Glendale Unified School District

Herbert Hoover High School
11000 Building Prop 39-HVAC Upgrade

651 Glenwood Road
Glendale, CA 91202

100% DD
TECHNICAL SPECIFICATIONS

NAC Architecture

Architect's Job No.
A161-16043

March 10, 2017

Architect
NAC Architecture
837 North Spring Street, Third Floor,
Los Angeles, California 90012

Mechanical, Plumbing, Fire Protection
Pocok Design Solutions inc.
14451 Chambers Rd#210,
Tustin, CA 92780

Structural Engineer
KPFF Consulting Engineers
301 N. Lake Ave., Suite 550
Pasadena, CA 91101

Electrical Engineers
Turpin & Rattan Engineering Inc.
2441 Honolulu Ave . Suite# 200
Montrose, CA 91020

IDENTIFICATION STAMP
DIV. OF THE STATE ARCHITECT
APP# 3 117998
AC FLS SS
Date AUG 07 2017

SECTION 00 01 10 - TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS
NOT USED

DIVISION 02 EXISTING CONDITIONS

02 41 19 (Selective) Site & Structure Demolition

DIVISION 03 CONCRETE

NOT USED

DIVISION 04 MASONRY

NOT USED

DIVISION 05 METALS

Not Used

DIVISION 06 WOOD, PLASTICS AND COMPOSITES

06 10 00 Rough Carpentry

DIVISION 07 THERMAL AND MOISTURE PROTECTION

07 51 13 Built-Up Asphalt Roofing
07 60 00 Flashing and Sheet Metal
07 84 00 Fire Stops and Smoke Seals
07 92 00 Joint Sealants

DIVISION 08 OPENINGS

Not Used

DIVISION 09 FINISHES

09 51 13 Acoustical Panel Ceilings

DIVISION 10 SPECIALTIES

Not Used

DIVISION 11 EQUIPMENT

Not Used

DIVISION 12 FURNISHINGS

NOT USED

DIVISION 13 SPECIAL CONSTRUCTION

Not Used

DIVISION 14 CONVEYING EQUIPMENT

Not Used

DIVISION 21 FIRE SUPPRESSION
Not Used

DIVISION 22 PLUMBING

Not Used

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING

23 05 00 Common Work Results for HVAC
23 05 13 Common Motor Requirements for HVAC Equipment
23 05 29 Hangers and Supports for HVAC Piping and Equipment
23 05 48 Vibration and Seismic Controls for HVAC Piping and Equipment
Vibration Isolator Cutsheet and Calculations
23 05 53 Identification for HVAC Piping and Equipment
23 05 93 Testing, Adjusting, and Balancing for HVAC
23 07 00 HVAC Insulation
23 09 13 Energy Management Control System
23 23 00 Refrigerant Piping
23 31 13 Metal Ducts
23 33 00 Air Duct Accessories
23 37 00 HVAC air Outlets and Inlets
23 81 26 HVAC split system AC

DIVISION 25
Not Used

DIVISION 26 ELECTRICAL

26 05 00 Common Work Results For Electrical
26 05 15 Electrical Bsic Materials and Methods
26 05 15 Electrical Basic Materials Methods
26 05 30 Conduit and Wire
26 24 16 Branch Circuit Panel Boards and Termianl Cabinets
26 24 19 Motor Control Equipment

DIVISION 27 COMMUNICATIONS

Not Used

DIVISION 28 ELECTRONIC SAFETY AND SECURITY

Not Used

DIVISION 31 EARTHWORK

Not Used

DIVISION 32 EXTERIOR IMPROVEMENTS

Not Used

DIVISION 33 UTILITIES

Not Used

APPENDICES

A Mechanical Equipment Cut Sheets

B Structural Calculations

END TABLE OF CONTENTS

SECTION 02 41 19 – SELECTIVE SITE & STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Demolition and removal of selected portions of building or structure.
2. Demolition and removal of selected site elements.

B. Related Requirements:

1. Division 01 Section "Summary" for restrictions on the use of the premises, Owner-occupancy requirements, and phasing requirements.
2. Division 31 Section "Site Clearing" for site clearing and removal of above- and below-grade improvements.

1.3 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to the District ready for reuse.

C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.

D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to District that may be uncovered during demolition remain the property of District.

1. Carefully salvage in a manner to prevent damage and promptly return to District.

1.5 PREINSTALLATION MEETINGS

A. Pre-demolition Conference: Conduct conference at Project site.

1. Review structural load limitations of existing structure.
2. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
3. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
4. Review areas where existing construction is to remain and requires protection.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For refrigerant recovery technician.

B. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.

C. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure school's operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Coordination of District's continuing occupancy of portions of existing building and of District's partial occupancy of completed Work.

D. Inventory: Submit a list of items to be removed and salvaged and deliver to the District prior to start of demolition.

E. Pre-demolition Photographs or Video: Submit before Work begins.

F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

G. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

1.7 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged.

B. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.8 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.

1.9 FIELD CONDITIONS

A. District will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so District's operations will not be disrupted.

B. Conditions existing at time of inspection for bidding purpose will be maintained by the District as far as practical.

C. Notify the District and Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

1. Hazardous materials will be removed by the District before start of the Work.
2. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and District. Hazardous materials will be removed by the District under a separate contract.

E. Hazardous Materials: Hazardous materials are present in buildings and structures to be selectively demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

1. Hazardous material remediation is specified elsewhere in the Contract Documents.
2. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
3. District will provide material safety data sheets for suspected hazardous materials that are known to be present in buildings and structures to be selectively demolished because of building operations or processes performed there.

F. Storage or sale of removed items or materials on-site is not permitted.

G. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.10 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties. Notify warrantor before proceeding.

B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS

2.1 PEFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting selective demolition operations.

B. Review record documents of existing construction provided by the District. The District does not guarantee that existing conditions are same as those indicated in record documents.

C. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect.

E. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.

1. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.

F. Survey of Existing Conditions: Record existing conditions by use of measured drawings, preconstruction photographs and templates.

1. Comply with requirements specified in Division 01 Section "Photographic Documentation."
2. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations.
3. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

1. Comply with requirements for existing services/systems interruptions specified in Division 01 Section "Summary."

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. The District will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated to be removed.

a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

C. Refrigerant: Remove refrigerant from mechanical equipment to be selectively demolished according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Comply with requirements for access and protection specified in Division 01 Section "Temporary Facilities and Controls."

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Division 01 Section "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.

2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly.

B. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.5 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

A. Concrete: Demolish in small sections. Using power-driven saw, cut concrete to a depth of at least ½ inch at junctures with construction to remain. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete. Neatly trim openings to dimensions indicated.

B. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, then remove concrete between saw cuts.

C. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.

D. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, then break up and remove.

E. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings." Do not use methods requiring solvent-based adhesive strippers.

F. Roofing: Remove no more existing roofing than what can be covered in one day by new roofing and so that building interior remains watertight and weathertight. See Division 07 Section for new roofing requirements.

1. Remove existing roof membrane, flashings, copings, and roof accessories.
2. Remove existing roofing system down to substrate.

3.6 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain District's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow demolished materials to accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
4. Comply with requirements specified in Division 01 Section "Construction Waste Management and Disposal."

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials and dispose of at designated spoil areas on District's property.

D. Disposal: Transport demolished materials off District's property and legally dispose of them.

3.7 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION

SECTION 07 51 00

BUILT-UP BITUMINOUS ROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Built-up roofing membrane, conventional application.

B. Deck sheathing.

C. Roofing cant strips and accessories.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Coordinate with installation of associated counterflashings installed by other sections as the work of this section proceeds.

B. Preinstallation Meeting: Convene one week before starting work of this section.

1. Review preparation and installation procedures and coordinating and scheduling required with related work.

1.03 SUBMITTALS

A. See Section 01 33 13 - Submittal Procedures.

B. Product Data: Provide data indicating membrane and bitumen materials, base flashing materials and insulation.

C. Shop Drawings: Indicate joint or termination detail conditions and conditions of interface with other materials.

D. Manufacturer's Installation Instructions: Indicate special procedures.

E. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Glendale Unified School District's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

A. Perform work in accordance with NRCA Roofing and Waterproofing Manual.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum ten years of documented experience.

C. Applicator Qualifications: Company specializing in performing the work of this section with minimum five years experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in manufacturer's original containers, dry, undamaged, with seals and labels intact.

B. Store products in weather protected environment, clear of ground and moisture.

1.06 FIELD CONDITIONS

A. Do not apply roofing membrane during unsuitable weather.

B. Do not apply roofing membrane when ambient temperature is below 40 degrees F.

C. Do not apply roofing membrane to damp deck surface or when precipitation is expected or

occurring.

D. Do not expose materials vulnerable to water or sun damage in quantities greater than can be weatherproofed the same day.

1.07 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. **Provide _____ year manufacturer's material and labor warranty to cover failure to prevent penetration of water, along with No Cost Replacement bond.**

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sheet and Bitumen Materials:

1. CertainTeed Corporation: www.certainteed.com.
2. GAF: www.gaf.com.
3. Johns Manville Corporation: www.jm.com.
4. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 ROOFING - CONVENTIONAL APPLICATION

A. Built-up Bituminous Roofing: Asphalt felt membrane, three ply plus base sheet. B.

Roofing Assembly Requirements:

1. Solar Reflectance Index (SRI): 78, minimum, calculated in accordance with ASTM E1980, based on 3-year aged data.
   a. Field applied coating may not be used to achieve specified SRI.
2. Roof Covering External Fire-resistance Classification: UL Class A.

2.03 SHEET MATERIALS

A. Vapor Retarder Felt: Asphalt-saturated organic, ASTM D226, Type I ("No.15") felt, unperforated.

B. Base Sheet: ASTM D4601 Type I; asphalt-coated glass fiber; unperforated. C.

Roofing Felt: ASTM D2178; Asphalt-saturated glass fiber felt; standard duty.

D. White Cap Sheet: Asphalt-saturated glass fiber roll roofing surfaced with flexible acrylic coating and ceramic granules; complying with ASTM D3909.

1. Solar Reflectance: 0.75, minimum, initial, and 0.60, minimum, 3-year aged, certified by Cool Roof Rating Council.
2. Thermal Emissivity: 0.80, minimum, initial, and 0.85, minimum, 3-year aged, certified by Cool Roof Rating Council.
3. Products:
   a. CertainTeed Corporation; Flintglas MS Cap CoolStar: www.certainteed.com. b.

   GAF; Energycap Mineral Surfaced Cap Sheet: www.gaf.com.

   c. Johns Manville Corporation; GlasKap: www.jm.com.
   d. Substitutions: See Section 01 60 00 - Product Requirements.

E. Flexible Flashing Material: Modified bitumen, SBS type; conforming to the following:

1. Thickness: 40 mil.
2. Tensile Strength: 1,200 psi.
3. Color: Black.
4. Product: Ice & Water Shield manufactured by Grace Building Products, or equal.

2.04 BITUMINOUS MATERIALS

A. Bitumen: ASTM D312 Type I, asphalt. B.

Primer: ASTM D41, asphalt type.

C. Roof Cement: ASTM D4586, Type I.

2.05 DECK SHEATHING

A. Deck Sheathing: Glass mat faced gypsum panels, ASTM C1177/C1177M, fire resistant type, 1/4 inch thick.

1. Products:

a. Georgia-Pacific DensDeck, DensDeck Prime, or DensDeck DuraGuard: www.densdeck.com.

b. Temple-Inland, Inc.; GreenGlass Roof Board or GreenGlass Primed Roof Board: www.templeinland.com.

c. Substitutions: See Section 01 60 00 - Product Requirements.

2.06 ACCESSORIES

A. Cant and Edge Strips: Bitumen-impregnated wood fiberboard, compatible with roofing materials; cants formed to 45 degree angle, tapered edge strips, and other configurations as detailed.

B. Sheathing Adhesive: Non-combustible type, for adhering gypsum sheathing to metal deck.

C. Insulation Joint Tape: Glass fiber reinforced type as recommended by insulation manufacturer, compatible with roofing materials; 6 inches wide; self adhering.

D. Insulation Fasteners: Appropriate for purpose intended and approved by roofing manufacturer. E.

Roofing Nails: Galvanized, hot dipped type, size and configuration as required to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces and site conditions are ready to receive work. B.

Verify deck is supported and secure.

C. Verify deck is clean and smooth, flat, free of depressions, waves, or projections, properly sloped and suitable for installation of roof system.

D. Verify deck surfaces are dry and free of snow or ice.

E. Verify that roof openings, curbs, and penetrations through roof are solidly set, and cant strips are in place.

3.02 METAL DECK PREPARATION

A. Install deck sheathing on metal deck:

1. Lay with long side at right angle to flutes; stagger end joints; provide support at ends.
2. Cut sheathing cleanly and accurately at roof breaks and protrusions to provide smooth surface.
3. Tape joints.
4. Fasten sheathing to roof deck with continuous mopping of adhesive on each flute.

3.03 MEMBRANE APPLICATION

A. Equiviscous Temperature (EVT) at Point of Application: In accordance with NRCA recommendations.

B. Lay base sheet, coated side down. Lap sides 2 inches; lap ends 6 inches.

1. Lay in bitumen mopped at 20 lb/square.

C. Apply membrane plies, weather lap edges and ends, and mop with 20 lb/square of bitumen per ply.

D. Apply smooth, free from air pockets, wrinkles, fish-mouths, or tears.

E. At end of day's operation, install two plies membrane and bitumen glaze coat for cut-off. Glaze exposed felts. Remove cut-off before resuming roofing.

F. At intersections with vertical surfaces:

1. Extend membrane and base sheet over cant strips and up a minimum of 4 inches onto vertical surfaces.
2. Mop on base flashing of two additional plies of felt and one ply of base flashing material.
3. Secure base flashing to nailing strips at 4 inches on center. G.

Coordinate installation of roof drains and related flashings.

3.04 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for general requirements for field quality control and inspection.

3.05 CLEANING

A. Remove bituminous markings from finished surfaces.

B. In areas where finished surfaces are soiled by bitumen or other source of soiling caused by work of this section, consult manufacturer of surfaces for cleaning advice and conform to their documented instructions.

C. Repair or replace defaced or damaged finishes caused by work of this section.

3.06 PROTECTION

A. Protect installed roofing and flashings from construction operations.

B. Where traffic must continue over finished roof membrane, protect surfaces using durable materials.

END OF SECTION

SECTION 07 84 00

FIRESTOPPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Firestopping systems.

B. Firestopping of all joints and penetrations in fire-resistance rated and smoke-resistant assemblies, whether indicated on drawings or not, and other openings indicated.

C. Joint sealants used in fire-resistive construction.

1.02 SUBMITTALS

A. See Section 01 33 13 - Submittal Procedures.

B. Schedule of Firestopping: List each type of penetration, fire rating of the penetrated assembly, and firestopping test or design number.

C. Product Data: Provide data on product characteristics, performance ratings, and limitations. HPI

D. Report: Submit VOC content documentation for all non-preformed materials. Manufacturer's

E. Installation Instructions: Indicate preparation and installation instructions. Manufacturer's Certificate:

F. Certify that products meet or exceed specified requirements.

1.03 QUALITY ASSURANCE

A. Fire Testing: Provide firestopping assemblies of designs that provide the scheduled fire ratings when tested in accordance with methods indicated.

1. Listing in the current-year classification or certification books of UL, FM, or ITS (Warnock Hersey) will be considered as constituting an acceptable test report.

2. Valid evaluation report published by ICC Evaluation Service, Inc. (ICC-ES) at www.icc-es.org will be considered as constituting an acceptable test report.

3. Submission of actual test reports is required for assemblies for which none of the above substantiation exists.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

C. Installer Qualifications: Company specializing in performing the work of this section and:

1. With minimum 3 years documented experience installing work of this type.

2. Able to show at least 5 satisfactorily completed projects of comparable size and type.

3. Approved by firestopping manufacturer

D. HPI requirements

1. See Section 01 61 13- Volatile Organic Compound Content Requirements.

2. Adhesives: Meet the volatile organic chemicals (VOC) content requirements in the applicable category of South Coast Air Quality Management District (SCAQMD) Rule 1168, Adhesive and Sealant Applications (current version).

3. Adhesives must follow the specifications of the CDPH Standard Practice

1.04 FIELD CONDITIONS

A. Comply with firestopping manufacturer's recommendations for temperature and conditions during and after installation. Maintain minimum temperature before, during, and for 3 days after installation of materials.

B. Provide ventilation in areas where solvent-cured materials are being installed. PART 2

PRODUCTS

2.01 FIRESTOPPING SYSTEMS

A. Firestopping: Any material meeting requirements.

1. Fire Ratings: Use any system listed by UL or tested in accordance with ASTM E814 that has F Rating equal to fire rating of penetrated assembly and T Rating Equal to F Rating and that meets all other specified requirements.

B. Acceptable manufacturers providing code approved systems:

1. 3M Fire Protection Products: www.3m.com/firestop.

2. Bio Fireshiel, www.bioshield.com.

3. Hilti, Inc: www.us.hilti.com.

4. Substitutions: See Section 01 60 00 – Product Requirements.

2.02 FIRESTOPPING; GENERAL

A. Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.

B. Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

C. Firestopping Materials are either "cast-in-place" (integral with concrete placement) or "post installed." Provide cast-in-place firestop devices prior to concrete placement.

2.03 FIRESTOPPING ASSEMBLIES

A. Firestopping: Any material meeting requirements.

B. Fire Ratings: Use any system listed by UL, FM, or ITS (Warnock Hersey) or tested in accordance with ASTM E 814 that has F Rating equal to fire rating of penetrated assembly and minimum T Rating Equal to F Rating and that meets all other specified requirements.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify openings are ready to receive the work of this section.

3.02 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter that could adversely affect bond of firestopping material.

B. Remove incompatible materials that could adversely affect bond.

C. Install backing materials to arrest liquid material leakage.

D. Priming: Prime substrates where recommended in writing by firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.03 INSTALLATION

A. Install materials in manner described in fire test report and in accordance with manufacturer's written instructions, completely closing openings.

B. Do not cover installed firestopping until inspected by authority having jurisdiction. Install

c. labelling required by code.

3.04 CLEANING

A. Clean adjacent surfaces of firestopping materials.

3.05 PROTECTION

A. Protect adjacent surfaces from damage by material installation.

3.06 SYSTEMS AND APPLICATIONS SCHEDULE

Construction Condition	Manufacturer	Product	Installation Spec.
Metal pipe or conduit through framed walls	3M	FB-CP2SWB+Caulk FB-Moldable Putty	UL System WL1133, WL1146, WL1166, WL1228
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 620	UL System WL1054, 1058, WL1164
	Tremco	Tremco Fyre Sil Sealant	
Metal pipe or conduit through concrete floors	3M	FB Silicone Sealant 3000 WT, FB-1000 NS, FB-1003SL	UL System CAJ1292
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 620 Fire Foam, CP 601 Elastomeric Firestop Sealant	UL System CAJ1126, FA 1017
	Tremco	Tremstop Fyre Sil Sealant	
Insulated metal pipe through framed walls	3M	FB CP2SWB+ Caulk, FB FS-195+ Wrap/Strip, FB IC 15 WB+ Caulk	UL System WL5001, WL5002, WL5011, WL5039, WL5040
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 618 Firestop Putty, CP Firestop Jacket	UL System WL5028, 5029,5047
	Tremco	Tremstop WBM Intumescent Firestop Sealant	

Construction Condition	Manufacturer	Product	Installation Specs
Insulated metal pipe through concrete floors and walls	3M	FB Silicone Sealant 3000 WT, FM CP 25WB+ Caulk, FB FS-195+ Wrap/Strip	UL System CAJ5080, CAJ5119, CAJ5156, CAJ5172, CAJ5172, CAJ5209, CAJ5211, CAJ5017
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 620 Fire Foam, CP 601 Elastomeric Firestop Sealant	CAJ5098, CAJ5061, FA5015,FA5016
	Tremco	Tremstop WBM Intumescent Firestop Sealant	
Plastic pipe through framed walls	3M	FB CP25W+ Caulk, FB FS-195+ Wrap/ Strip, FB IC15WB+ Caulk, FB Moldable Putty+, FireDam 150+ Caulk	Ul System WL2002, WL2003, WL2073, WL2087, WL2097, WL2148, WL2154, WL2162, WL2264
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 642 Firestop Jacket, CP 643 Firestop Jacket, CP 645 Wrap Strips	UL System WL2075, WL 2078, WL 2128

Construction Conditions	Manufacturer	Product	Installation Specs
Plastic pipe through concrete floors	3M	FM Silicone Sealant 3000WT, FB CP25WB+ Caulk, FB FS-195+ Wrap/Strip, FB IC 15WB+ Caulk	UL System CAJ2005, CAJ2161, CAJ 2214, CAJ2228, CAJ2242, CAJ2378
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 642 Firestop Jacket, CP 643 Firestop Jacket, CP 645 Wrap Strips	UL System CAJ2098, CAJ 2109, CAJ2141, CAJ2167, CBJ2021, FA2053, FA2025, CBJ2021
Cable tray through concrete floors and walls	3M	FB Moldable Putty +, FB Pillows, FB Self-Locking Pillows	CAJ4056
	Hilti	CP 637 Trowelable Firestop Compound, FS 657 Fire Block, CP 620 Fire Foam	UL System CAJ4034, CAJ4036, WJ401
Cable tray through framed walls	3M	FB CP25WB+ Caulk, FB CS-195+ Composite Sheet, FB E-FIS Flexible Seal, FB Moldable Putty+, FB Pillows	WL4018, WL4044, WL4052, WL4067
	Hilti	CP 637 Trowelable Firestop Compound, FS 657 Fire Block, CP 620 Fire Foam	UL System WL 4011, WL 4019
Alternately, terminate cable tray prior to fire wall			Design Modification
Telephone, fiber optic, and other small misc. conductors through framed walls	3M	FB CP25WB+ Caulk, FB FS-195+ Wrap/ Strip, FB IC 15WB+ Caulk, FB Moldable Putty+, FireDam 150+ Caulk	UL System WL3001, WL3030, WL3074, WL3149, WL3195, WL3337
	Hilti	FS-ONE, CP 620, CP 606, CP601S	UL System CAJ 3005, WL 3065, WL 3111, WL 3112

Construction Condition	Manufacturer	Products	Installation Specs
Control joints and wall/floor joints, at framed and concrete. Install UL rated assembly that meets ASTM C920, Class A movement.	3M	FireDam Spray 200, FB Silicone Sealant 1000 NS, FB 2000 N/S Silicone Sealant, FB CP25VVB+ Caulk, FB IC 15VVB+ Caulk, FireDam 150+ Caulk	UL System HWD0170, HWD0265, BWS0007,BVVS0008
	Hilti	FS-ONE High Performance Intumescent Firestop Sealant, CP 601S Elastomeric Firestop Sealant, CP 606 Flexible Firestop Sealant, CP 604 Self-leveling Firestop Sealant	Manufacturer's Specifications
Curtain wall/ construction gap - Install UL rated assembly that meets ASTM C920, Class A movement	3M	FB 2000 N/S Silicon Sealant, FB Silicone Sealant 1000 NS, FireDam Spray 200, FireDam 150+ Caulk,	3MU/PH 60-03, 3MU/PH 60-04, 3MU/PV6003
	Hilti	CP 672 Firestop Joint Spray, CP 601 Elastomeric Firestop sealant, CP 601S Elastomeric Firestop Sealant, CP 606 Flexible Firestop Sealant, CP 604 Self-leveling firestop Sealant	At concrete walls: CAJ 7046, CAJ 7051, at framed walls: VVL 7017, VVL 7040, VVL 7042
	Tremco	Tremstop Fyre Sil Sealant	
Non insulated HVAC ducts	3M	FB Duct Wrap 615-DVV, FB Silicone Sealant 1000 NS	3MU/PH 60-03, 3MU/PH 60-04, 3MU/PV6003
	Hilti	CP 601S	At concrete walls: CAJ 7046, CAJ 7051; at framed walls: VVL 7017, VVL 7040, VVL 7042
Seismic and other large building joints	Install UL rated assembly that meets ASTM C920, Class A movement		

END OF SECTION

SECTION 07 90 05

JOINT SEALERS

PART1 GENERAL

1.01 SECTION INCLUDES

A. Sealants and joint backing.

B. Precompressed foam sealers. C.

Related work:

1. Section 07 84 00 - Firestopping: Firestopping sealants.

1.02 DEFINITIONS

A. Based on ASTM C 920 Substrates:

1. M type substrates: Concrete, concrete masonry units, brick, mortar, natural stone. The term "masonry" means brick, stone, and concrete masonry work.

2. G type substrates: Glass and transparent plastic glazing sheets.

3. A type substrates: Metals, porcelain, glazed tile, and smooth plastics.

4. O type substrates: Wood, unglazed tile; substrates not included under other categories

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordinate the work with other sections referencing this section.

B. Ensure compatibility of sealant with adjacent materials.

1.04 SUBMITTALS

A. See Section 01 33 13- Submittal Procedures.

B. Product Data: Provide data indicating sealant chemical characteristics, performance criteria, substrate preparation, limitations, and color availability.

C. Samples: Submit two samples, 6 inch long illustrating sealant colors for selection.

D. Submit certification form seal manufacturer that sealant is compatible with adjacent materials. HPI

E. Report: Submit VOC content documentation for all non-preformed sealants and primers. Manufacturer's

F. Installation Instructions: Indicate special procedures.

1.05 QUALITY ASSURANCE

A. Maintain one copy of each referenced document covering installation requirements on site.

B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience.

C. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years experience.

D. HPI requirements

1. See Section 01 61 13- Volatile Organic Compound Content Requirements.

2. Adhesives: Meet the volatile organic chemicals (VOC) content requirements in the

applicable category of South Coast Air Quality Management District (SCAQMD) Rule 1168, Adhesive and Sealant Applications (current version).

3. Adhesives must follow the specifications of the CDPH Standard Practice

1.06 MOCK-UP

A. Provide mock-up of sealant joints in conjunction with window under provisions of Section 01 40 00.

B. Construct mock-up with specified sealant types and with other components noted, see Section 09 24 00 Portland Cement Plastering. C.

