	18–63
Efficacy Range (LPW)	118–146
Reported Life (Hours)	L80/60,000



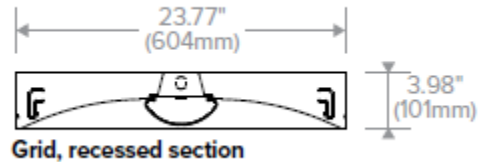


LCAT22

2' x 2' LED CONTEMPORARY ARCHITECTURAL TROFFER



KEY DATA	
Lumen Range	1510–4794
Wattage Range	12–35
Efficacy Range (LPW)	121–141
Reported Life (Hours)	L80/60,000

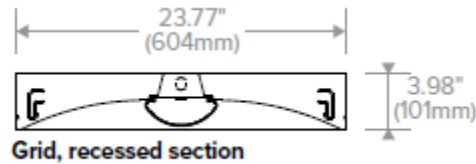


LCAT24

2' x 4' LED CONTEMPORARY ARCHITECTURAL TROFFER



KEY DATA	
Lumen Range	2350–8367
Wattage Range	18–63
Efficacy Range (LPW)	119–146
Reported Life (Hours)	L80/60,000



FEATURES

- High efficiency acrylic center lens features linear prisms for high performance without pixelation
- Appropriate for offices, schools, medical, and public spaces
- High performance reflector with matte white paint standard
- LED modules and electrical accessible from below
- Optional architecturally styled integration of daylight and occupancy sensor(s)
- QR code traceability
- Compatible with Dual-Lite inverters





Architectural Recessed Selections – Linear

(aka: slot lights)

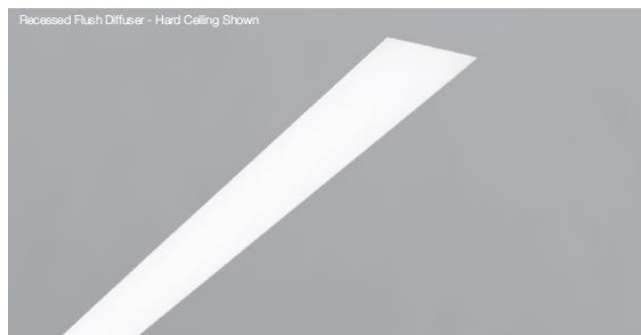
Linear Architectural Recessed fixture selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance LEDs types and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	Features	Typical Areas of Use
<ul style="list-style-type: none"> • Finelite HP-4 <p>Or</p> <ul style="list-style-type: none"> • ALW LightPlane 2 	<ul style="list-style-type: none"> • L70>200,000hrs min • Made In/Buy America! • Quick Ship available in less than 10days • Extruded aluminum with internal joiners • Integral sensors ability • Must have matching, surface, wall, recessed, & wet location products 	<ul style="list-style-type: none"> • Classrooms • Offices • Conference Rooms • General use for hard or T-grid ceilings with minimal accessories

Exclusions: Single product offerings without matching wall, surface, recessed, pendant or wet location products grid will not be used in any application throughout the University without special circumstances requiring their use and prior approval of Facilities and University Architect’s office.



High Performance 4" Aperture (HP-4)





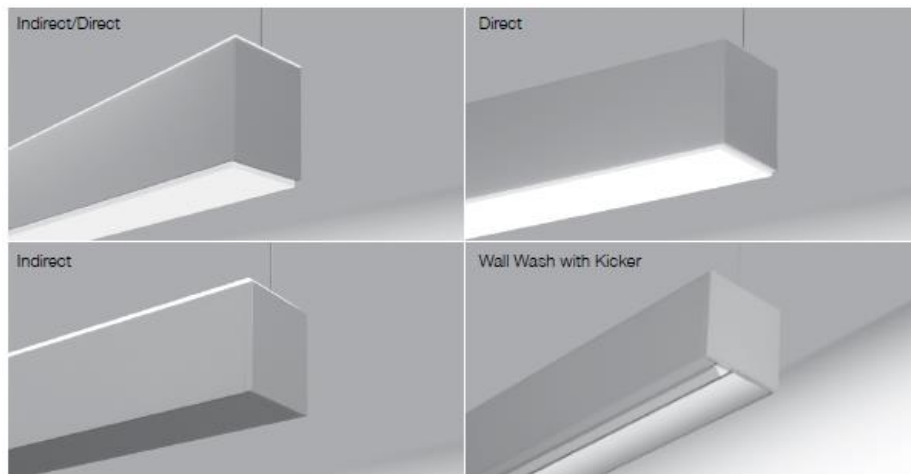
Pendant Linear Selections

(aka: linear slots, direct-indirect)

All Pendant Linear Selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance, LEDs types and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	Features	Typical Areas of Use
<ul style="list-style-type: none"> • Finelite “HP-4” OR <ul style="list-style-type: none"> • ALW Lightplane 2 	<ul style="list-style-type: none"> • L70>200,000hrs min • Made In/Buy America! • Quick Ship available in less than 10days • Extruded aluminum with internal joiners • Integral sensors ability • Must have matching, surface, wall, recessed, & wet location products 	<ul style="list-style-type: none"> • Offices • Corridors • Conference Rooms • General Use

Exclusions: Single product offerings without matching wall, surface, recessed, pendant or wet location products grid will not be used in any application throughout the University without special circumstances requiring their use and prior approval of Facilities and University Architect’s office.