Locate where directed.

D. Mock-up may remain as part of the Work.

1.07 FIELD CONDITIONS

A. Maintain temperature and humidity recommended by the sealant manufacturer during and after installation.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Correct defective work within a five year period after Date of Substantial Completion.

C. Warranty: Include coverage for installed sealants and accessories which fail to achieve airtight seal, exhibit loss of adhesion or cohesion, or do not cure.

PART 2 PRODUCTS

2.01 SEALANTS

A. Sealants and Primers - General: Provide only products having lower volatile organic compound (VOC) content than required by South Coast Air Quality Management District Rule No.1168.

B. Type SJ-1 -General Purpose Exterior Sealant: Polyurethane; ASTM C920, Grade NS, Class 25, Uses M, G, and A; single component.

1. Acceptable Manufacturer:

a. Product: Sikaflex -1a manufactured by Sika.

b. Product: Dynatrol II manufactured by Pecora Corp. c.

Product: Dymonic FC manufactured by Tremco.

d. Substitutions: See Section 01 60 00- Product Requirements.

2. Applications: Use for:

a. Control, expansion, and soft joints in masonry. b.

Joints between concrete and other materials.

c. Joints between metal frames and other materials.

d. Other exterior joints for which no other sealant is indicated.

C. Type SJ-2 - Exterior Expansion Joint Sealer: Multi-component self-leveling polyurethane sealant, ASTM C 920, Type M, Grade P, Class 25, Use T.

1. Size as indicated on drawings, if not detailed, then per manufacturer's recommendation to provide weathertight seal when installed.
2. Provide product recommended by manufacturer for traffic-bearing use.
3. Acceptable manufacturer's:
   a. Product: Sonolastic SL 2 manufactured by Sonneborn BASF. b.
   Product: DynaTrolll SG manufactured by Pecora Corp.
   c. Product: THC-900 manufactured by Tremco.
   d. Substitutions: See Section 01 60 00 - Product Requirements.
4. Applications: Use for:
   a. Exterior horizontal joints in concrete flatwork and extruded curbs.

D. Type SJ-3- Silicone Sealant: ASTM C 920, TypeS, Grade NS, Class 100/50, Uses NT, A, G; single component, solvent curing, non-sagging, non-staining, non-bleeding.

1. Color: Match adjacent finished surfaces.
2. Acceptable Manufacturers:
   a. Product: 790 manufactured by Dow Corning Corp. b.
   Product: SikaSii-C 990 manufactured by Sika Corp. c.
   Product: Spectrum 1 manufactured by Tremco.
   d. Substitutions: See Section 01 60 00 - Product Requirements.
3. Movement Capability: Plus 100 percent, minus 50 percent.
4. Service Temperature Range: -65 to 180 degrees F.
5. Shore A Hardness Range: 15 to 35.
6. Applications: Use for:
   a. Glazing at aluminum frames.

E. Type SJ-4 - Exterior Metal Lap Joint Sealant: One-part non-sag silyl terminated polyether sealant: ASTM C-920, TypeS. Grade NS, Class 25, Use NT, T, M, G, A, O.

1. Acceptable Manufacturer
   a. Product: DynaTrol I-XL manufactured by Pecora Corp.. b.
   Product: Sikaflex 721 UV manufactured by Sika.
   c. Product: Sonolastic 150 with VLM Technology manufactured by Sonneborn BASF. d.
   Substitutions: See Section 01 60 00- Product Requirements.
2. Applications: Use for:
   a. Concealed sealant bead in sheet metal work.

F. Type SJ-5- General Purpose Interior Sealant: Acrylic emulsion latex; ASTM C834, Type OP, Grade NF single component, paintable.

1. Color: To be selected by Architect from manufacturer's standard range.

2. Acceptable manufacturers;

a. Product: Tremcoflex 834 manufactured by Tremco.

b. Product: AC-20+SIIicone manufactured by Pecora Corp. c.

Product: Sonolac manufactured by Sonneborn BASF.

d. Substitutions: See Section 01 60 00- Product Requirements.

3. Applications: Use for:

a. Interior wall and ceiling control joints.

b. Joints between door and window frames and wall surfaces.

c. Other interior joints for which no other type of sealant is indicated.

G. Type SJ-6- Bathtub/Tile Sealant: White silicone; ASTM C920, Uses I, MandA; single component, mildew resistant.

1. Acceptable Manufacturers:

a. Product: Tremsil 200 with fungicide manufactured by Tremco. b.

Product: Pecora 989 manufactured by Pecora Corp.

c. Product: #786 manufactured by Dow Corning Corp.

d. Substitutions: See Section 01 60 00- Product Requirements.

2. Applications: Use for:

a. Joints between plumbing fixtures and floor and wall surfaces.

b. Joints between countertops with fawcets and wall surfaces and backsplash.

H. Type SJ-7- Acoustical Sealant: Non-skinning, sound dampering; single component, solvent release curing, non-skinning.

1. Acceptable Manufacturers:

a. Product: Acoustical Sealant manufactured by Tremco.

b. Product: Sheetrock Acoustical Sealant manufactured by United States Gypsum Co. c.

Product: AcoustiSeal (Professional Series) Acoustical Sealant manufactured by Acoustical Surfaces, Inc, Chaska, MN.

d. Substitutions: See Section 01 60 00- Product Requirements.

2. Applications: Use for concealed locations only:

a. Sealant bead between top stud runner and structure and between bottom stud track and floor.

2.02 ACCESSORIES

A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Joint Backing: Round foam rod compatible with sealant; ASTM D 1667, closed cell PVC; oversized 30 to 50 percent larger than joint width; Backer Rod manufactured by Backer Rod

Manufacturing, Inc., Denver, CO.

D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that substrate surfaces are ready to receive work.

B. Verify that joint backing and release tapes are compatible with sealant.

3.02 PREPARATION

A. Remove loose materials and foreign matter that could impair adhesion of sealant. Clean

B. and prime joints in accordance with manufacturer's instructions.

C. Perform preparation in accordance with manufacturer's instructions and ASTM C1193. Protect

D. elements surrounding the work of this section from damage or disfigurement.

3.03 INSTALLATION

A. Perform work in accordance with sealant manufacturer's requirements for preparation of surfaces and material installation instructions.

B. Perform installation in accordance with ASTM C1193.

C. Perform acoustical sealant application work in accordance with ASTM C919. Install

D. bond breaker where joint backing is not used.

E. Install sealant free of air pockets, foreign embedded matter, ridges, and sags.

F. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

G. Tool joints concave.

H. Precompressed Foam Sealant: Do not stretch; avoid joints except at corners, ends, and intersections; install with face 1/8 to 1/4 inch below adjoining surface.

I. Compression Gaskets: Avoid joints except at ends, corners, and intersections; seal all joints with adhesive; install with face 1/8 to 1/4 inch below adjoining surface.

3.04 CLEANING

A. Clean adjacent soiled surfaces.

3.05 PROTECTION

A. Protect sealants until cured.

3.06 SCHEDULE

A. Control and Expansion Joints in Paving: Type SJ-2.

B. Joints between concrete caps and between caps and adjacent ork: Type SJ-1.

C. Control, Expansion, and Soft Joints in Masonry, and Between Masonry and Adjacent Work: Type SJ-1.

D. Lap Joints in Exterior Sheet Metal Work: Type SJ-4.

E. Joints Between Exterior Metal Frames and Adjacent Work (except masonry): Type SJ-1. F.

Under Exterior Door Thresholds: Type SJ-4.

G. Interior Joints for Which No Other Sealant is Indicated: Type SJ-5; None; N/A. H.

Control and Expansion Joints in Interior Concrete Slabs and Floors: Type SJ-2.

I. Joints Between Plumbing Fixtures and Walls and Floors, and Between Countertops and Walls: Type SJ-6.

J. In Sound Rated Walls, Between Metal Stud Track/Runner and Adjacent Construction: Type SJ-:7.

END OF SECTION

SECTION 09 51 00

ACOUSTICAL CEILINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Suspended metal grid ceiling system. B.

Acoustical units.

C. Supplementary acoustical insulation above ceiling.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Sequence work to ensure acoustical ceilings are not installed until building is enclosed, sufficient heat is provided, dust generating activities have terminated, and overhead work is completed, tested, and approved.

B. Do not install acoustical units until after interior wet work is dry.

1.03 SUBMITTALS

A. See Section 01 33 13 - Submittal Procedures.

B. Shop Drawings: Indicate grid layout and related dimensioning. Product

c. Data: Provide data on suspension system components.

D. Samples: Submit two full size samples illustrating material and finish of acoustical units.

E. Samples: Submit two samples each, 12 inches long, of suspension system main runner.

F. Manufacturer's Installation Instructions: Indicate special procedures.

G. Maintenance Materials: Furnish the following for Glendale Unified School District's use in maintenance of project.

1. See Section 01 60 OO- Product Requirements, for additional provisions.

2. Extra Acoustical Units: Quantity equal to 5 percent of total installed.

1.04 QUALITY ASSURANCE

A. Suspension System Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

B. Acoustical Unit Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

c. Comply with Specifications of the California Department of Public Health (CDPH) Standard Practice.

1.05 FIELD CONDITIONS

A. Maintain uniform temperature of minimum 60 degrees F, and maximum humidity of 40 percent prior to, during, and after-acoustical unit installation.

PART 2 PRODUCTS

2.01 ACOUSTICAL UNITS

A. Acoustical Units- General: ASTM E1264, Class A.

B. Acoustical Panels Type AC-1: Painted mineral fiber, ASTM E 1264 Type Ill, Form 2, Pattern C E with the following characteristics:

1. VOC Content: As specified in Section 01 6116.
2. Size: 24 x 48 inches.
3. Thickness: 3/4 inches.
4. Composition: Wet felted.
5. Light Reflectance: 0.90 percent, determined as specified in ASTM E 1264.
6. NRC Rating: 0.70, determined as specified in ASTM E 1264.
7. Ceiling Attenuation Class (CAC): 35-39, determined as specified in ASTM E 1264.
8. Edge: square.
9. Surface Color: White.
10. Surface Pattern: medium textured.
11. Product: Ultima, Item 12913HRC, by Armstrong World Industries, www.armstrong.com.
12. Suspension System: Exposed grid Type 1.

2.02 SUSPENSION SYSTEM(S)

A. Manufacturers:

1. Same as for acoustical units.
2. Substitutions: See Section 01 60 00 - Product Requirements. B.

System Description:

1. Seismic Loads: Design and size components to withstand seismic loads in accordance with ASCE 7-05, Chapter 13 as specified by the International Building Code, Chapter 16. Specific seismic requirements for suspended ceiling are located in ASCE section 13.5.6
2. Comply with ASTM C635; die cut and interlocking components, with stabilizer bars, clips, splices, perimeter moldings, and hold down clips as required.

C. Exposed Steel Suspension System Type 1: Formed steel, commercial quality cold rolled; heavy-duty.

1. Profile: Tee; 15/16 inch wide face.
2. Construction: Double web.
3. Finish: White.
4. Product: Prelude XL HRC by Armstrong World Industries, Inc., www.armstrong.com.

2.03 ACCESSORIES

A. Support Channels and Hangers: Galvanized steel; size and type to suit application, seismic requirements, and ceiling system flatness requirement specified.

B. Attachment Devices: In accordance with the ASCE 7-05, Chapter 13 as specified by the International Building Code, Chapter 16. Specific seismic requirements for suspended ceiling are located in ASCE section 13.5.6, for Category D, E, and F.

C. Wire for Hangers and Ties: In accordance with the ASCE 7-05, Chapter 13 as specified by the International Building Code, Chapter 16. Specific seismic requirements for suspended ceiling are located in ASCE section 13.5.6.

D. Perimeter Moldings at walls: Same material and finish as grid.

1. At Exposed Grid: Nominal 15/16 inch x 15/16 inch hemmed, pre-finished angle molding (7809).

E. Ceiling Trim at exposed edges: 150 mm high Axiom Classic Ceiling Trim by Armstrong World Industries or approved equal.

1. Color: Match adjacent ceiling tile.

F. Provide BERC2- 2 inch Beam End Retaining Clip, 0.034 inch thick, hot-dipped galvanized cold-rolled steel per ASTM A568 - used to join main beam or cross tee to wall molding.

G. Provide SJCG- Seismic Joint Clip, 5 inches x 1-1/2 inch, hot-dipped galvanized cold-rolled steel per ASTM A568. The two piece unit is designed to accommodate a seismic separation joint. The clip is compatible with 15/16 inch and 9/16 inch grid systems including Prelude, Suprafine, and Silhouette The SJCG is not suitable for use with Vector panel installations.

H. Provide SJMR15- Seismic Joint Clip- Main Beam, 1 inch x 4 inches, commercial quality cold rolled hot dipped galvanized steel per ASM A568, chemical cleansed.

I. Touch-up Paint: Type and color to match acoustical and grid units. PART

3 EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Do not proceed with installation until all wet work such as concrete, terrazzo, plastering and painting has been completed and thoroughly dried out, unless expressly permitted by manufacturer's printed recommendations.

C. Verify that layout of hangers will not interfere with other work.

3.02 PREPARATION

A. Coordination: Furnish layouts for preset inserts, clips, and other ceiling anchors whose installation is specified in other sections.

1. Furnish concrete inserts and similar devices to other trades for installation well in advance of time needed for coordination of other work.

3.03 INSTALLATION - SUSPENSION SYSTEM

A. Install suspension system and panels in accordance with the ASCE 7-05, Chapter 13 as specified by the International Building Code, Chapter 16. Specific seismic requirements for suspended ceiling are located in ASCE section 13.5.6., except as noted in Section 4.4.3.1 of ESR-1308, and with the authorities having jurisdiction.

B. ESR-1308, Section 4.4.3.1, Alternate Seismic Design Category D,E and F Installation:

1. Under this installation, the runners must be rated heavy-duty and have a minimum simple span uniform load of 16.35 pounds per lineal foot (238 N/m); maximum ceiling weight permitted is 4.0 pounds per square foot (19.5 kg/m2).

2. The BERC-2 clip is used to secure the main runners and cross runners on two adjacent

walls to the structure and the two opposite walls to the perimeter trim, as detailed below. A nominal 7/8-inch (22 mm) wall molding is used in lieu of the 2- inch (51 mm) perimeter supporting closure angle required by Section 9.6.2.6.2.2 (b) of ASCE-7 for Seismic Design Categories D, E and F. Except for the use of the BERC-2 clip and the 7/8-inch (22 mm) wall molding and elimination of spreader bars, installation of the ceiling system must be as prescribed by the applicable code.

3. The BERC-2 clip is attached to the wall molding by sliding the locking lances over the hem of the vertical leg of the wall molding. Clips installed on the walls where the runners are fixed are attached to the runner by a sheet metal screw through the horizontal slot in the clip into the web of the runner.

   a. Alternate #2: If acceptable to architect, fixed attachment may be accomplished by pop-riveting the runner to the wall molding.

4. Clips installed on the walls where the runners are not fixed to the runner allow the terminal runner end to move 3/4 inch (19.1 mm) in both directions. BERC-2 clips installed in this manner are an acceptable means of preventing runners from spreading in lieu of spacer bars required in CISCA 3-4, which is referenced in ASCE 7, Section 9.6.2.6.2.2, which is referenced in ASCE 7-05, Chapter 13 as specified by the International Building Code; Chapter 16. Specific seismic requirements for suspended ceiling are located in ASCE section 13.5.6.

C. The SJCG Seismic Separation Joint Clip is to be installed per the manufacturer's instructions, CS-3815.

D. The SJMR15 Seismic Joint Clip Main Beam is to be installed per the manufacturer's instructions, CS-3955.

E. Install after major above-ceiling work is complete. Coordinate the location of hangers with other work.

F. Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.

G. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.

H. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability.

I. Support fixture loads using supplementary hangers located within 6 inches of each corner, or support components independently.

J. Do not eccentrically load system or induce rotation of runners.

3.04 INSTALLATION- ACOUSTICAL UNITS

A. Install acoustical units in accordance with manufacturer's instructions.

B. Fit acoustical units in place, free from damaged edges or other defects detrimental to appearance and function.

C. Fit border trim neatly against abutting surfaces. Install units after above-ceiling work is complete.

D. Install acoustical units level, in uniform plane, and free from twist, warp, and dents. Cutting

E. Acoustical Units:

F.

1. Cut to fit irregular grid and perimeter edge trim.
2. Make field cut edges of same profile as factory edges.
3. Double cut and field paint exposed reveal edges.

G. Where round obstructions occur, provide preformed closures to match perimeter molding.

3.05 TOLERANCES

A. Maximum Variation from Flat and Level Surface: 1/8 inch in 10 feet.

B. Maximum Variation from Plumb of Grid Members Caused by Eccentric Loads: 2 degrees.

3.06 ADJUSTING AND CLEANING

A. Replace damaged and broken panels.

B. Clean exposed surfaces of acoustical ceilings, including trim, edge moldings, and suspension members. Comply with manufacturer's instructions for cleaning and touch up of minor finish damage. Remove and replace work that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 22.

B. This Division is an integrated whole comprising interrelated and interdependent Section and shall be considered in its entirety in determining requirements of the Work.

C. Refer to other sections of this Division for additional requirements or information regarding the subjects of this Section.

1.02 SECTION INCLUDES

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:
   1. Submittals.
   2. Coordination drawings.
   3. Record documents.
   4. Maintenance manuals.
   5. Rough-ins.
   6. Plumbing installations.
   7. Cutting and patching.

1.03 DESCRIPTION

A. Provide a complete and operable installation, including all labor, supervision, materials, equipment, tools, apparatus, transportation, warehousing, rigging, scaffolding and other equipment and services necessary to accomplish the work in accordance with the intent and meaning of these drawings and specifications

1.04 DEFINITIONS

A. "Provide" means furnish, install and connect unless otherwise described in specific instances.

B. "Piping" means pipes, fittings, valves and all like pipe accessories connected thereto.

C. "Ductwork" means ducts, plenums, compartments, or casings including the building structure, which are used to convey or contain air.

D. "Extend", "Submit", "Repair" and similar words mean that the Contractor (or his designated subcontractor) shall accomplish the action described.

E. "Codes" or "Code" means all codes, laws, statutes, rules, regulations, ordinances, orders, decrees, and other requirements of all legally constituted authorities and public utility franchise holders having jurisdiction.

F. "Products", "Materials" and "Equipment" are used interchangeably and mean materials, fixtures, equipment, accessories, etc.

G. "Utility Areas" are defined as mechanical, electrical, janitorial, and similar rooms or spaces which are normally used or occupied only by custodial or maintenance personnel. "Public Areas" are defined as the rooms or spaces, which are not included in the utility areas definition.

H. "Building Boundary" includes concrete walkways immediately adjacent to the building structure.

I. "Below Grade" means buried in the ground.

J. "Substantial Mechanical Completion" means all components of all systems are functioning but lacking in final adjustment.

K. Pressure rating specified (such as for valves and the like) means design working pressure for and with references to the fluid, which the device will serve.

1.05 RELATED WORK

A. Coordination: Refer to Architectural, Civil, Structural, and Electrical Drawings for the construction details and coordinate the work of this Division with that of other Divisions. Order the work of this Division so that progress will harmonize with that of other Divisions and all work will proceed expeditiously. The work of this Division shall include direct responsibility for the correct placing and connection of mechanical work in relation to the work of other Divisions.

B. Examine other Divisions for work related to the Work of this Division, especially Electrical.

1.06 EXISTING CONDITIONS

A. Visit the site prior to bidding and investigate the existing conditions, which affect or will be affected by the work of this Division. Become thoroughly familiar with the working conditions and take into account any special or unusual features peculiar to this job. By the act of submitting a Bid, the Contractor will be deemed to have complied with the foregoing, to have accepted such conditions, and to have made allowance therefore in preparing his Bid.

B. The locations of existing concealed utility lines are shown in accordance with reference data received by the Architect. The Architect does not guarantee the accuracy of such data. The points of connection are therefore approximate and the Bidder shall include adequate funds in his Bid to cover costs of connection regardless of their exact location.

C. Exercise extreme caution during trenching operations. Repair the damage caused by such operations to existing utility lines at no cost to the Owner, whether the lines are shown on drawings or not.

1.07 DRAWINGS AND SPECIFICATIONS

A. These drawings and specifications do not include necessary components for construction safety.

B. All provisions shall be deemed mandatory except as expressly indicated as optional by the word "may" or "option".

C. Except where dimensioned, the drawings relating to this division are a diagrammatic presentation of the design concept, which indicates the general area where piping and ductwork is to be run. The drawings do not necessarily indicate any and all offsets and configurations required for coordination with other trades. The contractor is responsible for the correct placing of his work, and the proper location and connection of his work in relation to the work of other trades.

1.08 PERMITS AND INSPECTIONS

A. Obtain, schedule and pay for permits, licenses, approvals, tests, and inspections required by legally constituted authorities and public utility franchise holders having jurisdiction over the work.

B. Afford the Architect's representative every facility for evaluating the skill and competence of the mechanics and to examine the materials. Concealed work shall be reopened when so directed during his periodic visits.

1.09 CODES AND REGULATIONS

A. By submitting a Bid, Contractor is deemed to represent himself as competent to accomplish the work of this Division in conformance with applicable Codes. In case of conflict between the Contract Documents and Code requirements, the Codes shall take precedence. Should such

conflicts appear, cease work on the parts of the contract affected and immediately notify the Architect in writing. It shall be the Contractor's responsibility to correct, at no cost to the Owner, any work he executes in violation of Code requirements. Specific references to codes elsewhere in this Division are either to aid the Contractor in locating applicable information or to deny him permission to use options, which are permitted by Codes.

B. Applicable Codes: (Current editions unless otherwise noted)
   1. All local codes; city and/or county as applicable.
   2. OSHA requirements
   3. California Code of Regulations (CCR) Titles (as applicable)
   4. Fire Marshal Regulations
   5. State, County, City Health Department Ordinances and Regulations
   6. Regulations of all other authorities having jurisdiction.
   7. California Mechanical Code.
   8. California Plumbing Code.

C. Where conflict or variation exists amongst Codes, the most stringent shall govern.

1.10 SUBMITTALS

A. General: Follow the procedures specified in Division 01.

B. Mechanical Submittals: Increase the number of mechanical related shop drawings, product data, and samples submitted to allow for required distribution by one additional copy, which will be retained by the Mechanical Consulting Engineer.

C. Product Data: Assemble "product data" into tabbed brochures according to main areas of work i.e. Fire Protection; Plumbing; H.V.A.C.; Temperature Control; Testing, Adjusting, and Balancing.
   1. Assemble each brochure with tabbed separators for each Specification Section where products are noted to be submitted, with separate tabs for each product listed.
   2. Temperature "control shop drawings" may be submitted separately after preparations for review.
   3. For items such as valves, hangers and accessories, indicate specific items and where they are to be used.
   4. Contractor need only to submit for review those items specified to be submitted, unless requested by the Architect for special review.

D. Submit for review, only the specific items required in this Section or other Sections of Division 22.

E. Additional submittals shall include, but not limited:
   1. Air balance reports and equipment data record drawings.
   2. Certification of completion of testing.
   3. Certification of completion of operation instructions.
   4. Operating instruction brochure.
   5. Maintenance instruction brochures.
   6. Equipment guarantees.
   7. 1/4" = 1'-0" or larger scale layouts of "Equivalent" equipment or "Or Approved Equal" equipment.
   8. Coordination Drawings, where requested or required.

F. Submittal materials will be reviewed for substantial conformity with the intent of the contract plans and specifications only. Such review does not indicate approval of dimensions, quantities, coordination with other trades, or work methods of the contractor, which are indicated thereon.

G. Additional copies may be required by individual sections of these specifications.

1.11 COORDINATION

A. The Contractor shall be responsible for coordinating the layout of all building elements to avoid conflict of the work of the structural, mechanical, electrical systems, and architectural features of the building.

B. The cost of any extra work of any kind caused by a conflict due to this lack of coordination shall be borne by the Contractor.

C. Contractor shall designate an individual competent and versed in the mechanical trades to coordinate the mechanical work with the work of other trades.

1.12 COORDINATION OF DRAWINGS

A. Prepare coordination drawings in accordance with Division 01 to a scale of 1/4" = 1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of the installations are of importance to the efficient flow of the Work, including but not necessarily limited to the following:
   1. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:
      a. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
      b. Equipment for connections and support details.
   2. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

B. Submittal of "Or Approved Equal" substitutions of equipment will not be reviewed unless accompanied by coordination drawings.

1.13 RECORD AND DOCUMENTATION

A. Prepare record documents in accordance with the requirements in Division 01. In addition to the requirements specified in Division 01, indicate the following installed conditions:
   1. Record as specified in Division 01 the locations and invert elevations of underground installations.
   2. Accumulate the following and deliver to the Owner's representative prior to final acceptance of the work.
   3. Record (As-Built) Drawings:
      a. Maintain in good order in the field office a complete set of prints for all work being done under Division 23. Update the drawings daily with neat and legible annotations in red ink showing the work as actually installed.
      b. The actual size, location and elevation of all buried lines, valve boxes, manholes, monuments, and stub-outs shall be accurately located and dimensioned from building walls or other permanent landmarks.
      c. Furnish the originals.
   4. Operation and Maintenance Manual: Furnish an operation and maintenance manual covering the stipulated mechanical systems and equipment. Three copies of the manual, bond in hardback binders or an approved equivalent shall be provided to the Architect.
   5. Furnish one complete manual prior to the time that system or equipment tests are performed.
   6. Furnish the remaining manuals before the contract is completed.
   7. The following identification shall be inscribed on the cover:
      OPERATION AND MAINTENANCE MANUAL
      PROJECT TITLE . . . . . .
      CONTRACTOR
   8. Provide a table of contents. Insert tab sheets to identify discrete subjects. Instruction sheets shall be legible and easily understood, with large sheets of drawings folded in. The manual

shall be complete in all respects for all materials, piping, valves, devices and equipment, controls, accessories and appurtenances stipulated. Include as a minimum the following:

a. Updated approved materials lists, shop drawings and catalog information of all items of mechanical system equipment.
b. System layout showing piping, valves and controls.
c. Wiring and control diagrams with data to explain detailed operation and control of each component.
d. A control sequence describing start-up, operation and shutdown.
e. Detailed description of the function of each principal component of the system.
f. Procedure for starting.
g. Procedure for operating.
h. Shut-down instructions.
i. Installation instructions.
j. Adjustments, maintenance and overhaul instructions.
k. Lubrication schedule including type, grade, temperature range and frequency.
l. Safety precautions, diagrams and illustrations.
m. Test procedures.
n. Performance data.
o. Parts list, with manufacturer's names and catalog numbers.
p. Preventive maintenance schedule.
q. Service organization with name, address and telephone number.
r. Valve identification chart and schedule.
s. ASME certificates.
t. Air balance report.
u. Hydronic balance report.

B. Standards Compliance: Where equipment or materials are specified to conform with requirements of standards of recognized technical or industrial organizations such as American National Standards Institute (ANSI) American Society for Mechanical Engineers (ASME) American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), American Society for Testing and Materials (ASTM), Underwriters Laboratories (UL), American Gas Association (AGA), American Refrigeration Institute (ARI), or National Electrical Manufacturer's Association (NEMA), that use a label or published listing as a method of indicating compliance, proof of such conformance shall be submitted and approved. The label or listing of the specified organization will be acceptable evidence.

C. Certificates of Conformance or Compliance: Submit original and not pre-printed certifications. Do not make statements in the certifications that could be interpreted to imply that the product does not meet all requirements.

D. Certified Test Reports: Certified Test Reports are reports of tests conducted on previously manufactured materials or equipment identical to that proposed for use. Before delivery of materials and equipment, submit certified copies of test reports specified in the individual sections.

E. Factory Tests: Factory tests are tests, which are required to be performed on the actual materials or equipment, proposed for use. Submit results of the tests in accordance with the requirements for laboratory test results of this Contract.

F. Permits and Certificates of Inspection: Furnish the originals.

G. Testing procedures and test results required in this and other sections. Furnish 2 copies.

H. Other data required by other sections of this Division. Furnish 2 copies.

1.14 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01.

1.15 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.16 EQUIVALENT EQUIPMENT

A. These specifications and/or drawings names and specifies certain equipment in detail. It also names equivalent equipment by manufacturer, which is not considered to be a "substitution".

B. Submit equivalent equipment to the Architect for review per the requirements of Division 01, and Section "Basic Mechanical Requirements."

C. Equipment of Manufacturers named in Division 22 will be considered equivalent to that specified in detail and/or named on the drawings if:
   1. The proposed equipment is of equivalent quality, capacity.
   2. Equipment is as fully equipped, fits the space allotted, and has physical configuration and weight similar to the equipment specified in detail.

D. A complete lay out of an equipment room or area must be submitted for equivalent equipment. Notice space limitations. Layouts to include plans and section views at a scale of not less than 1/4" = 1 ft.

E. The Architect shall determine the acceptability of "Equivalent Equipment."

1.17 CONSTRUCTION COST BREAK DOWN

A. Prepare and submit for review a construction cost breakdown for the major subdivisions of the mechanical work in accordance with General and Supplemental Conditions and Division 1.

B. Subdivide each item on the breakdown into two headings: labor and materials. Include overhead and profit in each entry.

C. Submit one copy of the breakdown directly to the Engineer and the remaining copies sent through regular channels.

1.18 TOOLS

A. Provide all special tools needed for proper operation and routine adjustment and maintenance of systems and equipment. Deliver tools to Owner's representative and request a receipt for same.

1.19 WARRANTIES

A. Refer to Division 1 Section for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Where periods more than one year are specified in the specifications, such longer periods shall govern. However, when any component fails at any time during this period, the warranty period for such component and all other components, which are inactive because of, said failure shall be suspended. The warranty period for such components shall resume running for the remaining portion of the warranty period when failed component is completely repaired and in operation; however, in no case shall the resumed portion of the warranty period be less than 3 months in duration.

C. Neither payment for work, nor total or partial occupancy of work by the Owner, within or prior to the warranty period specified, shall be construed as acceptance of faulty work or shall condone any negligence or omission of Contractor in doing the work.

D. Compile and assemble the warranties specified in Division 23, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

E. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names and addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.20 SEISMIC RESTRAINT

A. Provide seismic restraint for mechanical equipment, piping, and ductwork.

B. Contractor shall submit certification of suitability of seismic restraint methods signed by Structural Engineer registered in State of California.

C. Contractor may refer to details applicable in the SMACNA, "GUIDELINES FOR SEISMIC RESTRAINT OF MECHANICAL SYSTEMS", using the 'g' forces for "other buildings" classification CCR Title 24. Deliver a copy of these Guidelines to the Owner's Resident Inspector.

1.21 SYSTEM OPERATIONAL TEST

A. The Contractor shall inform the Owner one week prior to starting this testing in order that the Owner's representative may be present.

B. After balancing and prior to final inspection, the contractor shall operate all systems continuously trouble free and stable for a minimum period of fourteen (14) consecutive days including Saturday and Sunday. Each day shall be a minimum of an 8-hour day. Should a problem arise, the fourteen (14) day period shall be restarted and repeated until successfully operated for full 14 days. A written report certified by the Owner's representative shall indicate the successful completion of a stable and trouble free 14-day period.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Standard Products: Materials and equipment shall be essentially the standard cataloged products of manufacturers regularly engaged in production of such materials or equipment and shall be their latest standard designs that comply with the specification requirements.

B. Materials and equipment shall duplicate items that have been in satisfactory commercial or industrial use at least two years prior to bid opening, unless more stringent requirements are specified. Where two or more units of the same type of equipment are required, these units shall be products of a single manufacturer. The components thereof, however, are not required to be exclusively of the same manufacturer.

C. Each major component of equipment shall have manufacturer's name, address, model, and serial number on a nameplate securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.

D. Whenever on the plans, or in these specifications, products are identified by the name of one manufacturer, it is intended that equivalent products of other manufacturers are acceptable, unless otherwise indicated, if accepted as a substitution by the Architect.

E. Where three or more manufacturers are listed as "acceptable manufacturers" however, then the products furnished shall be the product of one of the manufacturers listed. Manufacturers listed as "acceptable manufacturers" shall be considered "Equivalents" and shall meet quality and performance of a particular one specified by both name and catalog number.

2.02 PRODUCT LISTING

A. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and

grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in Work, except as otherwise indicated.

2.03 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, model name, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

2.04 SUBSTITUTIONS

A. General: Submittals of "Substitutions" shall be in accordance with requirements of Division 1.

B. By proposing a substitution, it is deemed that the Contractor shall bear the cost of any changes (whether architectural, structural, electrical or mechanical) necessary to accommodate the substitution, if said substitution is accepted.

C. Specific: Refer to other sections of this Division for additional requirements.

2.05 SUBMITTALS

A. General: Make submittals in accordance with requirements of Division 1.

B. Specific: Refer to other sections of this Division for additional requirements.

PART 3 EXECUTION

3.01 WORKMANSHOP AND INSTALLATION METHODS

A. Workmanship shall be in the best standard practice of the trade.

B. Install equipment in accordance with the manufacturer's instructions and recommendations unless otherwise noted or specified.

3.02 TEST

A. General:
1. Demonstrate that all components of the work of this Division have been provided and that they operate in accordance with the Contract Documents.
2. Provide instruments and personnel for tests and demonstrations. Submit signed test results.

B. Specific: Refer to the other sections of this Division for test requirements.

3.03 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 02 through 23 for rough-in requirements.

3.04 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
1. Coordinate mechanical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of mechanical system with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. All mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components in full compliance with the equipment manufacturer's recommendations. If the drawings or the manufacturer does not provide a specific space requirement for servicing equipment, provide as a minimum, horizontal distance of 36" from face of equipment to opposite vertical surface.
11. Install access panels or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Any equipment located above a ceiling that has any component, which is serviceable shall be installed within 12" of the top of the ceiling.

3.05 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 01. In addition to the requirements specified in Division 01, the following requirements apply:
   1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
   1. Uncover Work to provide for installation of ill-timed Work.
   2. Remove and replace defective work.
   3. Remove and replace Work not conforming to requirements of the Contract Documents.
   4. Remove samples of installed Work as specified for testing.
   5. Install equipment and materials in existing structures.
   6. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

F. Patch existing finished surfaces and building components using experienced installers and new materials matching existing materials. For installer's qualifications refer to the materials and methods required for the surface and building components being patched.

3.06 DELIVERY, HANDLING, STORAGE OF MATERIALS AND PROTECTION OF WORK

A. Protect materials against dirt, water, chemical and mechanical damage both while in storage and during construction.

B. Cover materials in such a manner that no finished surfaces will be damaged, marred or splattered with plaster or paint, and all moving parts will be kept clean and dry.

C. Replace or refinish any damaged materials including fronts of control panels, ductwork fittings, and shop-fabricated ductwork.

D. Keep cabinets and other openings closed to prevent entry of foreign matter.

E. Specific: Refer to other sections of this Division for additional requirements.

3.07 PROJECT CONDITIONS

A. Check and coordinate for clearance, accessibility and placement of equipment either by going through openings provided or by placing equipment during construction. Ordering of equipment to be shipped disassembled, or disassembly of equipment at Project Site and reassembly of equipment to accomplish this requirement shall be executed without additional cost. Where provided openings are inadequate to accommodate equipment, provide new openings and restoration of same, all at no additional cost. Obtain written approval for new openings before proceeding.

B. Verify location of all plumbing fixtures and equipment within finished spaces with the Architectural Drawings. In the event that Mechanical Drawings do not indicate exact locations, or are in conflict with the Architectural Drawings, obtain information regarding proper locations. Installation of work without proper instruction under such circumstances will result in relocation of work, when directed, without additional cost.

3.08 INSTRUCTION TO OWNER PERSONNEL

A. When specified in other sections, the Contractor shall furnish, without additional expense to the Owner, the services of competent instructors who will give full instruction to the designated personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the equipment or system specified. Each instructor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance of work. Instruction shall be given at the Owner's convenience. The number of man-days (eight-hours) of instruction furnished shall be as specified in other sections. When more than four man-days of instruction are specified, approximately half of the time shall be used for classroom instruction. All other time shall be used for instruction with the equipment or system. When significant changes or modifications are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications.

B. Contractor shall electronically record, both visual and audio, instruction to Owner's personnel on the maintenance and operation of the mechanical systems.

C. Submit certification, signed by Owner's agent that instructions have been completed and a DVD of the instruction has been reviewed and delivered to the Owner.

D. Printed operating instructions and a copy of wiring diagrams are to be mounted in all equipment areas, framed and behind glass or encased in plastic. Printed operating instructions shall include steps for starting up and securing equipment. As a precedent to final acceptance three (3) copies of instructions are to be submitted to the Architect for review. Contractor shall turn over to Owner in a neat brochure form, equipment guarantee and maintenance instructions.

3.09 CLEANING

A. Cleaning shall be done as the work proceeds. Periodically remove waste and debris to keep the site as clean as is practical.

B. Refer the Division 1 Section: for general requirements for final cleaning.

C. Leave exposed parts of the mechanical work in a neat, clean and usable condition, with painted surfaces unblemished and plated metal surfaces polished.

D. Thoroughly clean all materials, equipment and appliances. Clean and prepare all surfaces to be painted. Clean the entire premises of unused materials, debris, spots and marks to the satisfaction of the Architect.

E. Remove, thoroughly clean and replace all strainers and automatic valves after the system has been put in operation until system is clear of all foreign matter and repeat this operation after ten (10) days and again after the system has been in operation thirty (30) days. Submit certification that this operation has been completed.

3.10 SAFETY REQUIREMENTS

A. Enclose and guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts in accordance with OSHA requirements. Insulate, guard, and cover any high-temperature equipment and piping so located as to endanger personnel or create a fire hazard.

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This Section specifies the basic requirements for electrical components, which are an integral part of packaged mechanical equipment. These components include, but are not limited to factory-installed motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on Drawings.

C. All motors, power driven equipment and automatic control equipment, except motor starters as hereinafter set forth required and connected With the work of this section of the specifications are to be furnished and installed under Division 23.

D. Control low (24V) and control line (120V) voltage wiring, conduit and related switches and relays required for the automatic control and/or interlock of motors and equipment includes final connection, are to be furnished and installed under Division 23. Materials and installation to conform to Class 1 or 2, CAC Title 24, Article E725, and as restricted under Division 26 of these specifications.

E. Power wiring, conduit, outlets, disconnect switches, motor starters and motor-rated contactors, and making of final connections, except as hereinafter specified, are to be furnished and installed under the Division 26 of these Specification.

F. All power supply wiring for providing a control power source to control dampers, control valves, VAV boxes control, control transformers, etc., shall be furnished and installed under Division 26.

G. Identify circuits and equipment as outlined in the Electrical Sections of these Specifications.

H. Coordinate requirements for underground conduit only between buildings for control interlocks shown on the drawings. This conduit to be furnished and installed under Division 26 of these Specifications.

I. Space provisions have been made on electrical panels for control power source.

1.02 RELATED SECTIONS

A. Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

B. This section applies to all Division 23 sections specifying packaged mechanical equipment.

1.03 REFERENCES

A. NEMA Standards MG 1: Motors and Generators

B. NEMA Standards ICS 2: Industrial Control Devices, Controllers, and Assemblies

C. NEMA Standard 250: Enclosures for Electrical Equipment

D. NEMA Standard KS 1: Enclosed Switches

E. Comply with California Electrical Code.

1.04 SUBMITTALS

A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections.

1.05 QUALITY ASSURANCE

A. Electrical components and materials shall be UL labeled.

PART 2 PRODUCTS

2.01 MOTOR

A. Provide all motors necessary for equipment under the Mechanical Work. See Electrical Drawings for voltage and phase of electrical services.

B. The following are basis requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.
   1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
   2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
   3. 2-speed motors shall have 2 separate windings on poly-phase motors.
   4. Temperature Rating: As a minimum motors shall be rated for 40 degree C environment with maximum 50 degree C temperature rise for continuous duty at full load (Class A Insulation).
   5. Starting capability: Frequency of starts as indicated by automatic control system and not less than 5 evenly time spaced starts per hour for manually controlled motors.
   6. Service Factor: 1.15 for poly-phase motors and 1.35 for single-phase motors.
   7. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Deign "B", except "C" where required for high starting torque.
      a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit specific application.
      b. Bearings:
         1) Ball or roller bearings with inner and outer shaft seals.
         2) Re-greasable bearings, except permanently sealed where motor is normally inaccessible for regular maintenance.
         3) Bearings designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
         4) Bearings for fractional horsepower, light duty motors, sleeve type bearings are permitted.
      c. Enclosure Type:
         1) open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
         2) guarded drip-proof motors where exposed to contact by employees or building occupants.
         3) weather protected Type I for outdoor use, Type II where not housed (Epoxy encapsulated or TEFC).
      d. Overload protection: Polyphase built-in thermal overload protection and, where indicated, internal sensing device suitable for signaling and stopping motor at starter. Single phase, provide thermal overload protection.
      e. Noise rating: "Quiet".
      f. Efficiencies shall be guaranteed minimum values in accordance with the following tabulation. Efficiencies shall be established in accordance with NEMA Test Standards MG1-12.53A using IEEE Test Procedure 112, Method B:

HP	EFFICIENCY
1 - 2	81.5
3-5	86.5
7-1/2- 10	90.6
15	92.0

g. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
h. Provide all motors with junction boxes or terminals boxes and provide adjustable slide rails for all motors with belt drives.
i. Motors rated 1 HP and larger shall have shaft, bearings and etc. capable of operating with multiple grooved sheaves and two or more belts.
j. V Type Belt Drives: Drives requiring not more than 2 belts; variable pitch type; size for mid-point of operating range. Drives requiring 3 or more belts; nonadjustable constant speed type. Provide belts in matched sets.

2.02 MOTOR STARTERS

A. Unless provided as part of packaged mechanical equipment or otherwise indicated, starters for motors will be provided under Division 26. Provide to Division 26 the data necessary for motor starter heater sizing for all motors.

B. Starters for factory packaged mechanical equipment specified under Division 23 shall be provided as part of the package.

C. Motor Starter Characteristics:
1. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations, which shall have CEC proper class and division.
2. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

D. Manual switches shall have:
1. Pilot lights and extra positions for multi-speed motors.
2. Overload protection: melting alloy type thermal overload relays.

E. Magnetic Starters:
1. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
2. Trip-free thermal overload relays, each phase.
3. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-23 Controls sections.
4. Built-in control circuit transformer, fused from line side, where service exceeds 240 volts.
5. Externally operated manual reset.
6. Under-voltage release or protection.

F. Motor Connections:
1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

2.03 DISCONNECT SWITCHES

A. When applied as part of factory furnished and mounted equipment, disconnects shall meet the requirements for disconnect switches set forth in Division 26.

PART 3 EXECUTION

3.01 SEISMIC RESTRAINT

A. All electrical devices to be seismically restrained.

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. [**Section 230548 "Vibration and Seismic Controls for HVAC"**] [**Section 230548.13 "Vibration Controls for HVAC"**] for vibration isolation devices.
4. [**Section 233113 "Metal Ducts"**] [**and**] [**Section 233116 "Nonmetal Ducts"**] for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment[**and obtain approval from authorities having jurisdiction**].

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:[**Signed and sealed by a qualified professional engineer.**] Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] <**Insert material**>.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**stainless steel**] <**Insert material**>.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**copper-coated steel**] [**stainless steel**] <**Insert material**>.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of [**fiberglass**] [**polyurethane**] [**or**] [**stainless steel**] <**Insert material**>.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.

2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of [**stainless steel**] <**Insert material**>.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Flex-Strut Inc.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut Corporation; Tyco International, Ltd.
    g. Wesanco, Inc.
    h. <**Insert manufacturer's name**>.

3. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
4. Standard: MFMA-4.
5. Channels: Continuous slotted steel channel with inturned lips.
6. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] <**Insert material**>.
8. Metallic Coating: [**Electroplated zinc**] [**Hot-dipped galvanized**] [**Mill galvanized**] [**In-line, hot galvanized**] [**Mechanically-deposited zinc**].
9. Paint Coating: [**Vinyl**] [**Vinyl alkyd**] [**Epoxy**] [**Polyester**] [**Acrylic**] [**Amine**] [**Alkyd**] <**Insert paint type**>.
10. Plastic Coating: [**PVC**] [**Polyurethane**] [**Epoxy**] [**Polyester**] <**Insert plastic type**>.
11. Combination Coating: <**Insert coating materials in order of application**>.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

    a. Anvil International; a subsidiary of Mueller Water Products Inc.
    b. Empire Industries, Inc.
    c. ERICO International Corporation.

d. Haydon Corporation; H-Strut Division.
e. NIBCO INC.
f. PHD Manufacturing, Inc.
g. PHS Industries, Inc.
h. **<Insert manufacturer's name>**.

3. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
4. Standard: Comply with MFMA-4.
5. Channels: Continuous slotted steel channel with inturned lips.
6. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] **<Insert material>**.
8. Coating: [**Zinc**] [**Paint**] [**PVC**] **<Insert coating>**.

2.5 FIBERGLASS STRUT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. Allied Tube & Conduit.
2. Champion Fiberglass, Inc.
3. Cooper B-Line, Inc.
4. SEASAFE, INC.; a Gibraltar Industries Company.
5. **<Insert manufacturer's name>**.

C. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.

1. Channels: Continuous slotted fiberglass[**or other plastic**] channel with inturned lips.
2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**fiberglass**] [**stainless steel**] **<Insert material>**.

2.6 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.
10. <**Insert manufacturer's name**>.

C. Insulation-Insert Material for Cold Piping: [**ASTM C 552, Type II cellular glass with** 100-psig (688-kPa)] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with** 125-psig (862-kPa)] minimum compressive strength and vapor barrier.

D. Insulation-Insert Material for Hot Piping: [**Water-repellent treated, ASTM C 533, Type I calcium silicate with** 100-psig (688-kPa)] [**ASTM C 552, Type II cellular glass with** 100-psig (688-kPa)] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with** 125-psig (862-kPa)] minimum compressive strength.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, [**zinc-coated**] [**stainless-**] steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.8 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece [**plastic**] [**stainless-steel**] base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: [**Plastic**] [**Stainless steel**].
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.10 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [NPS 2-1/2 (DN 65)] <**Insert size**> and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

P. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.

d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for [**trapeze pipe hangers**] [**and**] [**equipment supports**].

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to [1-1/2 inches (40 mm)] <**Insert dimension**>.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in [**Section 099113 "Exterior Painting"**] [**Section 099123 "Interior Painting"**] [**and**] [**Section 099600 "High Performance Coatings."**]

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel [**pipe hangers and supports**] [**metal trapeze pipe hangers**] [**and**] [**metal framing systems**] and attachments for general service applications.

F. Use [**stainless-steel pipe hangers**] [**and**] [**fiberglass pipe hangers**] [**and**] [**fiberglass strut systems**] and [**stainless-steel**] [**or**] [**corrosion-resistant**] attachments for hostile environment applications.

G. Use copper-plated pipe hangers and [**copper**] [**or**] [**stainless-steel**] attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use [**powder-actuated fasteners**] [**or**] [**mechanical-expansion anchors**] instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART1 GENERAL

1.01 SECTION INCLUDES

A. Extent of vibration control work required by this section is indicated on drawings and schedules, and/or specified in other Division-23 sections.

B. Types of vibration control products specified in this section include the following:
   1. Fiberglass Pads and Shapes;
   2. Neoprene Pads;
   3. Vibration Isolation Springs;
   4. Pad-Type Isolators;
   5. Plate-Type Isolators;
   6. Double-Plate-Type Isolators;
   7. Threaded Double-Plate-Type Isolators;
   8. All-Directional Anchors;
   9. Neoprene Mountings;
   10. Spring Isolators, Free-Standing;
   11. Spring Isolators, Housed;
   12. Spring Isolators, Vertically-Restrained;
   13. Spring Isolators, Earthquake-Restrained;
   14. Seismic Snubbers;
   15. Thrust Restraints;
   16. Equipment Rails;
   17. Fabricated Equipment Bases;
   18. Inertia Base Frames;
   19. Roof-Curb Isolators;
   20. Isolation Hangers;
   21. Riser Isolators;
   22. Flexible Pipe Connectors.

1.02 RELATED SECTIONS

A. This section is part of each Division-23 section making reference to vibration control products specified herein.

B. Vibration control products furnished as integral part of factory-fabricated equipment are specified as part of equipment assembly in other Division-23 sections.

C. Refer to other Division-23 sections for equipment foundations, hangers, sealants, gaskets, and other work related to vibration control work.

D. Refer to other Division-23 sections for requirements of electrical connections to equipment isolated on vibration control products.

E. Refer to other Division-23 sections for requirements of duct connections to air handling equipment isolated on vibration control products.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration control product. Submit schedule showing size, type, deflection, and location for each product furnished.
   1. Catalog cuts and data sheets on specific vibration isolators to be utilized, showing compliance with the specification.

2. An itemized list showing the items of equipment, piping, etc., to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawing showing frame construction where applicable.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components. Detail bases and show location of equipment anchoring points, coordinated with equipment manufacturer's shop drawings.
   1. Drawings showing equipment frame construction for each item of equipment, including dimensions, structural member sizes, support point locations, etc.
   2. Written approval of the frame design to be used, obtained from the manufacturer.
   3. Drawings showing methods for suspension, support, guides, etc., for piping and ductwork, etc.
   4. Drawings showing methods for isolation of pipes, etc., piercing walls, slabs, beams, etc.

C. Maintenance Data: Submit maintenance data for each type of vibration control product. Include this data, product data, and shop drawings in maintenance manual in accordance with requirements of Division 1.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Except as otherwise indicated, obtain vibration control products from single manufacturer.

C. Engage manufacturer to provide technical supervision of installation of vibration control products.

D. Vibration isolation manufacturer shall have the following responsibilities:
   1. Determine vibration isolation sizes and locations.
   2. Provide piping and equipment isolation system as scheduled or specified.
   3. Guarantee specified isolation system deflection.
   4. Provide installation instruction and drawings.

1.05 SEISMIC RESTRAINT

A. Provide seismic restraint for mechanical equipment, in accordance with provisions of section 1614-A-1-13 ofTitle-24 2007 California Building Code and ASCE 7 section 13 (Sections 13.3, 13.4 & 13.6). Piping and ductwork restraint shall be in accordance with DSA Approved "SMACNA" Guidelines for Seismic Restraint of Mechanical Systems".

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide vibration control products of one of the following:
   1. Mason Industries, Inc.
   2. Consolidated Kinetics, Inc.
   3. Or approved equal

B. Except as otherwise indicated mechanical equipment shown on drawings shall be isolated from the structure by means of resilient vibration and noise isolators supplied by a single manufacturer to the Contractor.