Recessed Downlight Selections

(aka: hi-hats, cans, etc.)

Downlight selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance, LEDs types and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	Features	Typical Areas of Use
<ul style="list-style-type: none"> • HE Williams “DR” Series Or • Intense “SD” Series • Prescolite “LiteFrame” Series 	<ul style="list-style-type: none"> • Family of fixtures has full complement of aperture sizes, lumen packages, & shapes (i.e. square, round, etc) • L90@55,000hrs minimum • Made In/Buy America! • 90+CRI • Same fixture for varied ceiling conditions • Up to 8000lm 	<ul style="list-style-type: none"> • Offices • Corridors • Conference Rooms • General Use

Exclusions: “Junction-box mounted”, “wafer”, flat panel style, or ‘surface mounted downlights’ less than 2-inch will not be used in any application throughout the University without special circumstances requiring their use and prior approval of Facilities and University Architect’s office.

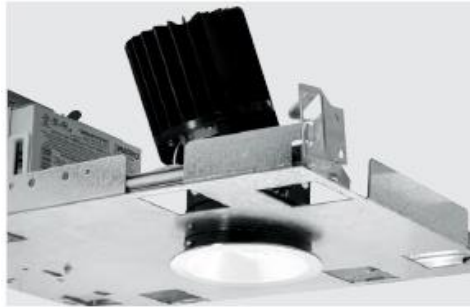


4DR LED
 4.5” Downlight – Round

NEW CONSTRUCTION AND REMODEL



2AR LED
2" Adjustable Downlight – Round



NEW CONSTRUCTION AND REMODEL

6DS LED
6" Downlight – Square



NEW CONSTRUCTION AND REMODEL



Surface Mounted Selections (industrial)

(aka: wraps, lensed industrials, vaportites)

Industrial style Surface Mounted fixture selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance, LEDs types and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	General Features	Typical Areas of Use
<u>Surface General Use</u> <ul style="list-style-type: none"> Columbia “MPS” Series 	<ul style="list-style-type: none"> Fixture selections for each application shall have matching smaller and larger sized fixtures L80@60,000hrs min Made In/Buy America! 80+CRI Row mounting avail Marine grade aluminum with UV stabilized polycarbonate lenses if available Up to 20,000lm Integral Sensors 	<ul style="list-style-type: none"> Back of house Storage rooms Corridors Stairwells
<u>Vandal Resistant</u> <ul style="list-style-type: none"> Williams “AVX” Series 		
<u>Vaportite</u> <ul style="list-style-type: none"> Williams 96, 97 Williams EGL2 (High Output) 		
<u>Stairwells</u> <ul style="list-style-type: none"> Lamar “Titan” Series Columbia “ESL” Family 		

Exclusions: None

Columbia
LIGHTING



MPS
MULTIPURPOSE LINEAR



AVX LED
Architectural Vandal Wrap



96 LED
Fully Enclosed & Gasketed Industrial



TITAN U Series





Exit Sign & Emergency Selections

All emergency & exit sign fixture selections are based on the concept that each product line selected offers a complete family of fixtures that will ensure consistency from fixture to fixture in appearance, quality, and overall construction details for ease of maintenance. All products used must include all features listed herein and on the complete product sheet, as well as meet specifications as called out within the guidelines.

Fixture Brands & Series	Features	Typical Areas of Use
<ul style="list-style-type: none"> Compass “CELC” Series Or Emergilite “Prestige” Series <p><u>Budget Selection</u></p> <ul style="list-style-type: none"> Compass “CE” Series Emergilite “Premiere” <p><u>Emergency Lights</u> <i>Matching the above series, respectively</i></p>	<ul style="list-style-type: none"> Edgelit with mirror divider Brushed aluminum housing & trim Wall, ceiling (grid or hard) mounting including with or without integral heads Red lettering with 10+ year life Suitable for use with generators but also capable of including an integral battery back-up UL924 	<ul style="list-style-type: none"> General use as required

Exclusions: None



CELC

EDGE-LIT COMBINATION EXIT AND EMERGENCY LIGHT



CE

LED EMERGENCY EXIT



ABB

Premier™ Exit Series

EMERGI-LITE