2.02 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

A. Type and Description:

1. Type PN is a molded pad. The area of pad shall be chosen to match the load in order to achieve the required static deflection.
2. Type MN is a molded neoprene in shear element equipped with leveling bolts and base-plate with bolt holes to permit attachment to the building structure where required.
3. Type HN is a suspension hanger with a steel box frame and a molded neoprene in shear element. A neoprene grommet shall be provided at the location where the hanger rod passes through the hanger box so that no metal-to-metal contact occurs.
4. Type MS is a bare, stable, steel spring equipped with leveling bolts and with a minimum 1/4" thick ribbed neoprene pad under the base-plate. Bolt holes shall be provided in the base-plate to permit attachment to the building structure where required.
5. Type MSL is a bare, stable, steel spring with a ribbed neoprene pad under the base-plate. Bolt holes shall be provided in the base-plate to permit attachment to the building structure. Limit stops shall be provided to prohibit spring extension if the load is removed. These stops may also serve as rigid blocking during erection so that the installed and operating heights shall be the same. Clearance shall be maintained around restraining bolts and between the limit stops and the housing so as not to interfere with the spring action.
6. Type HS is a suspension hanger with a steel box frame and a steel spring resting on a neoprene cup. The cup shall contain a steel washer designed to evenly distribute the load to the neoprene and prevent its overload or extrusion. The spring diameter and hanger box lower hole size shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the hole and short circuiting the spring. Hangers shall be provided with an eye bolt on the spring end.
7. Type CMS is prefabricated spring isolation curb for rooftop equipments. The lower member shall consist of a rectangular steel tube containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must resiliently resist wind and seismic forces. All-directional neoprene snubber bushings shall be a minimum of%" thick. Steel springs shall rest on %" thick neoprene acoustical pads and have a static deflection as indicated on the project drawings. Hardware must be cadmium plated or galvanized and the springs plated or provided with an approved rust-resistant finish. Weatherproofing shall be provided by a continuous flexible aluminum seal joined at the corners by flexible frictionless neoprene bellows. The aluminum seal must be nailed over and provided counter flashing to the curb's waterproofing. Access ports with waterproof covers shall be provided at each spring location and 2" thermal insulation shall be included on the lower sides of the curb.
8. Type SF is a flexible neoprene pipe connector. They shall be manufactured of multiple plies of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two spheres. Neoprene elbows shall be manufactured with a single sphere forming the corner of the joint itself. Connectors up to and including 2" diameter may have threaded ends. Connectors 2-1/3" and larger shall be manufactured with floating steel flanges recessed to lock the connector's raised face neoprene flanges. All connectors shall be rated with either flanged or screwed twin spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. Connectors shall be provided with control units, in accordance with the manufacturer's recommendations to limit expansion.

B. Specifications are based on the following Mason Industries models:

C.

Type	Description	Mason Model#
1)	PN Neoprene Pad	W
2)	MN Neoprene Mount	ND

3)	HN Neoprene Hanger	HD
4)	MS Spring Mount	SLF
5)	MSL Spring Mount with Limit Stop	SLR
6)	HS Spring Hanger	W30
7)	CMS Spring ISO Curb	RSC
8)	SF Flexible Pipe Connector	SFDEJ

2.03 EQUIPMENT FRAMES

A. General: Mounting frames and/or brackets shall be provided to carry the load of the equipment without causing mechanical distortion or stress to the equipment.

B. Frame Types:
1. Type A frame is wide flange structure steel frame with height saving brackets as shown on the drawings. Mason WFSL
2. Type B frame is a channel steel structural frame with brackets as shown on the drawings. Mason MSL
3. Type C no frame required, isolators directly attached to equipment.

2.04 SEISMIC RESTRAINTS

A. Type I, Rigidly Mounted Equipment: Attach to the structure with attachments to resist a lateral force per code requirements.

B. Type II, Vibration Isolated Equipment:
1. Mount all vibration isolated equipment on rigid steel frames as described in the vibration control specifications unless the equipment manufacturer certified direct attachment capability.
2. Each vibration isolated frame shall have a minimum of four all-directional seismic snubbers that are double acting and located as close to the vibration isolators as possible to facilitate attachment to the base and the structure.
3. The snubber shall consist of interlocking steel members restrained by shock absorbent rubber material compounded to bridge bearing specifications.
4. Elastomeric materials, replaceable and a minimum of 1/4 inch thick. Snubbers, manufactured with an air gap between hard and resilient material of not less than 1/8 inch or more than 1/4 inch. Install snubbers with factory set clearances.
5. Snubbers shall be pre-approved by the State of California.
6. The capacity of the seismic snubber at 3/8 inch deflection shall be 3 to 4 time the load assigned to the mount grouping in its immediate area. Submittals shall include the load deflection curves up to %-inch deflection in the x, y and z planes. Conduct test in an independent laboratory or under the signed supervision of an independent registered engineer. Bolt snubber assemblies to the test machine as the snubber is normally installed.
7. Test report shall certify that neither the neoprene elements nor the snubber body sustained any obvious deformation after release of load.

C. Type III, Seismic Restraint of Vibration Isolated Suspended Piping:
1. Brace all piping per DSA Approved "SMACNA Guidelines for Seismic Restraint of Mechanical Systems".
2. The cable size and attachment to the pipe and structure shall be designed and signed by a licensed engineer in the State of California.
3. Use a slack cable system of a minimum 5/16" aircraft at a minimum of 40 feet on center.
4. Support insulated piping systems per DSA Approved "SMACNA Guidelines for Seismic Restraint of Mechanical Systems".

5. Piping 2 inches and smaller is exempt from special seismic bracing requirement.

D. Type IV, Suspended Vibration Isolated Equipment:
   1. Utilize a slack cable restraint system.
   2. The cable size and attachment shall be designed and signed by an engineer licensed in the State of California.

E. All Mechanical ductwork shall be installed with seismic restraint per DSA Approved "SMACNA Guidelines for Seismic Restraint of Mechanical Systems". A copy of the guidelines published by SMACNA shall be kept on the job site at all times during construction.

2.05 DUCTWORK

A. Brace all ductwork including insulated ductwork per DSA Approved "SMACNA Guidelines For Seismic Restraint of Mechanical Systems".

B. Flexible connections shall be incorporated in the ductwork attachment to all fan and coil units.

PART 3 EXECUTION

3.01 GENERAL

A. Report - The vibration isolation manufacturer, or his representative, shall be responsible for providing such supervision as may be necessary to assure correct installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation, the manufacturer, or his representative, shall make a final inspection and submit his report to the Architect in writing, certifying the correctness of installation and compliance with approved submittal data.

B. No equipment or pipe shall be installed which makes rigid contact with the "building" unless it is approved in this specification or by the architect. "Building" includes slabs, beams, studs, walls, latch, etc.

C. Install flexible connectors at all connections to pumps and chillers. Connectors shall be Mason Safeflex constructed of peroxide cured EPDM material and Kevlar reinforcing.

3.02 MOUNTING

A. Isolation Configuration for Floor Mounted or Suspended Equipment: Provide a maximum of four vibration isolators located at the corners of the equipment unless approval is obtained for additional isolators. Where feasible, provide three isolators.

3.03 EQUIPMENT ISOLATOR

A. The equipment to be isolated shall be supported by a structural steel frame or attached directly to the machine where no frame is required.

B. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.

C. The minimum operating clearance between the frame and the pad or floor shall be 1 inch.

D. The minimum operating clearance between the bracket and the pad or floor shall be 1 inch.

E. The frame shall be placed in position and the brackets supported temporarily by 1 inch shims prior to the installation of the machine or isolators.

F. After the entire system installation is completed and under full operation load, the isolator shall be adjusted so that the load is transferred from the shims to the isolator. When all isolators are properly adjusted, the shims shall be used as a gauge to check that the clearance is maintained so that the system will remain free of stress.

3.04 PIPING ISOLATOR, VERTICAL RISER OR HORIZONTALLY SUPPORTED

A. The objective and installation procedure is similar to the Equipment Isolator Installation procedures.

3.05 PIPING ISOLATOR, HORIZONTALLY SUSPENDED PIPING

A. The isolators shall be installed with the isolator hanger box as close as possible to the structure.

B. The isolators shall be suspended from beams, never from slab diaphragms between beams unless specifically approved by the Architect.

C. Hanger rods shall be aligned to clear the hanger box.

3.06 DUCTWORK

A. Flexible connections shall be incorporated in the ductwork attachment to all air moving units supported with isolators. Connections shall be as herein specified.

3.07 INSTALLATION OF SEISMIC RESTRAINT

A. All seismic restraints must be installed and adjusted so that the equipment and piping vibration isolation is not degraded by utilization of the restraints.

B. Equipment:
1. Position all seismic restraints with equipment in operation for proper operating clearances.
2. Weld or bolt seismic restraints to the structure.

C. Piping:
1. Install seismic bracing without compromising vibration isolation.
2. Provide seismic restraint for all piping in equipment rooms, in shafts, and in ceilings of occupied spaces.

D. Ductwork:
1. Install seismic bracing without compromising vibration isolation.
2. Provide seismic restraint for all ductwork in equipment rooms, in shafts, and in ceilings of occupied spaces.

3.08 ISOLATION SCHEDULE

Vibration Isolation Schedule				
Equipment	Isolator Spec. Type	Deflectio n	Restraint Type	Notes
Chilled Water & Heating Water Piping at Pumps & oil Connections	SF	N/A	SFDEJ	Flexible Pipe Connector
Split Air Conditioner outdoor Condenser unit	LREBP	1.0"	MSL& Integral To	!Welded Angle Iron Frame
Suspended Chilled & Heating Water Piping	HS	1.0"	PC3 0/ Cable	Clevis or Trapeze Mount *Wl* Seismic Cables
Roof or Floor Supported Chilled & Heating Water Piping	SLRS	1.0"	MSL& Integral To SLRS	Welded Angle Iron Frame

Roof Mounted Exhaust Fan Unit	ISC	1.0"	Integral To ISC	Rooftop Spring Isolation Curb
Air Handling Units External to unit: Internal to unit:	N/A "		N/ A	Down Discharge Air Handling Units
Suspended Equipments	HS	1"	PC30	Fan coil units & Inline Exhaust fan units

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART1 GENERAL

1.01 SECTION INCLUDES

A. Extent of mechanical identification work required by this section is indicated on drawings or specified in other Division-23 sections, and includes the following:
   1. Painted Identification Materials
   2. Plastic Pipe Markers
   3. Plastic Tape
   4. Underground-Type Plastic Line Marker
   5. Plastic Duct Markers
   6. Valve Tags
   7. Diagram and Schedule Frames
   8. Engraved Plastic-Laminate Signs
   9. Plastic Equipment Markers
   10. Plasticized Tags
   11. Equipment Marker

1.02 RELATED SECTIONS

A. This section makes reference to identification devices specified herein.

B. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division-23 sections.

C. Refer to Division-26 Sections for identification requirements of electrical work; not work of this section.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Schedules and Diagrams:
   1. Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule.
   2. Submit temperature control diagrams and Sequence of Operation on bond paper suitable for framing.

D. Maintenance Data: Include product data and schedules in maintenance manuals; in accordance with requirements of Division 1 and Division 23, Section 23 05 00 "Common Work Results for HVAC".

1.04 QUALITY ASSURANCE

A. Codes and Standards:
   1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
   2. No adhesive type identification markers will be accepted. All markers and tags shall be permanently attached to pipe, etc.

3. All identification markers installed exterior of buildings shall be ultra-violet resistant.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide mechanical identification materials of one of the following:
   1. Allen Systems, Inc.
   2. Brady (W.H.) Co.; Signmark Div.
   3. Industrial Safety Supply Co., Inc.
   4. Seton Name Plate Corp.

2.02 MECHANICAL IDENTIFICATION MATERIALS

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-23 sections. Where more than a single type is specified for application, selection is Installer's option, but provide a single selection for each product category.

2.03 PLASTIC PIPE MARKERS

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

B. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on un-insulated pipes subject to fluid temperatures of 125oF (52oC) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

C. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
   1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
   2. Laminated or bonded application of pipe marker to pipe (or insulation).
   3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

D. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
   1. Laminated or bonded application of pipe marker to pipe (or insulation).
   2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide; full circle at both ends of pipe marker, taped lapped 3".
   3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

E. Lettering: Manufacturer's standard pre-printed nomenclature which best describes piping system in each instance, as selected by Architect/Engineer in cases of variance with names as shown or specified.
   1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.

2.04 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2-1/2" wide tape for larger pipes.

C.. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.05 UNDERGROUND-TYPE PLASTIC LINE MARKER

A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide tape with printing which most accurately indicates the type of service of buried pipe.
   1. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.06 VALVE TAGS

A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamped-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high and with 5/32" hole for fastener.
   1. Provide 1-1/2" diameter tags, except as otherwise indicated.
   2. Fill tag engraving with black enamel.

B. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

C. Access panel markers: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

D. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hole to allow attachment.

2.07 DIAGRAM AND SCHEDULE FRAMES

A. General: For each page of schedule and/or diagrams, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

2.08 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, white with black core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.09 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

2.10 EQUIPMENT MARKERS

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:
   a. Manufacturer, product name, model number, and serial number.
   b. Capacity, operating and power characteristics, and essential data.
   c. Labels of tested compliances.
2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
1. Terminology: Match schedules as closely as possible.
2. Data.
3. Name and plan number.
   a. Equipment service.
   b. Design capacity.
   c. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
4. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine sub-core, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Retain and edit subparagraph above or first subparagraph below.
4. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
5. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

D. Access Panel and Door Markers: 1/16-inch thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.11 PLASTIC DUCT MARKERS

A. Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finishes, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.02 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:
1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot-non-insulated pipes.

B. Locate pipe markers as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
3. Near locations where pipes pass through walls, floors ceilings, or enter non-accessible enclosures.
4. At access doors, manholes similar access points which permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.03 UNDERGROUND PIPING IDENTIFICATION

A. General: During back-filling/top-soiling of each exterior underground piping systems, except sanitary sewer and storm drainage install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.

3.04 VALVE IDENTIFICATION

A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve on valve schedule for each piping system.

B. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

3.05 MECHANICAL EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:
   1. Fuel-burning units including boilers, furnaces, heaters.
   2. Pumps, compressors, chillers, condensers and similar motor-driven units.
   3. Fans and blowers.
   4. Packaged HVAC central-station or zone-type units.
   5. Split air conditioner indoor and outdoor units
   6. Single Duct terminal units and all equipment in ceiling space.

   (In addition to the equipment tag, install an identification tag for VAV units in locations approved by architect to indicate where each unit is installed above the ceiling. Coordinate the Installation location, type, size and color of this tag with the architect.)

B. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

C. Test of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.06 ADJUSTING AND CLEANING

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
   1. Balancing airflow and water flow within distribution systems, including sub-mains, branches, and terminals, to indicated quantities according to specified tolerances.
   2. Test, adjust and balance hydronic system based on the requirements of the existing variable flow chilled and heating water systems (as applicable for site system).
   3. Adjusting total HVAC systems to provide indicated quantities.
   4. Measuring electrical performance of HVAC equipment.
   5. Setting quantitative performance of HVAC equipment.
   6. Verifying that automatic control devices are functioning_ properly.
   7. Reporting results of the activities and procedures specified in this Section.

B. Related Sections include the following:
   1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
   2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.03 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including sub-mains, branches, and terminals, according to design quantities.

C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

K. Test: A procedure to determine quantitative performance of a system or equipment.

L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

M. MBC: Associated Air Balance Council.

N. AMCA: Air Movement and Control Association.

O. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.04 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 3 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 3 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

C. Certified Testing, Adjusting, and Balancing Reports: Submit 6 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

D. Warranty: Submit 6 copies of special warranty specified in the "Warranty" Article below.

E. Provide a summary of any discrepancies found in the system, by Air balance contractor to each system as described hereafter. Include a complete list of deficiencies and problems found in system being tested and balanced. Add this report to final submittal package.

1.05 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by MBC. Agent certifications to be submitted for A&E approval before testing, etc.

B. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.
   1. Agenda Items: Include at least the following:
      a. Submittal distribution requirements.
      b. Contract Documents examination report.
      c. Testing, adjusting, and balancing plan.
      d. Work schedule and Project site access requirements.
      e. Coordination and cooperation of trades and subcontractors.
      f. Coordination of documentation and communication flow.

C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.

2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

D. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC "National Standards for Testing, Adjusting, and Balancing."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC national standards.

F. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.06 PROJECT CONDITIONS

A. This project will be connected to the NAME SCHOOL/SITEAS APPLICABLE plant. Scope of Test, adjust and balance of the hydronic systems is from point of connection to the campus chilled and heating water piping system and inside the building.

B. Full Owner Occupancy: The Owner may occupy the site and existing building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.07 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

D. Review division 23 contract documents to assure that the design has considered all required components necessary for a complete and successful testing, adjusting and balancing of the system as described hereafter. Prepare a report for this examination of contract documents and propose any additional components required to complete the scope of work this section no later than 45 days after the award of the contract.

1.08 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. National Project Performance Guarantee: Provide a guarantee on AABC "National Standards" forms stating that AABC will assist in completing the requirements of the Contract Documents if the testing,' adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
   1. The certified Agent has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (Not Applicable}

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
   1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
   2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 0 1 Section "Project Record Documents."

D. Examine Architect's and Engineer's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data, including fan curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine air-handling equipment to ensure new, clean filters (MERV 8, minimum, Pleated) in the correct size for the unit, have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine strainers for clean screens and proper perforations.

L. Examine 2-way valves for proper installation for their intended function.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices operate by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multi-zone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves, are properly connected.
5. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

P. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.02 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air, as applicable.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in Critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so design conditions for system operations can be met.
9. Ensure that all units have been properly sealed at their rooftop curb, and all ducting is connected and braced properly, so there is no supply air being shed to the atmosphere.
10. Ensure that OSA dampers, and economizers are properly installed, and verify that they are actually connected and working as designed.

3.03 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.04 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of fan coil unit components.

3.05 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for variable-air-volume, multi-zone, induction-unit supply-air systems and process exhaust-air systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.
   1. Measure fan static pressures to determine actual static pressure as follows:
      a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   2. Measure static pressure across each air-handling unit component.
      a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
   3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.
   4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
   5. Adjust fan speed higher or lower than design with the approval of the Architect. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
   6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

C. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to design airflows within specified tolerances.
   1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
      a. Where sufficient space in sub-mains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   2. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-mains and branch ducts to design airflows within specified tolerances.

D. Measure terminal outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.
   1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 MULTIZONE SYSTEMS' ADDITIONAL PROCEDURES

A. Set unit at full flow through the cooling coil if coil has that capacity.

B. Adjust each zone damper to design airflow.

3.07 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
   1. Open all manual valves for maximum flow.
   2. Check flow-control valves for specified sequence of operation and set at design flow.
   3. Set differential-pressure control valves at the specified differential pressure.
   4. Set system controls so automatic valves are wide open to heat exchangers.
   5. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.08 HYDRONIC SYSTEMS' BALANCING PROCEDURES

A. Set calibrated balancing valves, if installed, at calculated pre-settings.

B. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

C. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

D. Adjust balancing stations to within specified tolerances of design flow rate as follows:
   1. Determine the balancing station with the highest percentage over design flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
   3. Record settings and mark balancing devices.

E. Measure total building flow rate.

F. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.09 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating if high-efficiency motor.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

3.10 CONDENSING UNITS

A. Verify proper rotation of fans and measure entering- and leaving-air temperatures. Record compressor data.

3.11 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:
   1. Entering- and leaving-water temperatures.
   2. Water flow rate.
   3. Water pressure drop.
   4. Dry-bulb temperatures of entering and leaving air.
   5. Wet-bulb temperatures of entering and leaving air for cooling coils designed for less than 7500 CFM.
   6. Airflow.
   7. Air pressure drop.

3.12 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.13 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.

F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

G. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or non-grounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans: Minus 5 to plus 5 percent.
   2. Fresh air intake: 0 to plus 5%.
   3. Air Outlets and Inlets: 0 to plus 10 percent.
   4. Heating-Water Flow Rate: 0 to minus 10 percent.

5. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.15 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

A. General: Computer printout in letter-quality font, on standard bond paper, in a fine quality 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include the following:
   1. Fan curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of testing, adjusting, and balancing Agent.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address and field technician responsible for the project.
   8. Report date.
   9. Signature of testing, adjusting, and balancing Agent who certifies the report.
   10. Summary of contents, including the following:
      a. Design versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   11. Nomenclature sheets for each item of equipment.
   12. Data for terminal units, including manufacturer, type size, and fittings.
   13. Notes to explain why certain final data in the body of reports vary from design values.
   14. Test conditions for fans and pump performance forms, including the following:
      a. Settings for outside-, return-, and exhaust-air dampers.
      b. Conditions of filters.
      c. Cooling coil, wet- and dry-bulb conditions.
      d. Face and bypass damper settings at coils.
      e. Fan drive settings, including settings and percentage of maximum pitch diameter.
      f. Inlet vane settings for variable-air-volume systems.
      g. Settings for supply-air, static-pressure controller.

h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Balancing stations.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches, and bore.
   i. Sheave dimensions, center-to-center and amount of adjustments in inches.
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.
2. Motor Data: Include the following:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches.
3. Test Data: Include design and actual values for the following:
   a. Total airflow rate in CFM.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat coil static-pressure differential in inches wg.
   g. Cooling coil static-pressure differential in inches wg.
   h. Heating coil static-pressure differential in inches wg.
   i. Outside airflow in CFM.
   j. Return airflow in CFM.
   k. Outside-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:
1. Coil Data: Include the following:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch.
   f. Make and model number.
   g. Face area in sq. ft.

h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data: Include design and actual values for the following:
   a. Airflow rate in CFM.
   b. Average face velocity in FPM.
   c. Air pressure drop in inches wg.
   d. Outside-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in GPM.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data: Include the following:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches, and bore.
      h. Sheave dimensions, center-to-center and amount of adjustments in inches.
   2. Motor Data: Include the following:
      a. Make and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches, and bore.
      f. Sheave dimensions, center-to-center and amount of adjustments in inches.
      g. Number of belts, make, and size.
   3. Test Data: Include design and actual Values for the following:
      a. Total airflow rate in CFM.
      b. Total system static pressure in inches wg.
      c. Fan rpm.
      d. Discharge static pressure in inches wg.
      e. Suction static pressure in inches wg.

I. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data: Include the following:
      a. System and air-handling unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F.
      d. Duct static pressure in inches wg.
      e. Duct size in inches.
      f. Duct area in sq. ft.

g. Design airflow rate in CFM.
h. Design velocity in FPM.
i. Actual airflow rate in CFM.
j. Actual average velocity in FPM.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports: For terminal units, include the following:
1. Unit Data: Include the following:
a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device manufacturer.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft.
2. Test Data: Include design and actual values for the following:
a. Airflow rate in CFM.
b. Air velocity in FPM.
c. Preliminary airflow rate as needed in CFM.
d. Preliminary velocity as needed in FPM.
e. Final airflow rate in CFM.
f. Final velocity in FPM.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data: Include the following:
a. System and air-handling unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.
2. Test Data: Include design and actual values for the following:
a. Airflow rate in CFM.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

L. Instrument Calibration Reports: For instrument calibration, include the following:
1. Report Data: Include the following:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.17 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

3.17 ENERGY VALIDATION

A. The contractor shall validate the peak summer and peak winter energy consumption and balancing conditions after occupancy of the facility by the Owner. Even though the initial testing and balancing may have been performed during a near peak summer or near peak winter period, each shall be validated after occupancy by the Owner. Sufficient funds will be withheld after these tests and validations have been completed and the results approved by the Owner.

B. The contractor shall schedule and coordinate with the Owner dates for both the summer and winter peak energy validation testing and balancing. The contractor shall have the required instrumentation in place and sufficient personnel available to minimize disruption and inconvenience to the operation of the building and to the occupants of the building.

C. Using approved instrumentation, data shall be collected and recorded to compute the energy consumed by each system in the building. Totals shall be compared to the values indicated for the prime utilities supplied to the building.

D. Individual readings of flows, temperature, pressure, etc., taken with the contractor's test instruments shall be compared with corresponding, permanently installed building instrumentation. This data shall be included in the final test and balance report.

E. If an energy analysis was generated during the design, the theoretical and the actual shall be compared. If more than a 10% difference in total energy consumptions is indicated, the differences shall be examined and a determination made as to the cause. If the actual consumption is higher than predicted, a determination shall be made as to the cause and corrective measures listed for evaluation by the Owner.

SECTION 23 07 00

HVAC INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section, and includes the following:
   1. Piping Systems Insulation:
      a. Fiberglass.
      b. Calcium Silicate.
      c. Flexible Unicellular.
   2. Ductwork System Insulation:
      a. Fiberglass
      b. Flexible Unicellular.
   3. Equipment Insulation:
      a. Fiberglass
      b. Calcium Silicate
      c. Flexible Unicellular.
   4. Acoustical Insulation
      a. Fiberglass

1.02 RELATED SECTIONS

A. Refer to Division-23 section 23 05 29 for protection saddles, protection shields, and thermal hanger shields; not work of this section.

B. Refer to Division-23 section 23 05 53 for installation of identification devices for piping, ductwork, and equipment; not work of this section.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.04 QUALITY ASSURANCE

A. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

B. As a minimum, insulation shall meet installed thermo (R) value as set forth in Title 24 California Code of Regulations (CCR) Part 6 Section 123, 124; and Part 4 Section 605.0, or as indicated in contract documents, whichever is greater.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products of one of the following:
   1. Armstrong World Industries, Inc.
   2. Babcock and Wilcox; Insulating Products Div.
   3. Certainteed Corp.
   4. Knauf Fiber Glass GmbH.
   5. Manville Products Corp.
   6. Owens-Corning Fiberglas Corp.
   7. Pittsburgh Corning Corp.
   8. Rubatex Corp.

2.02 PIPING INSULATION MATERIALS

A. Fiberglass (Mineral Fiber) Piping Insulation: ASTM C547, Class 1 unless otherwise indicated. Manville Products Corp. Micro-Lok, Owens-Corning Fiberglas Corp., ASJ/SL-11 or equivalent.

B. Calcium Silicate Piping Insulation: ASTM C533, Type I. Owens-Corning Fiberglass Corp. "Kaylo Asbestos Free" or equivalent.

C. Flexible Unicellular Piping Insulation: ASTM C534, Type I. Armstrong World Industries, Inc. or Rubatex Corp. meeting ASTM E-84 25/50 index.

D. Jackets for Piping Insulation: ASTM C921, Type I (Vapor Barrier) for piping with temperatures below ambient. (Type II (Water Vapor Permeable) for piping with temperatures above ambient. Type I may be used for all piping at Installer's option.
   1. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations. Zeston PVC Insulated fitting covers or equivalent.
   2. Encase exterior piping insulation with aluminum jacket with weather-proof construction.

E. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

F. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

G. All Insulation shall be U.L. listed showing flame spread not greater that 25, nor smoke greater than 50, per NFPA 90A.

2.03 DUCTWORK INSULATION MATERIALS

A. Flexible Fiberglass Ductwork Insulation: ASTM C553, Type I, Class B-2, Owens-Corning Fiberglas Inc. un-faced duct wrap insulation, Type 100 or equivalent.
   1. Nominal thickness or equivalent to provide installed R-value as follows:
      a. 1.5" thick- Installed R = 4.2
      b. 2.0" thick- Installed R = 5.6

B. Flexible Fiberglass Ductwork Insulation: ASTM C612, with ASTM C921 Type I vapor barrier jacket. Owens/Corning Fiberglas All Service Wrap Insulation, Type 100 or equivalent:
   1. Nominal thickness or equivalent to provide an installed R-value as follows:
      a. 1.5" thick - Installed R = 4.2
      b. 2.0" thick - Installed R = 5.6

C. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

D. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

E. All Insulation shall be U.L. listed showing flame spread not greater than 25, nor smoke greater than 50, per NFPA 90A.

2.04 EQUIPMENT INSULATION MATERIALS

A. Flexible Fiberglass Equipment Insulation: ASTM C553, Type II, Class F-1, Owens-Corning Fiberglass, Inc., Type 701 1.5 lbs/Ft3.

B. Calcium Silicate Equipment Insulation: ASTM C533, Type I, Block; Owens/Corning Fiberglass, Inc., Kaylo Asbestos Free, U-Grooved block insulation.

C. Jacketing Material for Equipment Insulation: Provide canvas jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

D. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

E. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape corner angles, anchors and stud piping as recommended by insulation manufacturer for applications indicated.

F. All Insulation shall be U.L. listed showing flame spread not greater than 25, nor smoke greater than 50, per NFPA 90A.

2.05 ACOUSTICAL INSULATION

A. Rigid Fiberglass Insulation: ASTM C612, Class 1, Owens/Corning Fiberglass, Inc., 10 lbs/ft3.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 HVAC PIPING SYSTEM INSULATION

A. Insulation Omitted: Omit insulation on the following:
   1. Hot piping within radiation enclosures
   2. Hot unions, flanges, strainers, flexible connections and expansion joints.

B. Cold Piping (40°F to ambient):
   1. Application Requirements: Insulate the following cold HVAC piping systems:
      a. HVAC chilled water supply and return piping.
      b. Air conditioner condensate drains piping.
   2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
      a. Fiberglass: 1" thick for pipe sizes up to and including 4", 1-1/2" thick for pipe sizes over4".
      b. Flexible Unicellular: 1/2" thick for pipe sizes up to 1-1/2" (A.C. condensate piping only).

C. Hot Low Pressure Piping (to 250°F):
   1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi, water piping up to 250°F (121°C).
      a. HVAC heating water supply and return piping.
   2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1" thick for pipe sizes up to and including 1", 1-1/2" thick for pipe sizes 1-1/2"; 2" thick for piping over 2".

3.03 DUCTWORK SYSTEM INSULATION:

A. Insulation Omitted:
1. Do not insulate outside air and exhaust air ductwork unless otherwise indicated.
2. Do not insulate exhaust air ductwork unless otherwise indicated.
3. All ductwork specified to be insulated that is located in mechanical rooms, located on roofs, or where exposed in conditioned spaces or to weather shall be internally lined under Section 23 31 13 "Metal Ductwork"; unless noted otherwise in these specifications or on the drawings.

B. Insulate the following with flexible fiberglass insulation, unfaced, 1.5" thickness unless otherwise noted. Firmly wrap insulation around duct work with all joints lapped a minimum of 2 inches. Secure insulation to ducts by means of 16 gauge soft-annealed galvanized wire spaced 12 inches on centers at loose ends.
1. Warm air heating ductwork in concealed spaces; unless in ceiling plenum provide all service wrap insulation.
2. Return air ductwork in non-conditioned concealed spaces unless in ceiling supply plenum uses all service wrap insulation.
3. Return air ductwork located in return air ceiling plenums outside air ductwork supplying fan coil units.

C. Insulate the following with Flexible Fiberglass insulation with all service vapor barrier facing, 1.5" thickness unless noted otherwise.
1. HVAC hot/cold mixed air ductwork between fan discharge or HVAC unit discharge, and room terminal unit.
2. Outdoor air intake ductwork between air entrance and indoor fan inlet or indoor HVAC unit inlet.
3. Installation:
a. Neatly wrap insulation around ducts with all joints tightly butted together.
b. Seal transverse joints with vapor barrier facing tab overlapping all joints 2-inches and secure with vapor barrier adhesive or outward-clinch stapes on 4-inches centers.
c. Seal longitudinal joints with 4-inch wide vapor barrier adhesive tape.
d. Secure insulation to underside of ducts, 100 percent coverage, with ductwork insulation adhesive.
e. In addition to adhesive, on underside of ducts 24-inches or greater in width, use mechanical fasteners on maximum 12-inch centers.
f. Seal all penetrations of vapor barrier facing with vapor barrier mastic.

D. Insulate the following with Rigid Fiberglass Insulation, 2.0" thickness unless noted otherwise.
1. HVAC and unit housings not pre-insulated at the factory or where lining has been specifically omitted.
2. Installation: Fasten to ductwork with adhesive and pins per manufacturer's recommendations. Butt all joints and provide 16 gage corner angles at corners. Seal all joints with approved duct tape.

E. Contractor's Option: Contractor may provide duct liner as set forth in Section 23 31 13, using equivalent installed "R" values; in lieu of external duct wrap or rigid insulation as specified above unless ductwork is specifically indicated as being unlined.

F. Hot Ductwork:
1. Application Requirements: Insulate range and hood exhaust ductwork with PABCO "Super Fire Temp" asbestos free, non-combustible fireproofing board.

a. Provide 1 to 4 hour fire rating as indicated.
b. Install per manufacturer's instructions.

3.04 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):
1. Application requirements: Insulate the following cold equipment:
a. Refrigeration equipment, including chillers, tanks and pumps.
b. Drip pans under chilled equipment.
c. Cold and chilled water pumps.
d. Pneumatic water tanks.
2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:
a. Fiberglass: 2" thick for cold surfaces above 35°F and 3" thick for surfaces 35°F and lower.

B. Hot Equipment (Above Ambient Temperature):
1. Application Requirements: Insulate the following hot equipment:
a. Boilers (not pre-insulated at factory).
b. Water heaters.
c. Hot water expansion tanks.
d. Hot water pumps.
2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation.
a. Fiberglass: 2" thick, except 3" thick for low-pressure boilers and steam-jacketed heat exchangers.

C. Breeching and Stacks:
1. Application Requirements: Insulate the following breechings and stacks:
a. Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.

3.05 INSTALLATION OF PIPING INSULATION

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulated each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

3.06 INSTALLATION OF DUCTWORK INSULATION

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor barrier on ductwork insulation, and protect it to prevent puncture and other damage.

E. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

F. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

G. Ductwork Exposed to Weather: Where external insulation has been specifically indicated, protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

H. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

3.07 INSTALLATION OF EQUIPMENT INSULATION

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, breechings, or stacks while hot.

E. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

F. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

H. Do not insulate hot water storage tank manholes, hand-holes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

J. Equipment exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, or jacketing, as recommended by the manufacturer.

3.08 ACOUSTICAL INSTALLATION

A. Install within confines of roof curbs for roof mounted air handlers and air conditioning units, and elsewhere as indicated on drawings

B. Cut to fit snugly within curb and around duct at duct penetrations, 4" minimum thickness.

3.09 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION

PART 1 – GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Owners Project Requirements.

C. Basis of Design

D. Contractor and Vendor field start-up reports.

E. Contractor QA/QC Testing reports.

F. Close-out documentation including O&M Manuals.

G. Related Sections:

1. Section 013300 "Submittals"

2. Section 013515 "LEED Requirements"

3. Section 019100 "Cx Requirements"

4. Section 250800 "Commissioning Integrated Automation"

5. Section 260800 "Electrical Systems Commissioning"

6. Division 22 - "Plumbing"

7. Division 23 - "Heating Ventilating and Air Conditioning"

8. Division 26 - "Electrical"

1.2. SUMMARY

A. This Section includes requirements for commissioning the HVAC system and its subsystems and equipment as required by LEED. This Section supplements the general requirements specified in Division 01 Section 019100 "Commissioning Requirements".

1.3. CONTRACTOR'S RESPONSIBILITIES

A. The following responsibilities are in addition to those specified in Division 01 Section "General Commissioning Requirements." Refer to the project Commissioning Plan for more detailed descriptions of the Contractor's roles.

B. Contractor:

1. Attend procedures meeting for TAB Work.

2. Certify that TAB Work is complete.

C. Mechanical Contractor:

1. Develop full startup and initial checkout plan using manufacturer's startup procedures and prefunctional checklists from Commissioning Authority for commissioned equipment. Submit to Commissioning Authority for review and approval prior to startup.

2. Perform and clearly document completed startup and system operational checkout procedures, providing copy to Commissioning Authority.

3. Attend TAB verification testing.

4. Provide measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period.

5. Participate in functional performance testing of HVAC equipment with Commissioning Authority.

D. HVAC Instrumentation and Control Contractor

1. Review control designs for compliance with the OPR and BoD, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

2. Participate in functional performance testing of HVAC equipment with Commissioning Authority.

E. TAB Contractor:

1. Prepare a TAB agenda and send to the Commissioning Authority for review. Before developing TAB procedures verify the following:
    a. Accessibility of equipment and components required for TAB Work.
    b. Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
    c. Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
    d. Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.
    e. Air and water flow rates have been specified and compared to central equipment output capacities.
2. Additional Responsibilities: Participate in HVAC functional performance tests specified by the Commissioning Plan.

F. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.
2. Fill out electrical connection portions of HVAC construction checklists.

PART 2 – PRODUCTS

2.1. FUNCTIONAL PERFORMANCE TESTING EQUIPMENT AND INSTRUMENTS

A. Contractor shall provide all tools, instruments, laptop computers, PDAs, software programs and services required to perform system Functional Performance Testing procedures. This includes providing the connection to systems to be tested, operation of the test equipment & instrumentation and generating test results as required.

PART 3 – EXECUTION

3.1. TESTING PREPARATION

A. Prerequisites for Testing, in addition to those listed in Section 019100 "Commissioning Requirements"

1. TAB work is complete and a preliminary copy of the TAB report has been sent to the Commissioning Authority for review.
2. The HVAC control system is operating as per the approved submittal with all applicable operating modes programmed.

3.2. FUNCTIONAL PERFORMANCE TESTING

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
2. Alter set points when simulating conditions is not practical.

C. Scope of HVAC Contractor Testing:

1. Testing scope shall include entire HVAC installation. It shall include measuring capacities and effectiveness of operational and control functions.
2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. Detailed Testing Procedures: CxA, with HVAC Contractor, TAB Contractor, and HVAC Instrumentation and Control Contractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented

and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.

2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

END OF SECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary conditions and Division-1 Specification sections, apply to work of this section.

1.02 DESCRIPTION OF WORK: Provide all work for the complete installation of automatic temperature controls.

A. Work in this Section: Principal items include:
   1. Electronic and electric controls, includes sensors, switches, relays, control panels for instruments.
   2. Electric motors for air dampers, valves, etc.
   3. Local control panels.
   4. Adjustment and validation of control system. Instruction of Owner's representative on maintenance and operation of control equipment.
   5. Electric diagrams showing interlocks between equipment furnished under the other sections and control furnished herein.
   6. Direct digital control for systems.
   7. Wiring and Conduit: low voltage wire for the control system under Division 23, all low voltage control conduit, all required power wiring, high voltage wire and high voltage conduit under Division 26.
   8. Contractor shall install the latest version of DDC Control Software.

1.03 SYSTEM

A. The Temperature Control System shall be installed as a installed project and shall consist of all sensors, actuators, direct digital controllers, supervisory controller, electrical low voltage (24 VAC) and line voltage control wiring for a complete and operating installation as specified herein. The system shall be a standard product with the manufacturer who will guarantee ongoing parts availability and factory trained field support for five (5) years after system acceptance.

1.04 RELATED SECTIONS

A. Refer to Division 09 for patching and painting required for the control system installation. Not work of this section.

B. Automatic dampers in ductwork, casings, etc. furnished and installed by the Mechanical Division under control people's supervision. The dampers shall be correctly installed so that they operate freely and close tightly. Provide and install blank off plates when the control application requires dampers smaller than duct size.

C. Refer to Division-26 sections for the following work; not work of this section:
   1. Power supply wiring for power source to power connection on controls and/or unit control panels, including starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.05 QUALITY ASSURANCE

A. Codes and Standards:
   1. General: The publications listed below form a part of this specification to the extent applicable:

ASHRAE	Handbook of Fundamentals, Latest Edition.
EIA	Electrical Characteristics of Balanced Voltage Digital Interface Circuits;
RS-485.	
NEMA	Enclosures for Electrical Equipment (1000 volts maximum); 250-1979
NFPA 70	National Electrical Code; 1981
NFPA 90A	Air Conditioning and Ventilation Systems; 1981

1.06 SUBMITTALS

A. Submit installation drawings, sequences of operation and catalog cut sheets for each device of the proposed system prior to installation for engineer's approval. The drawings shall include the location and intercommunication of all stand-alone and subordinate control panels; the schematic diagrams, of the controlled equipment with sensors and actuators shown interconnected to the system controllers; and logic diagrams that depict the sequence of operation.

B. After completion of the installation and commissioning of the system including final adjustments, a full set of as-built documentation shall be turned over to the Owner. The as-builts shall include one (1) set of reproducible drawings and two (2) copies of the database on flexible or removable hard disk for each stand-alone controller and the supervisory computer.
   1. As-built documentation shall include diagrammatic layouts of the automatic control systems specified herein. Layouts shall show all control equipment, and the function of each item shall be indicated for the different seasons, Layouts shall be located in plastic protective folder and placed in the control panels.
   2. All Drawings shall be accompanied with a complete description of sequence of operation. Each control element mentioned in the sequence description shall be identified with the same mark as shown- on the control diagram.

C. Submittal of Materials:
   1. Material submittals shall be manufacturers prepared catalog cuts indicating type, size and technical details.
   2. Reference catalog cuts to the applicable specification article (e.g. 2.02A).
   3. Catalog cuts shall be submitted in complete groups of manufacturer's material.
   4. Partial submittals of groups or systems are not acceptable.
   5. Verify that the submittal has been reviewed in detail and is in fact the Contractor's choice of materials.

D. Upon receipt of contract and prior to the delivery of parts, submit eight copies of the following drawings:
   1. Submit eight copies of schematic drawings showing the respective locations of components, as applicable and interconnecting wiring between all devices. Also all field terminal and sensing devices. Also all field terminal and sensing devices shall be listed by function and point number and shall display interconnecting wiring and terminals of controlled systems and devices.

E. Submit eight copies of schematic drawings showing electric connection details for actuators, transducers, and other electric components. All connections shall be labeled to coordinate with the description of operation, including descriptions to indicate action of components, normal positions, spring ranges, etc.

1.07 MANUFACTURERS

A. Carrier I-VU Controls. No substitutions will be accepted.

B. Controls installation will be by Russell Sigler, Inc. Controls Group Certified Installer, Brea, California.

1.08 WARRANTY

A. Provide all labor, material and equipment necessary to maintain beneficial performance of the entire Building Automation System for a period of one (1) year after acceptance of the system, or parts thereof, by an authorized representative of the Owner. Any defects in workmanship or material during the warranty period shall be promptly corrected by the Contractor at no charge to the Owner. All work shall be accomplished during normal working hours, Monday through Friday excluding legal holidays. Precaution shall be taken to minimize disruption of facility operations.

B. A prepaid Warranty Service Agreement shall be turned over to the Owner at the time of the acceptance test as a prerequisite of system acceptance. The contract shall include the terms and conditions stated herein.

C. Service work shall be performed by service personnel in the direct employ of the control contractors. The service technicians shall be factory trained and certified by the manufacturer to be competent in all aspects of the installed system. The technician shall have a working knowledge of calibration techniques, preventive maintenance, troubleshooting, software diagnostics and microprocessor repair.

D. Provide preventive maintenance at one (1) month intervals such that one twelfth of the system is tested and re-commissioned if necessary at each monthly inspection. An Owner's representative shall certify that the monthly test has been conducted and the control system is functioning properly. A log of tasks performed at each test shall be maintained by the controls contractor and signed by the Owner as evidence of satisfactory completion of the Warranty Service Agreement. The log shall be retained on site and available for review by authorized personnel.

E. System modifications shall be incorporated into the as-built documentation and/or operators and maintenance manuals when operating parameters, control point settings or control strategies are changed. System modifications made by the user of the controls contractor shall have both parties' approvals in order to maintain the Warranty Service Agreement. All database changes shall be saved on disk for backup to the system.

F. Software upgrade program shall be implemented on the anniversary or anniversaries of the warranty period. The upgrade shall provide all enhancements offered by the manufacturer for programs in the accepted systems.

G. System enhancements beyond the scope of the project shall be field upgradable with pull out/plug-in ease. Provided at reasonable value added cost these upgrades may be purchased at the Owner's option.

PART 2 - PRODUCTS

2.01 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data and status shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

2.02 FIELD INSTALLED SENSORS

A. Temperature Sensors
1. Type. Temperature sensors shall be nominal 10K ohm thermistor type.
2. Duct Sensors. Duct sensors shall be single point.
3. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.

B. Status Indication
1. Status indication for fans shall be provided by a current sensing sensor. The sensor shall be installed at the motor starter or motor to provide load indication. The unit shall consist of a current transformer, a solid state current sensing circuit (with adjustable set point) and a solid state switch. A red light emitting diode (LED) shall indicate the on off status of the unit. The switch shall provide a N.O. contact for wiring back to the Field Installed Controller.

2.03 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be configurable through the operator workstation, web browser interface, or engineering workstation.

B. Memory and System Time. All controllers shall have a Non-Volatile Memory providing indefinite storage of application and configuration data. The system must have an ability to maintain time, and automatically correct for daylight savings time and leap year

adjustments. In the event of power failure or user generated power cycle, all system components must automatically updated with current time and date from a network Time Sync device. The controller shall also have the capability of changing occupancy mode by reading a set of discrete, dry contacts controlled by an external time clock.

C. Stand alone capability. All controllers shall be capable of providing all control functions of the HVAC system without the use of a computer. The controllers shall include the inherent capability to access the system control selections as well as to monitor system performance by means of a communicating network with a PC and EMS software program.

D. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms.

E. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

F. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

G. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of preconfigured minimum on-time and off-time settings, customized for the specific requirements of the application.

H. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

2.04 CONTROLLERS

A. General. The control system shall be available as a complete package with the required input sensors and devices readily available. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Sensors (SEN) as required to achieve performance specified in Paragraph 2.4.

B. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. unless otherwise specified.

C. BACnet.
   1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
   2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
   3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
   4. BACnet Communication.
      a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
      b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
      c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
      d. Each ASC shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

D. Communication.
   1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

E. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

F. Keypad. Where specified provide a local keypad and display for each BC and ASC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and ASC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

G. Serviceability.
1. Controllers shall have diagnostic LEDs for power, communication, and processor.
2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
3. All controllers in the system shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory.
   1. Controller memory shall support operating system, database, and programming requirements.
   2. Each controller in the system shall use nonvolatile memory providing indefinite storage of BIOS, application programming, and all configuration data in the event of power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

J. Rooftop Unit Controller (RTC). Defined as Application Specific Controllers (ASC), shall control all associated HVAC Constant Volume rooftop equipment functions, this operation shall be provided when operating within a zoning system application, as specified for an air source control, in Paragraph 2.4 or in a stand-alone mode. The resident algorithms shall use error reduction logic as designated in ASHRAE standard 90.1 to provide temperature control and energy usage.
   1. Capacity control shall be based on the use of a conventional thermostat, or programmable thermostat, or alternatively, a constant volume unit may utilize its own internal time clock and setpoints (cooling and heating) coupled with a room (wired or network communicating) sensor for capacity control. The controls shall provide separate occupied and unoccupied cooling and heating setpoints – except if a conventional thermostat is used.
   2. RTC shall feature and maintain a 365-day Real-Time Clock/Calendar with holiday functions.
   3. RTC shall be capable of stand-alone or networked operation.
   4. In the stand alone mode, each RTC shall establish occupancy scheduling based on its own local occupancy schedule, the closure of a contact connected to an external time clock or EMS system, or by a timed override request (1 to 24 hours) through its space temperature sensor override button.
   5. When networked, RTC occupancy may be established by user interface or occupancy signal from other controller located in network.
   6. RTC shall utilize fan control, 2 stages of cooling, and up to 3 stages of heating to maintain zone temperature at setpoint.
   7. RTC shall provide analog output signal for economizer control.

K. Integration to Lighting Panel(s)
   1. Control Contractor Provide a Carrier I-V Link for Intergration BACnet/IP.
   2. Lighting panel(s) provided and installed by Division 26 for monitoring and controlling of lighting and operation oriented graphic user interface.
   3. Lighting panels provided will support BACnet/IP. Any gateways or additional cards required will be provided and installed by Division 26.
   4. Refer to Electrical and Mechanical drawings for points will be integrated to the Carrier I-Vu web server BACnet/IP.

2.05 SYSTEM INTERFACE (District Wide Web Server Existing)

A. Description. The control system shall be as shown and consist of a high-speed, peer-to-peer network of DDC controllers and a stand alone web server operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. Operators with sufficient access level shall have an ability to make changes to all system and equipment graphics in the web server in addition to having full DDC system access to make configuration changes to the control system. Any tools required for making graphic changes shall be provided with web server.

B. Operator Interface. Operators shall be able to access all necessary operational information in the DDC system via client computer utilizing IE web browser. Client computer and IE web browsing software shall not be furnished under this section.
   1. Web server shall connect via the LAN and be able to simultaneously serve up controller information to multiple operators connected via LAN with IE web browsers. Each client web browser connected to server shall be able to access all system information.
   2. Web server shall be compatible with Wireless Access Protocol (WAP) enabled cellular telephone or personal digital assistant (PDA). The PDA/WAP interface may be text-based and shall provide a summary of the most important data.

3. With the use of a remote SMTP email server the operators interface web server shall be able to notify personnel of an alarm or record information about an alarm in the DDC system.

C. Web Server Hardware. Furnish one compact web server with Ethernet port for LAN or direct operator client computer access. The web server shall be capable of communicating to the peer to peer DDC controller network. Any required installation or commissioning software shall be pre-installed on the web server. Installation or commissioning of the web server shall be done through a client computer with a standard web browser.

D. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet Annex J.

E. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:
   1. Log In and Log Out. System shall require user name and password to log in to operator interface.
   2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
   3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as set points, PID gains, on and off controls, and sensor calibration.
   4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
   5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms. Remote users shall be able to receive alarms via emails or cell phone text messages.

6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

F. System Software.
1. Operating System and required software. Web server operator interface shall be a self contained web server without the need for any type of maintenance. Any required operating system or software shall be factory loaded and maintenance free.
2. System Graphics. Operator interface shall be graphical and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
    a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
    b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
    c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

G. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard Windows compatible PCs with no limit on the number of copies that can be installed under the system license.
1. Automatic System Database Configuration. Each web server shall store internally store a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. Operators shall be able to configure the system.
4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
5. Security. System shall require a user name and password to view, edit, add, or delete data.
   a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.
   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
   c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Points List. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server from each workstation or web browser interface.
11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Points List. Trends shall be BACnet trend objects.
12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:
    a. Reports shall be filtered based upon the selected equipment
    b. Alarm Reports
        1) Alarm Summary - Current alarms
        2) Alarm Sources – List of equipment and associated alarm conditions

3) Alarm Actions – Configured alarm actions such as e-mail and alarm pop-up

c. Schedule Reports
   1) Effective Schedules – Displays effective schedules for each equipment
   2) Schedule Instances – Displays all schedules entered

d. Security Reports – Maintains audit of all actions taken through user interface

e. Commissioning Reports – Provide equipment checkout status and notes

f. Equipment Reports – Provide reports showing trended points and available network points

15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

PART 3 - EXECUTION

3.01 GENERAL

A. All system components and appurtenances shall be installed in accordance with the manufacturer's instructions and requirements. All necessary interconnections, services and adjustments required for a complete and operable system, shall be provided by this contractor who shall be a Carrier certified installer of the systems herein.

302 INSTALLATION

A. GENERAL
   1. Electric Wiring: This contractor is responsible for all electrical installation and wiring for a fully operational Building Control System as shown on the drawings and shall include all items not shown on the electrical plans or required as per the electrical specifications. Perform all electrical installation in accordance with local and national electrical codes. Plenum wire may be used in ceilings where anchored support is provided every 10 feet.
   2. Provide shields as required by equipment manufacturer.

3.03 PERMITS AND FEES

A. This contractor shall secure and pay for all necessary permits, licenses and inspections as required by federal, state or local law. This includes providing required notices, plans, licenses, and fees, obtaining any necessary approvals from authorities having jurisdiction, and delivering any certificates of inspection as may be required. No work is to proceed until all proper certificates and licenses are obtained and posted.

3.04 CLEAN-UP

A. This contractor shall clean up regularly in order to maintain clean site conditions. In general, clean-up programs shall be scheduled by contractor at least once per week; however, the contractor shall clean up more often if required to meet OSHA standards.

B. This contractor is responsible for coordinating the work with other trades so as to eliminate unnecessary cutting and patching.

3.05 EQUIPMENT INSTALLATION

A. Space Thermostat and Sensor Locations: In general, locate thermostats and sensors for room control immediately inside door, next to light switch at approximately 48 inches from floor. Coordinate thermostat locations with General Contractor and approval by Engineer.

B. Local Control Panels: Mount all local control panels as indicated on the control drawings.

3.06 CUTTING AND PATCHING

A. This contractor is responsible for coordinating the work with other trades so as to eliminate unnecessary cutting and patching.

3.07 EQUIPMENT INSTALLATION

A. Space Thermostat and Sensor Locations: In general, locate thermostats and sensors for room control immediately inside door, above light switch at approximately 60 inches from floor. Coordinate thermostat locations with General Contractor and approval by Engineer.

B. Local Control Panels: Mount all local control panels as indicated on the control drawings.

3.08 OWNER TRAINING

A. Provide classroom training for 2 owner technicians, classes to include i-VU-Standard and Plus, i-VU-Open VVT, and i-VU-Advanced Graphics, total of 32 hours per student. Owner's representatives shall be provided a booklet showing the system layout, components, and operation and maintenance data.

B. Training to include.
   1. Explanation of drawings and diagrams.
   2. Walk-thru of jobsite to locate control components
   3. Overview of operation and maintenance features.
      a. System front end operation (where applicable)

C. Manufacturer will operate a free 40 hour a week customer support hotline for additional user support services that are required within the first 12 months after installation is accepted by Owner's Representative.

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-22:

1. Suction Lines for Air-Conditioning Applications: 185 psig (1276 kPa).
2. Suction Lines for Heat-Pump Applications: 325 psig (2241 kPa).
3. Hot-Gas and Liquid Lines: 325 psig (2241 kPa).

B. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

C. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

D. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.

2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: [1/4 inch equals 1 foot (1:50)] <**Insert value**>.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: [ASTM B 88, Type K or L (ASTM B 88M, Type A or B)] [**ASTM B 280, Type ACR**].

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.

2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
7. Maximum Operating Temperature: 330 deg F (165 deg C).

F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:

   a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
   b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.

2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [**24**] [**115**] [**208**]-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: [40 deg F (4.4 deg C)] <**Insert temperature**>.
6. Superheat: [**Adjustable**] [**Nonadjustable**].
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: [700 psig (4820 kPa)] [450 psig (3100 kPa)] <**Insert value**>.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: [**Internal**] [**External**].
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [**24**] [**115**] [**208**]-V ac coil.
8. End Connections: Socket.
9. Set Pressure: <**Insert** psig (kPa).>
10. Throttling Range: Maximum 5 psig (34 kPa).
11. Working Pressure Rating: 500 psig (3450 kPa).
12. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [**alumina**] [**charcoal**].
4. Designed for reverse flow (for heat-pump applications).

5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: [2 psig (14 kPa)] <**Insert value**>.
8. Rated Flow: <**Insert** tons (kW)**.**>
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [**alumina**] [**charcoal**].
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: [2 psig (14 kPa)] <**Insert value**>.
8. Rated Flow: <**Insert** tons (kW)**.**>
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.4 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.
5. **<Insert manufacturer's name.>**

C. ASHRAE 34, R-22: Monochlorodifluoromethane.

D. ASHRAE 34, R-134a: Tetrafluoroethane.

E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

F. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-22

A. Suction Lines [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [NPS 4 (DN 100) **and Smaller**] [NPS 2 to NPS 4 (DN 50 to DN 100)] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [NPS 2 to NPS 3 (DN 50 to DN 80)] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

1. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [NPS 2 to NPS 3 (DN 50 to DN 80)] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [NPS 4 (DN 100) **and Smaller**] [NPS 2 to NPS 4 (DN 50 to DN 100)] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

1. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**]joints.
3. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [NPS 4 (DN 100) **and Smaller**] [NPS 2 to NPS 4 (DN 50 to DN 100)] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [NPS 1 (DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1 (DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [NPS 1-1/4 to NPS 2 (DN 32 to DN 50)] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

1. [NPS 1 (DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 1 (DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**]joints.

3. [NPS 1-1/4 to NPS 2 (DN 32 to DN 50)] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [NPS 4 (DN 100)] <**Insert pipe size**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines [NPS 1-1/2 (DN 40) **and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [NPS 3-1/2 (DN 90) **and Smaller**] [NPS 2 to NPS 3-1/2 (DN 50 to DN 90)] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [L (B)], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

C. Suction Lines [NPS 4 (DN 100) **and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

F. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

G. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

H. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [NPS 5/8 (DN 18) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 3/4 to NPS 1 (DN 20 to DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [NPS 1-1/4 (DN 32) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

4. [NPS 1-1/2 to NPS 2 (DN 40 to DN 50)] <**Insert pipe size range**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

I. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**] [NPS 2 to NPS 4 (DN 50 to DN 100)] <**Insert pipe size range**>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

J. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

K. Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

L. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

M. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

N. Safety-Relief-Valve Discharge Piping:

1. [NPS 5/8 (DN 18) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [NPS 3/4 to NPS 1 (DN 20 to DN 25) **and Smaller**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [NPS 1-1/4 (DN 32) **and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. [NPS 1-1/2 to NPS 2 (DN 40 to DN 50)] <**Insert pipe size range**>: Copper, Type [**ACR**] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

O. Safety-Relief-Valve Discharge Piping [NPS 2 to NPS 4 (DN 50 to DN 100)] <**Insert pipe size range**>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.5 VALVE AND SPECIALTY APPLICATIONS

A. Install [**diaphragm packless**] [**packed-angle**] valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install [**diaphragm packless**] [**packed-angle**] valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve[, **and in the suction line at the compressor**].

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.6 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.

3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.7 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
2. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
3. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).

4. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).

E. Support multifloor vertical runs at least at each floor.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 23 31 13

METAL DUCTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Rectangular and round metal ducts and plenums for heating, ventilating, and air conditioning system from minus 2" to plus 5" water gage.

B. Section does not include laboratory exhaust system ductwork.

1.02 RELATED SECTIONS

A. Refer to other Division-23 sections for exterior insulation of metal ductwork.

B. Refer to other Division-23 sections for ductwork accessories

C. Refer to other Division-23 sections for fans and air handling units

D. Refer to other Division-23 sections for testing, adjusting and balancing of metal ductwork systems;

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for metal ductwork materials and products including but not limited to flexible ductwork, acoustical flexible ductwork, pre manufactured ductwork, duct liner, duct sealant and duct liner adhesive.

B. Record Drawings: At project closeout, submit record drawings of installed metal ductwork and ductwork products, in accordance with requirements of Division 01.

C. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Division 01.

D. Certified test data for the flexible duct.

1.04 QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.

B. Codes and Standards:
   1. SMACNA Standards: Comply with SMACNA "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork.
   2. ASHRAE Standards: Comply with ASHRAE Handbook, Equipment Volume, Chapter 1 "Duct Construction", for fabrication and installation of metal ductwork.
   3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" and NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems".

C. Field Reference Manual: Have available for reference at project field office, copy of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".

1.05 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Oil film on sheet metal should be removed before shipment to site. Contractor shall inspect ducts on site to confirm that no oil film is present. Remove any oil.

B. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

C. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

D. Cleaning: Dust and dirt on ducts shall be cleaned prior to installation, prior to substantial completion and prior to air circulation utilizing the ducts. HVAC system components or ductwork shall only be cleaned, coated, or have applied to its surface with disinfectants, pesticides or biocides that are registered and particularly labeled for use in HVAC systems by state and federal EPA.

PART 2 PRODUCTS

2.01 DUCTWORK MATERIALS

A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A527, lock forming quality, with G90 zinc coating in accordance with ASTM A525; and mill phosphatized for exposed locations.

2.02 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 18-degree change of direction per section. Unless specifically detailed otherwise, use 45-degree laterals and 45-degree elbows for branch takeoff connections. Where 90-degree branches are indicated, provide conical type tees.

C. Duct Liner:
1. Rectangular ductwork: one and two inch thick fiberglass with approved fire resistant coating for erosion control, located as shown on the drawings and as outlined on table below. Apply to flat sheets with full coverage adhesive and insulation pins prior to fabrication of duct or fittings. Duct liner to be from R. J. Manville, Knauf, Owen-Corning, CertainTeed, Manson or an approved equal manufacturer.
2. Circular Ductwork: Fiberglass duct liner manufactured to fit small and large radius round ducts. One inch thick with approved fire resistant coating for erosion control located as shown on the drawings. Apply to round ducts with full coverage adhesive prior to fabrication of ducts or fittings. Duct lining to be R. J. Manville,Spiracoustic Plus in ducts over 24" diameter and Schuler/Manville Permacote Spiracoustic in ducts under 24" diameter. Equal by Owen-Corning or CertainTeed. Duct sizes shown are net inside diameter. Increase duct sizes accordingly.
3. Duct liner shall comply with Thermal Insulation Manufacturer's Association {TIMA) AHC-101; of thickness indicated above and on the drawings. Provide 2" thick above roofline, unless indicated otherwise.
4. Duct insulation shall be installed on the exterior of ductwork. Duct lining for sound attenuation may be installed on the interior of ductwork. Lining material shall be certified to meet ASTM C1071 and ASTM C 1104 for surface erosion resistance and water vapor absorption. Refers to plan for lining requirement. (HPI EQ 2.0A)

D. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation". Adhesive used on the project shall meet the requirements of CALGreen section 5.504.4.1.

E. Duct Liner Fasteners: Comply with SMACNA "HVAC Duct Construction Standards", Article S2.11.

F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. Sealant used on the project shall meet the requirements of CALGreen section 5.504.4.1.

G. Duct Cement. Non-hardening migrating mastic or liquid neoprene based cement, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for cementing fitting components, or longitudinal seams in ductwork. Cement used on the project shall meet the requirements of CALGreen section 5.504.4.1.

H. Ductwork Support Materials; Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork. Provide seismic restraint as required.

I. Flexible ducts: Acoustical flexible air duct for connection between air distribution ductwork and air inlets and outlets shall be factory fabricated assembly consisting of a porous inner sleeve of spun-bounded non-woven nylon, insulation and an outer moisture barrier, flameproof vinyl jacket, complying with UL 181; with factory installed metal collar connectors and maximum length 5 feet. Acoustical performance of the acoustical air duct shall be in accordance with Air Diffusion Council Flexible Air Duct Test FD72R1: Paragraph 3.2.1, sound attenuation. The test data shall be made by an accredited independent laboratory in accordance with the above testing procedure. The sound attenuation (Insertion loss) of the acoustical flexible air duct shall meet or exceed the values tabulated below:

Straight Duct Insertion Loss in Decibels per Foot of length

Octave Band Center Frequency, Hertz								
Acoustical Flexible Duct Inner Diameter	63	125	250	500	1000	2000	4000	8000
6"	-	3.0	4.0	3.6	3.8	3.8	3.4	3.0
8"	-	1.6	3.4	3.2	3.5	4.0	3.6	2.2
12"	-	2.0	2.6	2.8	3.4	3.6	2.6	2.0

J. Provide Acoustical flexible ductwork of one of the following:
1. JP Lamborn Co. AMF-07 (www.jplflex.com), Fresno, CA
2. Casco, Silent-Flex II (www.casco-flex.com)
3. Or approved equal

K. Under slab Ducts: For ductwork placed in concrete slabs, or under slabs on grade, fabricate ductwork of one of the following materials:
1. Galvanized Steel.

2.03 FABRICATION

A. Shop-fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field

assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.

B. Shop-fabricate ductwork of gages and reinforcement complying with SMACNA "HVAC Duct Construction Standards".

C. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 degrees for contracting tapers and 20 degrees for expanding tapers.

D. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-23 section "Air Duct Accessories" for accessory requirements.

E. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners.

2.04 FACTORY-FABRICATED LOW PRESSURE DUCTWORK

A. General: At Installer's option, provide factory-fabricated duct and fittings, in lieu of shop-fabricated duct and fittings.

B. Material: Galvanized sheet steel complying with ASTM A517, lock forming quality, with ASTM A525, G90 zinc coating, mill phosphatized.

C. Gage: 28-gage minimum for round and oval ducts and fittings, 4" through 24" diameter.

D. Elbows: One-piece construction for 90 degrees and 45 degree elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint.

E. Divided Flow Fittings: 90-degree tees, constructed with saddle tap spot welded and bonded to duct fitting body.

F. Manufacturers: Subject to compliance with requirements, provide factory-fabricated ductwork of one of the following or equal:
1. Semco Mfg., Inc.
2. United Sheet Metal Division, United McGill Corp.

PART 3 EXECUTION

3.01 INSPECTION

A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION OF METAL DUCTWORK

A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight (5% leakage for systems rated 3" and under; 1% for systems rated over 3") and noiseless (no objectionable noise) systems capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type, which will hold ducts true-to-shape, and to prevent buckling. Support vertical ducts at every floor.

B. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

C. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

D. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

E. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2". Fasten to duct and substrate.
   1. Where ducts pass through fire-rated floors, walls, or partitions, provide fire stopping between duct and substrate.

F. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

G. Installation: Install metal ductwork in accordance with SMACNA "HVAC Duct Construction Standards".

3.03 INSTALLATION OF DUCT LINERS

A. General: Install duct liner in accordance with SMACNA "HVAC Duct Construction Standards".

3.04 INSTALLATION OF FLEXIBLE DUCTS

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5'-0" extended length.

B. Installation: Install in accordance with Section III of SMACNA, "HVAC Duct Construction Standards, Metal and Flexible" and shall be installed in accordance with the manufacturer's installation guide lines and recommended procedures. Before entering to the rear of any diffuser or grille, acoustical flex duct shall be straight and perpendicular to the diffuser for at least 3 duct diameters. Provide plenum box as shown on mechanical drawings for connection of flexible duct to the air inlet or outlets.

C. Bends in flexible ducts shall have a radius of not less 1.5 times the internal diameters.

3.05 INSTALLATION OF KITCHEN EXHAUST DUCTS

A. General: Fabricate joints and seams with continuous welds for watertight construction. Provide for thermal expansion of ductwork through 2000 degrees F (1093 degrees C) temperature range. Install without dips or traps, which may collect residues, except where traps have continuous or automatic residue removal. Provide access openings at each change in direction, located on sides of duct 1-1/2" minimum from bottom, and fitted with grease-tight covers of same material as duct.

3.06 EQUIPMENT CONNECTIONS

A. General: Connect metal ductwork to equipment as indicated; provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.07 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances, which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

B. Temporary closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Balancing: Refer to Division-23 section "Testing, Adjusting and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

END OF SECTION

SECTION 23 33 00
AIR DUCT ACCESSORIES

A. Types of ductwork accessories required for project include the following:

1. Damper
   a. Low pressure manual dampers
   b. Control dampers
   c. Counter-balanced relief dampers
2. Fire and smoke dampers
3. Turning vanes
4. Duct hardware
5. Duct access doors
6. Flexible connections
7. Duct Silencer

1.02 RELATED SECTIONS

A. Refer to other Division-23 sections for testing, adjusting, and balancing of ductwork accessories; not included in work of this section.

B. Division 23 Section "Metal Ductwork".

C. Division 25 Section "Automatic Temperature Control Systems".

D. Division 23 Section "Mechanical Identification".

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction, performance; and installation instructions.

1.04 QUALITY ASSURANCE

A. Codes and Standards:
1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
3. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers".
4. Fire dampers shall bear California State Fire Marshal Listing Number.
5. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

PART 2 PRODUCTS

2.01 DAMPERS

A. Low Pressure Manual Dampers: Provide dampers of single blade type of multi-blade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards". "Jiffy" type dampers are not acceptable.

2.02 BACKDRAFT DAMPERS

A. General: Provide back-draft dampers of types and sizes indicated. Construct casings of 0.090-thickness aluminum with mitered corners.

B. Blades, 0.025" formed aluminum with extruded vinyl edge seals. Bearings, Zytel. Linkage 1/8" x 1/8" aluminum tie bars concealed in frame.

C. Counter-balance: Zinc plated bar on blades (except top blade). Adjustable for final setting Mill finish.

D. Manufacturers: Subject to compliance with requirements, provide dampers of one of the following:
   1. Ruskin Manufacturing Co.
   2. Air Balance Co.
   3. Pottorff Company, Inc.

E. Control Dampers: Refer to Division-25 section "Control Systems" for control dampers; not work of this section.

F. Counterbalanced Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-ga. aluminum provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/2" x 16-ga channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

G. Manufacturer: Subject to compliance with requirements, provide dampers of one of the following:
   1. Air Balance, Inc.
   2. Ruskin Mfg. Co.
   3. Pottorff Company, Inc.

2.03 FIRE AND SMOKE DAMPERS

A. California State Fire Marshal approved, designed and constructed in accordance with NFPA 90A and UL Standard 555 and bear stamp showing compliance.

B. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-ga galvanized steel. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) (unless otherwise indicated.) Provide damper with positive lock in closed position, and with the following additional features.
   1. Damper Blade Assembly: Curtain type.

C. Manufacturer: Subject to compliance with requirements, provide fire and smoke dampers of one of the following:
   1. Air Balance, Inc.
   2. Ruskin Mfg. Co.
   3. Pottorff Company, Inc.

2.04 TURNING VANES

A. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2" wide curved blades set at 3/4" O.C., supported with bars perpendicular to blades set at 2" O.C., and set into side strips suitable for mounting in ductwork.

B. Acoustic Turning Vanes: Provide acoustic turning vanes constructed of airfoil shaped aluminum extrusion with perforated faces and fiberglass fill.

C. Manufacturer: Subject to compliance with requirements, provide turning vanes of one of the following:
   1. Aero Dynen Co.
   2. Anemostat Products Div.; Dynamics Corp. of America.
   3. Duro Dyne Corp.
   4. Environmental Elements Corp.; Subs, Koppers Co., Inc.
   5. Souther, Inc.

2.05 DUCT HARDWARE

A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
   1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
   2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Manufacturer: Subject to compliance with requirements, provide duct hardware of one of the following:
   1. Ventfabrics, Inc.
   2. Young Regulator Co.

2.06 DUCT ACCESS DOORS:

A. General: Provide duct access doors where required.

B. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for un-insulated ductwork, extended frames for externally insulated duct. Provide one side hinged other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

C. Manufacturer: Subject to compliance with requirements, provide duct access doors of one of the following:
   1. Air Balance Inc.
   2. Duro Dyne Corp.
   3. Register & Grille Mfg. Co., Inc.
   4. Ruskin Mfg. Co.
   5. Ventifabrics, Inc.
   6. Zurn Industries, Inc.; Air Systems Div.

2.07 FLEXIBLE CONNECTORS

A. General: Provide flexible duct connections wherever ductwork connects to vibration-isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse and torsional movement, and also capable of absorbing vibration of connected equipment.

B. Manufacturer: Subject to compliance with requirements, provide flexible connections of one of the following:
   1. American/Elgen Co.;Energy Div.
   2. Duro Dyne Corp.
   3. Flexaust (The) Co.
   4. Ventfabrics, Inc.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90-degree elbows in supply and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

E. Install duct silencer strictly per manufacturer's recommendation based on project specific sound attenuation requirements and to meet all requirements by acoustical engineer of the record.

3.03 FIELD QUALITY CONTROL

A. Operate install ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.

3.04 ADJUSTING AND CLEANING

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
   1. Label access doors in accordance with Division-23 section "Mechanical Identification".
   2. Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting, and Balancing".

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.05 EXTRA STOCK

A. Furnish extra fusible links to Owner, through the process in Section 01 70 00, one link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION

SECTION 23 37 00

AIR OUTLETS AND INLETS

PART1 GENERAL

1.01 SECTION INCLUDES

A. Types of outlets and inlets required for project include the following:
   1. Linear slot diffusers and returns.
   2. Ceiling air diffusers, rectangular, square, round.
   3. Wall registers and grilles.

1.02 RELATED SECTIONS

A. Refer to other Division-23 sections for ductwork and duct accessories required in conjunction with air outlets and inlets; not work of this section.

B. Refer to other Division-23 sections for balancing of air outlets and inlets; not work of this section.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:
   1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
   2. Data sheet for each type of air outlet and inlet, and accessories furnished; indicating construction, finish, and mounting details.
   3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.
   4. ANSI/ASHRAE Standard 70-1991.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 0 1.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver air outlets and inlets wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors, when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

1.05 QUALITY ASSURANCE

A. Codes and Standards:
   1. ANSI/ASHRAE Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ANSI/ASHRAE Standard 70-1991.
   2. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

PART 2 PRODUCTS

2.01 CEILING AIR DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems, which will contain each type of ceiling air diffuser.

2.02 MANUFACTURER

A. Subject to compliance with requirement diffusers of one of the following:
   1. Price Industries.
   2. Kreuger Mfg. Co.
   3. Nailor Industries, Inc.
   4. Titus Air Distribution Products
   5. Anemostat Air Distribution Products

B. Manufacturers and model numbers are listed and/or scheduled to set a standard of quality. Equivalent manufacturers and models accepted by Architect/Engineer may be used. Equivalents must be for review.
   1. Equivalents: Other manufacturers offering a similar product which is in accordance with the design criteria indicated may be submitted upon architect's written acceptance prior to bidding. The cost to conduct all tests as may be directed by the architect to demonstrate that the equivalent product can achieve the criteria indicated, including all travel costs, shall be borne by the submitting contractor.

2.03 LINEAR SLOT DIFFUSER AND RETURN

A. General: Provide acoustical ceiling air distribution system. Consisting of ceiling slot air diffusers, base frames, air chambers and entry collars.

B. Air Distribution Base Frames:
   1. Linear air diffusers base frames shall mechanically lock into the grid system. The base frames shall be extruded aluminum sections. Length shall be 48" unless otherwise noted or required.
   2. Provide air distribution base frame with full supply air pattern control air weir gates. When used for return air, these air weir gates act as a return airflow control damper. Close air weir gates where return is not necessary.
   3. Base frame shall present a substantially uniform appearance through the air slot when used as supply, returns or fully closed. All interior portions of the throat, including the vertical stems of the extrusions, shall be painted flat black to prevent unsightly visual deviations. Paint all exposed surfaces baked white enamel. Base frame shall be compatible with type of ceiling where linear slot diffuser is installed.
   4. Base frame shall be provided with spacer channels located on the ceiling module. The spacer channel shall act as the support means for the adjustable full pattern control air weir gates, which are provided throughout the entire length of the base frame.
   5. The noise criteria of the air distribution base frame shall be expressed in sound power levels (decibels 10-12 watts) in octave bands 2 through 7 with a room attenuation of 10 decibels and shall not exceed a noise criteria of 30. All data shall be based on tests performed in a certified laboratory.
   6. Where noted on drawings or as required, blank-off airtight backside of supply air linear slot where duct connection is not made.

C. Supply or Return Air Chambers:
   1. Supply or Return air plenum chambers shall be designed, tested, and fabricated by the same manufacturer that furnishes the base frames. Shop fabricated air chambers not acceptable. Provide with damper at inlet to plenum, which is accessible through face of linear diffuser for adjustment.
   2. Provide adjustable air pattern controllers that are accessible through the base frame slot for field adjustment of the spread of the air stream. This will be accomplished without the removal of acoustical tile.
   3. Provide a round neck air entry collar sized for maximum average air entry velocity of 750 FPM. A volume damper shall be installed at connection to plenum, which is accessible through face of diffuser for adjustment.
   4. Construct supply air chamber from not less than 26 gauge galvanized steel and will be lined with one- quarter inch 2 lb./cu. ft. density thermal acoustical insulating. All surfaces visible through the slot will be painted flat black.
   5. Provide spring clip keepers to securely attach the chamber to the base frame when in operation. These spring clips permit releasing of the air chamber for easy relocation.
   6. The supply air chamber shall have been tested as composite assembly with the linear base frame for air distribution and noise level performance. The tests shall be conducted in accordance with ANSI/ASHRAE Standard 70-1991.
   7. For return air plenums above the ceiling, install Krueger model DFRH plenum hood on all linear return air bars.

D. Manufacturer: Krueger model DFL linear slot diffuser or approved equal.

2.04 CEILING RETURN AND EXHAUST GRILLES AND REGISTERS

(All constant air volume systems unless otherwise noted.)

A. Concealed Spline - Krueger ASDT

B. Glued on Acoustile - Krueger ASDT

C. Plaster or drywall- Krueger EGC5 or EGC5-01.

D. 24" x 24" T-bar- Krueger EGC5 or EGC5-01.

Note: For 24" x 48" T-bar ceilings, coordinate with ceiling installer for auxiliary tees as required to provide 24" x 24" space.

2.05 SIDEWALL SUPPLY AND RETURN REGISTERS AND GRILLES

A. Supply register- Krueger aaov.

B. Return register- Krueger sao.

C. Return grille - Krueger sao.

2.06 TRANSFER GRILLES

A. Ceiling - Same as return grilles.

2.07 CEILING DIFFUSERS (SUPPLY)

(Constant air volume systems unless otherwise noted.)

A. Concealed Spline - Krueger ASDT

B. Glued on Acoustile - Krueger ASDT

C. Plaster or Drywall- Krueger 1240

D. 24" x 24" T-Bar- Krueger 1240

Note: For 24" x 48" T-bar ceilings, coordinate with ceiling installer for auxiliary tees as required to create 24" x 24" space.

2.08 MODULAR CEILING DIFFUSERS

(All V.A.V. systems unless otherwise noted.)

A. Krueger Model 1900SQ and shall have a frame style to interface with the ceiling grid system being used.

B. Manufactured from extruded aluminum. Provided with air pattern control weirs, and an integral deflection rail allowing for one- to four-way direction air flow producing uniform ceiling effect.

C. The air motion in the occupancy zone at maximum cubic feet per minute shall not exceed 50 feet per minute. Inner panel of matching acoustical tile shall provide an airtight joint.

D. Supply, Return and Exhaust Chambers:
   1. Designed and fabricated by the manufacturer of the base frames. Field fabricated chambers will not be accepted. Chamber to be supplied with spring clips to attach to the base frame. Constructed from not less than 26 gauge galvanized steel and lined with 1/4" 2 LB./CU. FT. density thermal insulation. All surfaces visible through the air slot painted flat black.
   2. Chamber shall be supplied with a factory installed round entry collar for flex duct connection. Collar shall be sized for maximum average air entry velocity of 750 fpm. Chamber must be tested as a composite assembly with the base frame for air distribution and noise level performance by a certified testing laboratory. If used with side inlet, furnish and install vertical pressure equalizing baffle.

2.09 MODULAR CEILING RETURN

(All V.A.V. systems unless otherwise noted.)

A. Krueger Model 1900SQ return diffuser.

B. Base frame from extruded aluminum. Frame shall have fixed weirs creating a continuous one-inch closed slot. Provide opposite blade volume damper.

C. The slots connection to each other is provided with tabs at each corner of slots. These tabs shall be solid and no holes shall be on these tabs, to reduce the visibility of these tabs paint with dark color (Black).

2.10 SUPPLY, RETURN AND EXHAUST CONNECTIONS TO METAL LINEAR CEILING

A. Air Factors sheet metal air boot (eight-slot) for connecting to back of metal linear ceiling with slot openings (with labyrinths, as applicable) for supply, return, and exhaust. Air boot shall lock onto back of ceiling system.

2.11 CIRCULAR CEILING DIFFUSERS

(All circular ceiling diffusers unless otherwise noted.)

A. Krueger Model RA2 circular diffuser with adjustable inner cone.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

C. Coordinate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

D. Supply outlets to provide the required air throw and spread with no apparent drafts or excessive air movement within space being supplied. Contractor to provide necessary accessories to accomplish satisfactory air distribution.

E. Provide felt, cork or rubber gasket between finish surface and frame to prevent vibration and assure tight fit. Contractor shall be responsible for the correct location of ductwork and outlets.

F. For filler panel type outlets the manufacturer shall coordinate his design with the ceiling suspension system being used. The Contractor and manufacturer shall match up sizes of outlets to properly fit in ceiling systems, between concrete or masonry components, between architectural items before fabrication.

G. When installing removable core type outlets, secure to frame with screws.

H. Secure outlets to ceiling suspension systems as required by Division of the State Architect.

END OF SECTION

SECTION 23 81 26

SPLIT AIR CONDITIONING SYSTEM

PART1 GENERAL

1.01 SECTION INCLUDES

A. Split DX cooling only and heat pump system with indoor split DX fan coil and outdoor cooling/condensing unit.

1.02 RELATED SECTIONS

A. Related sections include but are not limited to the following:
   1. Division 23
      a. Section Common Work Results for HVAC
      b. Section Common Motor Requirements for HVAC
      c. Section Temperature Control Systems required in conjunction with split cooling system
      d. Section Testing, Adjusting and Balancing
      e. Section "Maximum Sound Power Level for Fan Equipment"
   2. Division - 26:
      a. Section Electrical Connections for Equipment

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit shop drawings detailing the manufacturer's electrical requirements for power supply wiring for rooftop cooling/condensing and DX fan coil units.

   Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

   2. Submit shop drawings detailing the mounting, securing, and flashing of the outdoor unit to redwood sleepers and sleepers to the roof structure. Indicate coordinating requirements with roof membrane system.

C. Operation and Maintenance Data: Submit maintenance data and parts list for each split cooling system, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual in accordance with requirements of Division 01.

1.04 QUALITY ASSURANCE

A. Codes and Standards:
   1. Refrigerating system construction of split cooling system shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
   2. Seasonal Energy Efficiency Ratio (SEER) of split cooling system shall be equal to or greater than prescribed by Title 24 California Administrative Code "2005 Building Energy Efficiency Standards".
   3. Split cooling system shall be designed, manufactured, and tested in accordance with UL requirements.

1.05 DELIVERY, STORAGE AND HANDLING

A. Handle split cooling system and components carefully to prevent damage. Replace damaged rooftop units or components with new.

B. Store split cooling system and components in clean dry place, off the ground, and protect from weather, water, and physical damage.

C. Rig outdoor units to comply with manufacturer's rigging and installation instructions for unloading outdoor units, and moving them to final location.

1.06 SCHEDULING AND SEQUENCING

A. Coordinate installation of outdoor unit sleepers with roof structure.

B. Coordinate roof-opening locations for mechanical and electrical connections.

1.07 SPECIAL WARRANTY

A. Warranty on Compressor: Provide written warranty, agreeing to replace/repair, including all parts and labor within warranty period, compressors with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform a required provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.

B. Warranty period shall be for a period of one year from the agreed start of the District's beneficial use.

C. Extended warranty period. Provide written warranty signed by manufacturer, agreeing to replace components parts only, for an additional four (4) years for all hermetically sealed compressors.

1.08 MAINTENANCE

A. Extra Materials: Furnish to District, with receipt, the following spare parts for each split cooling system:
   1. One set new filters for each unit set.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Provide product of one of the following manufacturers:
   1. Carrier Corp.
   2. York

2.02 SPLIT COOLING SYSTEM (GENERAL)

A. Split cooling only and heat pump system shall be factory assembled and tested, consist of an indoor, wall mounted direct expansion fan coil unit and an outdoor roof mounted, air cooled unit with a hermetic compressor, an air cooled coil, up-blast propeller type blow-through condenser fans, accumulator, holding refrigerant charge, and control box.

2.03 INDOOR UNIT

A. General: Indoor, direct-expansion, wall-mounted or ceiling-mounted fan coil. Unit shall be complete with coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, integral temperature sensing, and a holding charge of R-410A refrigerant. Unit shall be furnished with integral wall-mounting or ceiling-mounting bracket.

B. Unit Cabinet: Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene.

C. Fan: Shall be tangential blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic motor-driven horizontal air sweep shall be provided standard.

D. Coil: Shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate.

E. Motors: Shall be permanently lubricated with inherent overload protection. Fan motors shall be multi-speed.

F. Controls: Shall consist of a microprocessor-based control system that shall control space temperature, determine optimum fan speed, and run self-diagnostics. The unit shall have:
1. An automatic restart after power failure at the same operating conditions as at failure.
2. A timer function to provide a minimum 15-hour timer cycle for system on or off.
3. Temperature-sensing controls and a high discharge temperature shut down.
4. Wired control or wireless infrared control to enter set points and operating controls (required accessory).
5. Filter status indication after 250 hours of indoor fan operation.
6. Test mode button to run self-diagnostics and aid in troubleshooting.

G. Filters: Unit shall have filter track with factory-supplied cleanable filter.

2.04 OUTDOOR UNIT

A. General: Factory assembled, single piece, air-cooled outdoor unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, and holding charge of R-41OA refrigerant.

B. Unit Cabinet:
1. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a baked enamel finish.
2. Unit access panels shall be removable with minimal screws and shall provide full access to the compressor, fan, and control components.
3. Compressor compartment shall be isolated and have an acoustic lining to assure quiet operation.

C. Fans:
1. Condenser fans shall be direct-drive propeller type, discharging air horizontally, and blowing air through the condenser coil.
2. Condenser fan motors shall be totally enclosed, single-phase motors with class B insulation and permanently lubricated ball bearings. Motor shall be protected by internal thermal overload protection.
3. Shaft shall have inherent corrosion resistance.
4. Fan blades shall be corrosion resistant and shall be statically and dynamically balanced.
5. Condenser fan openings shall be equipped with PVC grille cover and screen protection grille.

D. Compressor:
1. Compressor shall be fully hermetic reciprocating or scroll type.
2. Compressor shall be equipped with oil system, operating oil charge, and motor. Internal overloads shall protect the compressor from over temperature and current. Scroll compressors shall also have high discharge gas temperature protection.
3. Motor shall be NEMA rated class F, suitable for operation in a refrigerant atmosphere.
4. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigeration accumulation in compressor during shut down and to prevent refrigerant dilution of oil.
5. Compressor assembly shall be installed on rubber vibration isolators and shall have internal spring isolation.

E. Condenser Coil: Shall be constructed of aluminum fins mechanically bonded to internally enhanced, seamless copper tubes that are cleaned, dehydrated, and sealed.

F. Refrigeration Components: Refrigerant circuit components shall include external liquid line service valve with service port, suction line service valve with service gage connection port, service port connections on compressor suction and discharge lines with Schrader-type fittings, 4-way valve on heat pumps, accumulator, filter drier, pressure relief, and a holding charge of refrigerant.

G. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control function shall include:
   1. Controls:
      a. Time delay restart to prevent compressor short cycling.
      b. Automatic restart on power failure.
      c. Three-pole contactors on 3-phase units.
      d. Safety lockout.
      e. High and low pressure switches.
      f. Automatic fan motor protection.
      g. Start capacitor and relay only on single-phase units.
      h. When heat pump units are matched with high wall and ceiling suspended units, defrost control shall be based on demand determined by the outdoor air temperature and the coil temperature.
   2. Safeties:
      a. High temperature protection.
      b. System diagnostics.
      c. Compressor motor current and temperature overload protection.
      d. High-pressure relief.
      e. Condenser fan failure protection.

H. Electrical Requirements:
   1. Unit electrical power shall be a single point connection.
   2. Unit control voltage to the indoor fan coil shall be 24V.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which split cooling system is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION

A. General: Install split cooling system in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support: Install and secure redwood sleepers to roof structure, in accordance with National Roofing Contractor's Association (NRCA) installation recommendations and shop drawings.

C. Electrical Connections: Refer to Division-26 Electrical Connections for Equipment for final connections to equipment and installation of loose-shipped electrical components.

3.03 DEMONSTRATION

A. Provide the services of a qualified service representative to start-up split cooling system in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
B. Provide two, 1-hour training sessions for staff/operations and maintenance. One session before beneficial occupancy, and one session within 3 months after beneficial occupancy.

END OF SECTION

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to, the following:
   1. Examine all other sections for work related to those other sections and required to be included as work under this section.
   2. Electrical General Provisions and requirements for electrical work.
   3. Division-1; General Requirements; General Conditions.

B. Organization of the specifications into divisions, sections and articles, and arrangement of drawings shall not control the CONTRACTOR in dividing the contract work among subcontractors or in establishing the extent of work to be performed by any trade.

1.02 GENERAL SUMMARY OF ELECTRICAL WORK

A. The specifications and drawings are intended to cover a complete installation of systems. The omission of expressed reference to any item of labor or material for the proper execution of the work in accordance with present practice of the trade shall not relieve the CONTRACTOR from providing such additional labor and materials.

B. Refer to the drawings and shop drawings of other trades for additional details, which affect the proper installation of this work. Diagrams and symbols showing electrical connections are diagrammatic only. Wiring diagrams do not necessarily show the exact physical arrangement of the equipment.

C. Before submitting a bid, the CONTRACTOR shall become familiar with all features of the building drawings and site drawings, which may affect the execution of the work. No extra payment will be allowed for failure to obtain this information.

D. If there are omissions or conflicts between the drawings and specifications, clarify these points with the District's Representative before submitting bid and before commencing work.

E. Provide work and material in conformance with the manufacturer's published recommendations for respective equipment and systems.

1.03 LOCATIONS OF EQUIPMENT

A. The drawings indicate diagrammatically the desired locations or arrangements of conduit runs, outlets, equipment, etc., and are to be followed as closely as possible. Proper judgment must be exercised in executing the work so as to secure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structure conditions encountered.

B. Where outlets are placed on a wall, locate symmetrically with respect to each other, furniture, cabinets, and other features or finishes on the wall.

C. In the event changes in the indicated locations or arrangements are necessary, due to developed conditions in the building construction or rearrangement of furnishings or equipment, such changes shall be made without cost to the contract, providing the change is ordered before the conduit runs, etc., and work directly connected to same is installed and no extra materials are required.

D. Lighting fixtures in mechanical spaces are shown in their approximate location only. Do not install light outlets or fixtures until mechanical piping and ductwork is installed; then install lights in a location to provide best lighting.

E. Coordinate and cooperate in every way with other trades in order to avoid interference and assure

a satisfactory job.

F. The location of the existing utilities, building, equipment and conduit shown on the drawings is approximate. Verify exact locations and routing of existing systems by potholing all trench routes prior to digging the trench. Pothole at least 100 feet ahead of the actual trenching to allow space to alter the new conduit routing to accommodate existing conditions.

1.04 AIR CONDITIONING, HEATING, PLUMBING EQUIPMENT WIRING

A. Provide electrical work, materials, and control components required for proper operation of the air conditioning, heating and plumbing systems as indicated on the electrical, mechanical, and plumbing Contract Documents and specified herein.

1.06 PERMITS

Take out and pay for all required permits, inspections and examinations without additional cost to the DISTRICT.

1.07 QUALITY ASSURANCE

A. Work and materials shall be in full accordance with the latest rules and regulations as follows. The following publications shall be included in the contract documents requirements. If a conflict occurs between the following publications and any other part of the contract documents, the requirements describing the more restrictive provisions shall become the applicable contract definition:
   1. California Code of Regulations Title 24.
   2. California Part 3 "California Electrical Code" CEC, Title 24 and Title 8 "Division of Industrial Safety".
   3. California Building Code - CBC.
   4. California Fire Code – CFC
   5. The National Electrical Code – NEC/NFPA 70.
   6. The Life Safety Code – NFPA 101.
   7. The Uniform Building Code - UBC.
   8. International Building Code – IBC.
   9. National Fire Protection Agency-NFPA.
   10. National Fire Alarm Code – NFAC/NFPA 72.
   11. Underwriter's Laboratory-UL.
   12. Other applicable State and Local Government Agencies laws and regulations.
   13. Electrical Installation Standards National Electrical Contractors Association (NECA) and National Electrical Installation Standards (NEIS):
      a. NECA/NEIS-1: Standard of Practices for Good Workmanship in Electrical Contracting
      b. NECA/NEIS-101: Standard for Installing Steel Conduit (Rigid, IMC, etc.)
      f. NECA/NEIS-230: Recommended Practice for Installing Motors
      j. NECA/NEIS-400: Recommended Practice for Installing and Maintaining Switchboards
      k. NECA/NEIS-402: Recommended Practice for Installing and Maintaining Motor Control Centers
      n. NECA/NEIS-407: Recommended Practice for Installing Panelboards

B. All material and equipment shall be new and shall be delivered to the site in unbroken packages. All material and equipment shall be listed and labeled by Underwriters Laboratories or other recognized testing laboratories, where such listings are available. Comply with all installation requirements and restrictions pertaining to such listings.

C. Work and material shown on the drawings and in the specifications is new and included in the contract unless specifically indicated as existing or N.I.C. (not in contract).

D. Keep a copy of all applicable codes and standards available at the job site at all times for reference while performing work under this contract. Nothing in plans or specifications shall be construed to permit work not conforming to the most stringent of building codes.

E. Where a conflict or variation occurs between applicable Codes, standards and/or the Contract

Documents, the provisions of the most restrictive provision shall become the requirement of the Contract Documents.

1.08 SUBMITTALS (ADDITIONAL REQUIREMENTS)

A. General

1. Review of CONTRACTOR'S submittals is for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the plans and specifications. CONTRACTOR is responsible for quantities; dimensions which shall be confirmed and correlated at the job site; fabrication processes and techniques of construction; coordination of work with that of all other trades and satisfactory performance of their work.
2. The CONTRACTOR shall review each submittal in detail for compliance with the requirements of the contract documents prior to submittal. The CONTRACTOR shall "Ink Stamp" and sign each item of the submittal with a statement "CERTIFYING THE SUBMITTAL HAS BEEN REVIEWED BY THE CONTRACTOR AND COMPLIES WITH ALL THE REQUIREMENTS OF THE CONTRACT DOCUMENTS". The CONTRACTOR shall clearly and specifically identify each individual proposed substitution, substitution of equal, or proposed deviation from the requirements of the contract documents with a statement "THIS ITEM IS A SUBSTITUTION".
   The burden of research, preparation of calculations and the furnishing of adequate and complete shop drawings information to demonstrate the suitability of CONTRACTOR's proposed substitutions and suitability of proposed deviations from the contract documents is the responsibility of the CONTRACTOR.
3. Departure from the submittal procedure will result in resubmittals and delays. Failure of the CONTRACTOR to comply with the submittal requirements shall render void any acceptance or any approval of the proposed variation. The CONTRACTOR shall then be required to provide the equipment or method without variation from the contract documents and without additional cost to the contract.
4. The CONTRACTOR at no additional cost or delays to the contract shall remove any work, material and correct any deficiencies resulting from deviations from the requirements of the contract documents not approved in advance by the DISTRICT prior to commencement of work.
5. Shop drawings submitted by the CONTRACTOR, which are not specifically required for submittal by the Contract Documents, or CONTRACTOR shop drawings previously reviewed and resubmitted without a written resubmittal request to the CONTRACTOR, will not be reviewed, considered, or commented on. The respective shop drawing submittal /resubmittal will not be returned to the CONTRACTOR and will be destroyed without comment or response to the CONTRACTOR. The respective submittal shall be considered null and void as being not in compliance with the requirements of the Contract Documents.
6. Refer to Division-1 for additional requirements.

B. Material Lists and Shop Drawings

1. Submit material list and equipment manufacturers for review within 35 days of award of contract. Give name of manufacturer and where applicable, brand name, type and/or catalog number of each item. Listing of more than one manufacturer for any one item of equipment, or listing items "as specified", without both make and model or type designation, is not acceptable. Shop drawings shall not be submitted before review completion of manufacturers list. The right is reserved to require submission of samples of any material whether or not particularly mentioned herein.
2. After completion of review of the material and equipment manufacturers list, submit shop drawings for review. Shop drawings shall be submitted in completed bound groups of materials (i.e., all lighting fixtures or all switchgear, etc.). The CONTRACTOR shall verify dimensions of equipment and be satisfied as to fit and that they comply with all code requirements relating to clear working space about electrical equipment prior to submitting shop drawings for review. Submittals, which are intended to be reviewed as substitution or departure from the contract documents, must be specifically noted as such. The requirements of the contract documents shall prevail regardless of the acceptance of the submittal.
3. Shop drawings shall include catalog data sheets, instruction manuals, dimensioned plans,

elevations, details, wiring diagrams, and descriptive literature of component parts where applicable. Structural calculations and mounting details, signed by a Structural ENGINEER registered by the State of California, shall be submitted for all equipment weighing over four hundred pounds, and shall be in compliance with Title 21 of the California Code of Regulations.

4. Each shop drawing item shall be identified with the specification section and paragraph numbers, lighting fixture types and drawing sheet numbers; the specific shop drawing is intended to represent. Shop drawings 11-inches by 17-inches or smaller in size shall be bound in three (3) ring binders. Divider tabs shall be provided in the three (3) ring binders identifying and separating each separate shop drawing submittal item. Shop drawings larger than 11-inches by 17-inches, shop drawing pages/sheets submittals shall be sequentially numbered with unique alphanumeric numbering system to facilitate correspondence referencing identification of individual sheets.
5. The time required to review and comment on the CONTRACTOR'S submittals will not be less than 14 calendar days, after receipt of the submittals at the office of FBA Engineering. The review of CONTRACTOR submittals and return to CONTRACTOR of submittals with review comments will occur in a timely manner conditioned upon the CONTRACTOR complying with all of the following:
   a. The submittals contain complete and accurate information, complying with the requirements of the Contract Documents.
   b. CONTRACTOR'S submittals are each marked with CONTRACTOR'S approval "stamp", and with CONTRACTOR signatures.
   c. The submittals are received in accordance with a written, shop drawing submittal schedule for each submittal. The CONTRACTOR distributes the schedule not less than 35-calendar days in advance of the Shop Drawing Submittals, and the schedule identifies the calendar dates, the CONTRACTOR will deliver the various submittals for review.
6. Shop drawings shall include the manufacturers projected days for shipment from the factory of completed equipment, after the CONTRACTOR releases the equipment for production. It shall be the responsibility of the CONTRACTOR to insure that all material and equipment is ordered in time to provide an orderly progression of the work. The CONTRACTOR shall notify the District's Representative of any changes in delivery, which would affect the project completion date.
7. Submittal Identification
   a. Each submittal shall be dated: with submittal transmission date; sequentially numbered and titled with submittal contents identification and applicable specification/drawing references *(i.e., Submittal dated: 5/12/98 Submittal #4 Contents: Branch circuit panelboards Sheet #E5.1 and transformers Specification Section 16050 Paragraph 2.11, etc.)*.
   b. Each resubmittal shall be dated: with original submittal date and resubmittal transmission dates; sequentially numbered with original submittal number and sequential resubmittal revision number and titled with submittal contents identification and applicable specifications/drawing references *(i.e., Original Submittal Date: 5/12/98 Resubmittal Date: 10/9/98 Original Submittal #4 resubmittal Revision R2 Contents: Transformer resubmittal Specification Section - 16050 Paragraph 2.11, etc.)*.
   c. Contractor shall provide a written response narrative with each resubmittal. Describe each response-action, resubmittal addition, change and deletion. Correspond each response to A/E specific review comment.

C. The CONTRACTOR shall be responsible for incidental, direct and indirect costs resulting from the CONTRACTOR'S substitution of; or changes to; the specified contract materials and work.

D. The CONTRACTOR shall pay, upon request by the District's Representative, a fee for the District's Representative time involved in the review of substitution submittals and design changes resulting from the CONTRACTOR'S requested substitutions. The fee shall be not less than $125.00 per hour but, in no case, less than stated in Division-1, whichever is greater.

E. Maintenance and Operating Manuals
   1. The CONTRACTOR shall furnish three (3) copies of type-written maintenance and operating manuals for all electrical equipment, etc., to the District.
   2. Instruct the District's personnel in correct operation of all equipment at completion of project. Provide the quantity and duration of instruction class as specified; but in no case less than two (2) 4-hour duration separate instruction classes for each individual equipment group furnished as part of the contract. Instruction classes shall be presented by Manufacturer's authorized field service

ENGINEER at the project site. Instruction class size shall be at the District's discretion, not less than one (1) or more than fifteen (15) students shall attend each instruction session. Submit fifteen (15) written outline copies of the proposed instruction class curriculum, 14-days prior to the class-scheduled dates.

3. Maintenance and operating manuals shall be bound in three-ring, hard-cover, plastic binders with table of contents. Manuals shall be delivered to the District's Representative, with an itemized receipt.

F. Portable or Detachable Parts: The CONTRACTOR shall retain in his possession, and shall be responsible for all portable and detachable parts or portions of the installation such as fuses, keys, locks, adapters, locking clips, and inserts until final completion of contract work. These parts shall then be delivered to the District's Representative with an itemized receipt.

G. Record Drawings (ADDITIONAL REQUIREMENTS)

1. Provide and maintain in good order a complete set of electrical contract "record" prints. Changes to the contract to be clearly recorded on this set of prints. At the end of the project, transfer all changes to one set of transparencies to be delivered unfolded to the District's Representative.
2. The actual location and elevation of all buried lines, boxes, monuments, vaults, stub-outs and other provisions for future connections shall be referenced to the building lines or other clearly established base lines and to approved bench marks. If any necessary dimensions are omitted from the record drawings, the CONTRACTOR shall, at THE Contractor's own expense, do all excavation required to expose the buried work and to establish the correct locations.
3. The CONTRACTOR shall keep the "record" prints up to date and current with all work performed.
4. Refer to Division-1 for additional requirements.

1.09 CLEANING EQUIPMENT, MATERIALS, PREMISES

All parts of the equipment shall be thoroughly cleaned of dirt, rust, cement, plaster, etc., and all cracks and corners scraped out clean. Surfaces to be painted shall be carefully cleaned of grease and oil spots and left smooth, clean and in proper condition to receive paint finish.

1.10 JOB CONDITIONS - PROTECTION

Protect all work, materials and equipment from damage from any cause whatever and provide adequate and proper storage facilities during the progress of the work. Provide for the safety and good condition of all the work until final acceptance of the work by the District and replace all damaged or defective work, materials, and equipment before requesting final acceptance.

1.11 EXCAVATION, CUTTING, BACKFILL AND PATCHING ADDITIONAL REQUIREMENTS

A. General

1. Perform excavation, cutting, backfill, core drilling, directional boring, and patching of the construction work required for the proper installation of the electrical work.
2. Patching shall be of the same material, thickness, workmanship, and finish as existing and accurately match-surrounding work to the satisfaction of the District's Representative.
3. Prior to penetrating, coring, drilling or cutting existing building elements, concrete and/or masonry, provide imaging equipment examinations of each specific location. The imaging process shall identify existing internal embedded components and locations, including structural elements/anchors, conduit, and piping that are present. Do not penetrate or damage the existing internal embedded elements. Imaging shall employ one (1) of the following, with GPR methodology preferred:
   a. Non-invasive imaging employing high frequency, ground penetrating radar (GPR), single side echo reflection technology.
   b. Non-invasive imaging employing x-ray radiography, through-and-through imaging technology.

1.12 IDENTIFICATION

A. Equipment Nameplates
   1. Panelboards, terminal cabinets, circuit breakers, disconnect switches, starters, relays, time switches, contactors, push-button control stations, and other apparatus used for the operation or control of feeders, circuits, appliances, or equipment shall be properly identified by means of descriptive nameplates or tags permanently attached to the apparatus and wiring.
   2. Provide nameplate label on electrical service entrance equipment describing available short circuit information calculated by the CONTRACTOR, including:
      a. Calculation date, month-day-year.
      b. Calculate maximum available short circuit fault current.
      c. Description of parameters and changes affecting the requirements for recalculation of the fault current information.
   3. Electrical equipment including switchgear, switchboards, electric panels and control panels, motor control centers, combination motor starters, transformers, disconnects, etc., shall each be labeled by the manufacturer with "Electric-ARC-FLASH" warning signs. The signs shall explain a hazard to personnel may exist if the equipment is worked on while energized or operated by personnel while energized. The sign shall instruct personnel to wear the correct protective equipment/clothing (PPE) when working "Live", or operating "Live" electrical equipment and circuits.
   4. Nameplates shall be engraved laminated phenolic. Shop drawings with dimensions and format shall be submitted before installation. Attachment to equipment shall be with escutcheon pins, rivets, self-tapping screws or machine screws. Self-adhering or adhesive backed nameplates shall not be used.
   5. Provide black-on-white laminated plastic nameplates engraved in minimum ¼-inch high letters to correspond with the designations on the drawings. Provide other or additional information on nameplates where indicated.

B. Plates: All cover and device plates shall be furnished with engraved or etched designations under any one of the following conditions (minimum character size not less than 0.188 inch. Engraving shall indicate circuits and equipment controlled or connected):
   1. More than two (2) devices under a common coverplate.
   2. Lock switches.
   3. Pilot switches.
   4. Switches in locations from which the equipment or circuits controlled cannot be readily seen.
   5. Manual motor starting switches.
   6. Where so indicated on the drawings.
   7. As required on all control circuit switches, such as heater controls, motor controls, etc.
   8. Receptacles other than standard 15 ampere 120 volt duplex receptacles; shall indicate circuit voltage, ampere, phase and source circuit number.
   9. Where outlets or switches are connected to emergency power circuit; provide panelboard and circuit number engraved on plate.
   10. Low voltage and signal system outlets.

C. For equipment and access doors or gates to equipment containing or operating on circuits of more than 100 volts AC or DC nominal. Provide red-on-white laminated warning signs engraved in ½-inch high letters to read: "DANGER - 480 *(or applicable voltage)* VOLTS KEEP OUT AUTHORIZED PERSONNEL ONLY".

D. Wire and Cable Identification
   1. Provide identification on individual wire and cable including signal systems, fire alarm, electrical power systems (each individual phase, neutral and ground), empty conduit pull ropes, and controls circuit.
   2. Permanent identification shall be provided at each termination location, splice location, pullbox, junction box and equipment enclosure.
      a. Individual wire and cable larger than #6AWG or 0.25-inch diameter, shall be provided with polypropylene identification tag holders, with yellow polypropylene tags interchangeable black alphanumeric characters, character height 0.25 inch. Attach identification tags with plastic "tie" wraps, minimum of two (2) for each tag. As manufactured by Almetek Industries- "EZTAG" series; or TECH Products - "EVERLAST" series.
      b. Individual wire and cable #6AWG and smaller or smaller than 0.25 inch diameter, shall be

provided with water and oil resistant, flexible, self-laminating pressure sensitive machine embossed plastic tags that wrap a minimum of 360 degrees around the wire/ cable diameter. The entire tag shall then be covered with a clear flexible waterproof plastic cover wrapped a minimum of 540 degrees around the wire/cable diameter and completely covering the identification. As manufactured by Brady Identification; or 3M; or Panduit.

c. Each identification tag location shall indicate the following information: circuit number, circuit phase, source termination and destination termination equipment name (or outlet number as applicable).

3. Install permanent identification after installation /pulling of wire/cable is complete, to prevent loss or damage to the identification.

E. Cardholders and cards shall be provided for circuit identification in panelboards. Cardholders shall consist of a metal frame retaining a clear plastic cover permanently attached to the inside of panel door. List of circuits shall be typewritten on card. Circuit description shall include name or number of circuit, area, and connected load.

F. Junction and pull boxes shall have covers stenciled with box number when shown on the drawings, or circuit numbers according to panel schedule. Data shall be lettered in a conspicuous manner with a color contrasting to finish.

1.13 TESTING

A. The CONTRACTOR shall obtain an independent testing laboratory, provide all instrumentation and perform tests on the electrical system and equipment as hereinafter described and further directed by the District's Representative. The test shall be performed after the completion of all electrical systems included in the Contract Scope of Work. All tests shall be recorded and documented and submitted to the District's Representative for review.

1. All equipment and personnel required for set-up and testing shall be provided by the CONTRACTOR.

B. Test for Phase to Ground and Neutral Condition:

1. Open main service disconnects.
2. Isolate the system neutral from ground by removing the neutral disconnects link located in the service switchboard.
3. Close all submain disconnects.
4. Close all branch feeder circuit breakers.
5. Turn all switches to "on" position, unplug all portable equipment from outlet receptacles.
6. Measure the resistance of each phase to ground and phase to neutral. A properly calibrated "megger" type test instrument shall be used. The test voltage shall be a nominal 500 volts.
7. Record all readings after 1-minute duration and document into a complete report.
8. Isolating Grounds: In the event that low resistance ground neutral connections are found in the system, they shall be isolated and located by testing each circuit individually as outlined above. Make proper corrections to restore the resistance values to an acceptable value.

C. Method of obtaining ground resistance shall be in accordance with the latest edition of the James G. Biddle (Plymouth Meeting, Pennsylvania) manual published on this subject.

1. Perform "fall-of-potential" three (3) point tests on the main grounding electrode of system per IEEE Standard No. 81, Section 8.2.1.5. when suitable locations for test rods are not available, a low resistance dead earth or reference ground shall be utilized.
2. Perform the two (2) point method test per IEEE Standard No. 81, Section 8.2.1.1, to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

D. The testing, calibrating and setting of all ground and ground fault equipment, circuit breakers, circuit device protection relays, and meters adjustable settings shall be by an independent testing laboratory. Set as recommended by the respective manufacturer and coordination study so as to be coordinated with other protection devices within the electrical design. Bound and tabulated copies of the test and settings shall be sent to the District's Representative.

E. Ampere and Voltage Measurements
   1. Measure and record ampere and line voltage measurements under full load on all panel feeders, switchboard, and switchgear feeders, motor control centers and motor circuits provided in the contract. Record measurements at the equipment tested and submit to the District's Representative for review.
   2. Ampere voltage readings shall be:
      a. Phase A-B, A-C and B-C.
      b. Phase A-Neutral, B-Neutral and C-Neutral.
   3. The ampere and voltage readings shall be not less than 20-minutes duration for each test. Record and submit the measured minimum, maximum and 20-minute average for each ampere and voltage value and test location. Voltage and ampere measurements shall occur at the connected load end of each respective feeder, not at the source of supply end of each feeder.
   4. Test equipment shall be accurate within plus or minus 1%.
   5. Branch circuit devices 40 ampere or less and motor loads ten (10) horsepower or smaller are excluded from ampere and voltage testing requirement.
   6. If, in the opinion of the District's Representative, the voltages and regulations are not met within acceptable limits, make arrangements with the serving utility for proper electrical service. Retest feeder line voltages, and submit to District's Representative for review, after the utility company has completed corrective actions. Reset "voltage taps" on transformers provided or modified as part of the contract work, to adjust line voltages to within acceptable values, as directed by the District's Representative.

F. The Contractor shall complete the following work before any electrical equipment is energized.
   1. All equipment shall be permanently anchored.
   2. All bus connections and conductor/wire connections shall be tightened per manufacturer's instructions and witnessed by the District's Representative.
   3. All ground connections shall be completed and identified. Perform and successfully complete all required megger and ground resistance tests.
   4. Feeders shall be connected and identified.
   5. The interiors of all electrical enclosures including busbars and wiring terminals shall be cleaned of all loose material and debris, paint, plaster, cleaners or other abrasive's over spray removed and equipment vacuumed clean. The District's Representative shall observe all interiors before covers are installed.
   6. All wall, ceiling, and floor work and painting shall be completed within areas containing electrical equipment prior to installation of equipment. The equipment indoor rooms and spaces shall be weather-tight and weather protected from environmental incursions.
   7. All doors to electrical equipment rooms shall be provided with locks in order to restrict access to energized equipment.
   8. Electrical spaces and rooms shall not be used as storage rooms after power is energized.
   9. Outdoor electrical equipment enclosures and housings shall be weather protected.
   10. The electrical system time current coordination and ARC-Fault study shall be complete for circuit breakers, ground relays sets, and circuit relay sets, fuses; set-up, tested and calibrated accordingly.

1.14 COMMISSIONING - Cx

A. General
   1. The commissioning shall verify the electrical systems for the term of the contract, by observation; and by calibration; and by testing. The commissioning shall ensure the electrical systems perform interactively and correctly, according to the contract and operational requirements.
   2. Commissioning shall provide startup, testing and documented confirmation of the contract constructed systems, materials and work, functions in compliance within the criteria set forth in the Contract Documents to the satisfaction of the District's needs. The commissioning scope shall encompass each system identified as requiring "commissioning" by the Contract Documents, including but not limited to:
      a. Electrical circuits' protection, short circuit, overcurrent, and ground fault devices.
      b. Electrical circuits monitoring and metering.
      c. Light fixtures, lamps and ballasts.
      d. Lighting control devices, equipment and lighting control systems.

e. Standby and emergency electric power supply equipment and systems. f. Fire alarm, equipment, devices and fire alarm systems.
g. Additional systems described in the contract documents.

3. Commissioning process shall review all of the shop drawing submittals, including:
   a. Controls, operation and maintenance requirements.
   b. Facility performance testing compliance.
   c. Project contract requirements compliance.
   d. Compliance with basis for design and operational descriptions provided in the contract.
4. Commissioning shall be the process of ensuring all the systems described in the Contract Documents comply with the Contract Document design; all systems are installed properly; all systems are functional, tested and capable of being operated and maintained to perform within the contract requirements and design intent.
5. Functional setup, recalibration, correcting deficiencies, retesting and the associated costs, for system(s) that fail commissioning, shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall include all commissioning costs in the contract scope of work.
6. Complete all commissioning functions prior to the occupancy of the facility by the District, unless directed otherwise by the District's Representative.
7. Submit three (3) copies of commissioning documentation to District's Representative.
8. Commissioning, unless specifically indicated otherwise, shall be performed by factory- trained technician(s) authorized and certified by the Manufacturers of the respective equipment/systems. Where specifically indicated, commissioning shall be performed by Independent Test Lab.

B. Commissioning Procedures
1. Prepare a commissioning matrix identifying components and systems included in the commissioning scope; the status; actions completed and actions to be completed.
2. Verify CONTRACTOR compliance with Contract Document requirements manufacturer's recommendations and approved shop drawings.
3. Perform startup, functional tests, reports, and document results.
4. Evaluate and document the setup parameters, software, operating condition and performance of each system at the time of functional test completion. Document and record each performance parameter and condition, in the commissioning report.
5. Schedule testing and prepare descriptions of testing.
6. Describe measures performed to correct deficiencies.
7. Verify that instructions to District's Representatives, Operations and maintenance manuals comply with Contract Documents.
8. Prepare warranty matrix identifying the start dates, expiration dates, routine preventative maintenance dates and the District's responsibility for performing preventative maintenance and keeping logs for each maintenance function and warranty claims.
9. Confirm completion of all punch list items that have been acceptably accomplished and a list of what has not been acceptably completed.
10. Describe uncorrected deficiencies accepted by the DISTRICT.

C. Commissioning Phasing

The commissioning phases of work shall include the following activities:
1. SDQ - Shop Drawing Qualification shall verify complete and correct shop drawings have been submitted.
2. IQ – The Installation Qualification of contract work shall verify systems are correctly and properly installed.
3. OQ - Verify systems interfaces and software are correctly and properly operational.
4. ITM - Verify the contract Inspection, Testing and procedures for Maintenance are complete.
5. PQ - Performance Qualification complete the functional performance testing to validate each building system.

1.15 POWER OUTAGES

A. All electrical services in all occupied facilities of the contract work are to remain operational during the entire contract period. Any interruption of the electrical services for the performance of this work shall be at the convenience of the District and performed only after consultation with the District's Representative. Work involving circuit outages shall be only at such a time and of such a duration as

approved in writing. Work involving circuit outages for the work required to connect new equipment and disconnect existing equipment shall be performed at the convenience of the DISTRICT Representative, with approval in writing.

B. Contract work involving outages or disruption of normal function in electrical power systems, telephone/communication systems, fire alarms, shall be performed during the following time periods. The contract work shall be phased to limit outages in the respective systems to the stated periods:
   1. 11:30 p.m. Friday to 11:30 p.m. Sunday of the same weekend. Work shall occur on multiple weekend periods if a single weekend is not sufficient time to complete the work.
   2. The contract work involving outages shall be phased in multiple work time units, to comply with the permitted outage limitations.

C. Work involving system outages to the building fire alarm system shall be performed only after consultation with the DISTRICT and shall be only at such a time and of such duration as approved in writing. Contractor shall provide continuous "Fire-Watch" during fire alarm system outages and comply with AHJ "Fire-Watch" requirements.

D. Provide overtime work; double shift work; night time work; Saturday, Sunday, and holiday work to meet outages schedule.

E. Provide temporary electrical power to meet the requirements of this Article.

F. Any added costs to CONTRACTOR due to necessity of complying with this Article shall be included in the Contract Scope of Work.

G. When electrical work involving power disruptions to existing areas is initiated, the work shall proceed on a continuous basis without stopping until electric power is restored to the affected areas.

H. The CONTRACTOR shall request in writing to the DISTRICT'S Representative a minimum of 3- weeks in advance, for any proposed electrical outage.

1.16 TEMPORARY ELECTRICAL POWER

A. Provide temporary electrical power if work requiring power outages cannot be completed in time permitted and approved by the DISTRICT'S Representative.

B. Temporary electrical power shall be a standby diesel engine generators. Voltage, frequency, regulation, etc. shall be equal to that of normal utility source. Exhaust system shall have a critical silencing muffler. Generator voltage shall match the existing secondary voltage required at the site. The CONTRACTOR shall furnish all necessary cables, switches, etc., to make all required connections to existing panels, feeders, etc. Generator shall be sized to adequately carry the demand load. If record of demand load is not available, size generator to match corresponding transformer, maximum capacity circuit as directed by the District's Representative.

C. After completion of required usage of the temporary generators, prior to completion of the project, the CONTRACTOR shall remove the generators. All temporary cables, switches, etc. shall be removed and all permanent equipment left in satisfactory condition.

D. Each generator shall be housed in security type sound attenuated housing to prevent access by unauthorized personnel. Temporary power cables, connections, etc. shall be protected from unauthorized personnel.

E. The CONTRACTOR shall be responsible for complete operation of the generator including personnel, fuel supplies, proper safety precautions, etc. Generator shall not be left unattended while in operation.

F. The CONTRACTOR shall provide temporary construction lighting and power as required in areas where work is being performed. Temporary power arrangements, outages, installation, work schedules, etc., shall be submitted in writing 3-weeks prior to requested outage date, and approved by the DISTRICT'S Representative prior to start of work.

1.17 ASBESTOS, POLYCHLORINATED BIPHENYL (PCB) OR HAZARDOUS WASTE:

A. It is understood and agreed that this contract does not contemplate the handling of asbestos, PCB or

any hazardous waste material. If asbestos, PCB or any hazardous waste material is encountered, notify the District's Representative immediately. Do not disturb, handle or attempt to remove.

1.18 TIME/CURRENT COORDINATION, SHORT CIRCUIT, ARC-FLASH AND SERIES RATED EQUIPMENT

A. Series rated equipment.
   1. Circuit protective Devices identified as "Series Rated" or "Current Limiting" (i.e., CLCB - current limiting circuit breaker; CLF - current limiting fuse, etc.) shall be series rated and tested (UL 489 and CSA5) by the manufacturer with all equipment and circuit protective devices installed down stream of the identified series rated or current limiting device.
   2. Provide nameplates on all equipment located down stream, including the CLCB and CLF devices, to comply with CEC/NEC paragraphs 110-22 and 240-83 "CAUTION SERIES RATED SYSTEM - NEW DEVICE INSTALLATIONS AND REPLACEMENTS SHALL BE THE SAME MANUFACTURER AND MODELS".

B. Short circuit, coordination and ARC-Flash
   1. Perform engineering analysis and submit engineered settings for each equipment location, fuse and circuit breaker device, showing the correct time and current settings to provide the selective coordination within the limits of the specified equipment. Shall comply with the latest application standards of IEEE and ANSI. Provide electrical system short circuit worst case bolted-fault analysis, both 3-phase line-to-line and 1-phase line-to-ground calculations as part of the coordination analysis recommendations. Provide Electric ARC-FLASH calculations as part of the coordination analysis recommendations.
   2. The information shall be submitted in both tabular form and on time current log-log graph paper, with an engineering narrative. Written narrative describing data, assumptions, analysis of results and prioritized recommendations, six (6) copies.
   3. The goal is to minimize an unexpected but necessary electrical system outage and personnel exposure to the smallest extent possible within the fault occurrence location, using the specified contract equipment. Shall comply with, but not limited to:

      a. IEEE-242, Recommended Practices for Protection and Coordination of Industrial and Commercial Distribution.
      b. IEEE-399, Recommended Practices for Industrial and Commercial Power System Analysis.
      c. IEEE-1584, Guide to Performing ARC-FLASH Hazard Study.
      d. CEC/NEC
   4. Provide permanent warning labels on each equipment location. The labels shall describe ARC-FLASH, Short-Circuit and Time/Current Coordination, including safety precautions and protective clothing. Also described actions to be taken if any circuit changes or equipment modifications occur.
   5. Shall be submitted with the shop drawing submittals for the respective equipment.

1.19 INDEPENDENT TESTING LABORATORY

A. Testing Laboratories Definition
   1. The Testing Laboratory shall meet Federal OSHA criteria for accreditation of Nationally Recognized Testing Laboratories (NRTL) Title 29 Part 1907 and 29 CFR-1910.
   2. Membership in the National Electrical Testing Association (NETA) shall also constitute acceptance of meeting said criteria, for testing of electrical systems.

1.20 SPARE FUSES

A. Provide three (3) spare fuses [for each size and type] [at each location] to match the installed fuses where the fuses are provided as part of the Contract. Provide spare fuse holders on inside door of each respective fuse compartment. Provide engraved nameplate on front of fuse access door indicating fuse type/catalog number ampere rating and manufacturer of fuse.

1.21 EQUIPMENT SEISMIC AND WIND LOAD REQUIREMENTS (ADDITIONAL REQUIREMENTS)

A. Seismic Performance and Seismic Restraint Requirements
   2. Refer to Structural, Architectural, and Soils report contract documents for additional requirements.

B. General
1. Equipment supports and anchorage's provided as part of the contract shall be designed, constructed and installed in accordance with the earthquake regulations of the California Building Code (CBC), International Building Code (IBC).
2. Provide equipment anchorage details, coordinated with the equipment mounting provision, prepared, signed and "stamped" with PE registration in good standing, by a Civil or Structural Engineer licensed as a Professional Engineer (PE) in the State of California.
3. Mounting recommendations shall be provided by the manufacturer based upon approved shake-table tests used to verify the seismic design of that type of equipment.
4. The equipment manufacturer shall document the details necessary for proper wind-load and seismic mounting, anchorage, and bracing of the equipment for floor, ceiling, and wall/ back installation location.

5. Seismic performance shall be based on actual install location of the respective equipment in the building and height above or below grade.
6. The seismic requirements are typical for each equipment item exceeding 19-pounds, including but not limited to the following:
   a. Switchgear, switchboards, and motor control equipment
   b. Transformers
   c. Equipment racks and terminal cabinets
   d. Panels
   e. Conduits with floor, ceiling or wall attachment support and conduits with suspension attachments.
   f. Busway, wire way and cable tray

C. Certification
1. Electrical equipment manufacturers and Contractor shall provide Special Seismic Certification (SCC) for each specific equipment configuration with shake-table verification, all furnished as part of the contract documents requirements. The SCC shall include the specific installation location characteristics of the respective equipment including as follows:
   a. Ground or floor attachment
   b. Wall attachment
   c. Ceiling attachment
   d. Roof attachment
2. Wind Loading
   Electrical equipment and anchorages shall withstand the wind-load imposed at the install location. Wind loading withstand requirements shall apply to all electrical equipment installed in outdoor locations and to all electrical equipment exposed to the weather. The equipment shall be tested and certified by the manufacturer and Contractor. The wind-load withstand qualification of the equipment and anchorages shall be verified by the following methods:
   a. Areo-dynamic wind tunnel test method.
   b. Analytical calculation method, for oversized equipment too large for wind tunnel test method.
3. The wind-load withstand rating and the SCC shall comply with the requirements of the Authority Having Jurisdiction (AHJ), and include the latest revisions, but not limited to the following:
   a. American Society of Civil Engineers; ASCE-7
   b. CBC/IBC; including but not limited to Sections 1702, 1708, 1709, 1708A and 1709A.
   c. California Office of Statewide Health Planning and Development OSHPD; OPA-Preapproval of Anchorage; Code Application Notice CAN 2-1708A.5 and OSP-Special Seismic Certification Approval
   d. US Department of Homeland Security; FEMA- (installing seismic restraints for electrical equipment)

D. Wall Mounted Electrical Equipment
1. Surface Mounted Equipment
   a. Provide multiple horizontal sections of metal "C" channels for support and attaching wall mounted equipment to walls. Channels shall provide "turned lips" at longitudinal edges to hold "lock-in" fasteners and shall comply with ANSI-1008 and ASTM-A569 latest revision.

The channels shall be steel hot dip zinc galvanized. As manufactured by Unistrut or Kindorf.

b. The "C" channels shall be positioned horizontally within 3-inches of the top and bottom of each, equipment section cabinet and located behind each equipment vertical section. Provide additional intermediate "C" channels at not less than 36-inches on center between the "top" and "bottom" "C" channel positions, located behind each equipment vertical section.

c. The "C" channels shall be of sufficient length to provide connection to not less than two (2) vertical structural wall framing elements separated by not less than 16-inches; but in no case shall the "C" channel length be less than the width of the respective equipment section.

d. Attach the "C" channels to the wall structural elements after the wall, finish surface, installation (including painting) is complete.

e. Attach the "C" channels with fasteners to the building wall framing structural elements as follows: welded to steel framing; bolted to wood framing; cast in place concrete inserts for masonry and concrete construction; drilled "afterset" expansion anchors for existing masonry and concrete construction.

f. Attach the equipment to the "C" channels with threaded and bolted fasteners to "pre-locate" and lock into the channel "turned lips" and channel walls.

2. Flush mount equipment
   a. Provide anchor attachment of equipment into adjacent wall structural elements.

E. Housekeeping Pad
   1. Provide cast-in-place, steel re-enforced concrete raised "housekeeping" pads under all floor standing electrical equipment (except data network equipment racks).
   2. Pad sizes
      a. The raised housekeeping pad height shall extend 4-inches above the surrounding finished floor elevation for interior building locations.
      b. The pad shall extend 8-inches below finish grade plus 4-inches above finish grade for outdoor equipment location on grade.
      c. The pads shall extend 7-inches past the "footprint" edge of the respective floor standing equipment.
   3. Anchor equipment to pads. Anchor pads to the building structural floor. Equipment pad, equipment re-enforcing and equipment anchoring shall comply with seismic earthquake requirements and wind load requirements.
   4. Unless shown otherwise on drawings. The equipment housekeeping pad steel re-enforcing shall consist of two (2) layers of number 4-size steel-rebar laid horizontally and uniformly spaced 6-inches on center. Position rebar in two (2) directions (90-degrees opposed) and centered inside the concrete house keeping pad. Horizontal rebar shall extend to within 3- inches of the edge of the concrete pad in all directions. Metal wire "tie-wrap" shall be provided at each rebar crossing.
   5. Equipment anchor attachments shall extend through the housekeeping pad and into the structural concrete below the pad a minimum of not less than 2-inches.

1.22 ELECTRICAL WORK CLOSEOUT

A. Prepare the following items and submit to the District's Representative before final acceptance.
   1. Two (2) copies of all test results as required under this section.
   2. Two (2) copies of local and/or state code enforcing authorities final inspection certificates.
   3. Copies of record drawings as required under the General Conditions, pertinent Division One Sections and Electrical General Provisions.
   4. Two (2) copies of all receipts transferring portable or detachable parts to the DISTRICT'S Representative when requested.
   5. Notify the District's Representative in writing when installation is complete and that a final inspection of this work can be performed. In the event any defect or deficiencies are found during this final inspection they shall be corrected to the satisfaction of the District's Representative before final acceptance can be issued.
   6. List of spare fuses and locations identified by equipment name and building designation.
   7. Prior to energizing, retighten to the proper torque, each circuit conductor lug landing, each bus bar (phases, neutral and ground) and circuit protection device threaded connections in all switchboards, switchgear, motor control centers, transformers, busways, disconnect switches, motor starters, motor terminals and panelboards, after the equipment is installed/ connected and prior to energizing the equipment. The torque values shall comply with manufacturer's recommendations.

B. Electrical power single line diagrams – SLD
   1. Provide single line diagrams showing the contract document work complete electrical power system (normal and emergency). SLD shall show inter-connection circuits, electrical equipment, panels, and circuit protection devices, nominal 50% (½-size) approximately 18-inches by 24-inches. Show installed voltages and electrical capacity sizes.
   2. SLD shall be mounted in metal (picture frame) rigid enclosure frame with rigid-backing (backer-board) and clear/transparent front, for hanging on wall. Provide clear transparent cover over SLD inside the frame.
   3. Provide a wall-hung (48-inches) SLD in each "main" and "sub" electrical equipment room. If wall space is limited, alternatively securely attach SLD frame to room door facing into the respective electrical room.

END OF SECTION

SECTION 26 05 15

BASIC ELECTRICAL MATERIALS AND METHODS

PART1 GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other sections for work related to those other sections and required to be included as work under this section.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS (ADDITIONAL REQUIREMENTS)

A. Submit product data sheets for all outlet boxes, floor boxes, wiring devices, device plates, relays, contactors, timeswitches, and disconnects fuses.

B. Submit detailed shop drawings including dimensioned plans, elevations, details, schematic and point-to-point wiring diagrams and descriptive literature for all component parts for transformers, relays, time clocks, and photocells.

C. Submit transformer test reports.

D. Submit material list for outlet boxes.

PART 2 PRODUCTS

2.01 OUTLET AND JUNCTION BOXES

A. General
   1. Flush or concealed outlet and junction boxes: Pressed steel, steel thickness not less than 0.062-inch, hot-dip galvanized, knockout (KO) type with conduit entrances and quantities size to match conduits shown connecting to respective outlet box. U.L.-514 listed and labeled. Minimum required box depth is exclusive of extension-ring depth.
   2. Provide boxes of proper code size for the number of wires or conduits passing through or terminating therein, but in no case shall box be less than 4.0 inch square by 2.125 inch deep, unless specified elsewhere or noted otherwise on the drawings. 2.5 inch minimum depth for box widths exceeding 2-gang.
   3. Increase the minimum outlet box size to 4.69 inches square by not less than 2.125 inches deep, where one or more of the following conditions occurs:
      a. More than two (2) conduits connect to the outlet box.
      b. Conduit "homerun" connects to outlet box.
   4. Provide extension rings on flush outlets to finish face of extension ring flush with finished building surfaces. Extension ring shall match outlet box construction and contain "attachment mounting-tabs" for wiring devices. Extension rings shall be "screw-attached" to respective outlet box and maintain "ground" bonding continuity.
   5. Boxes installed in masonry or concrete shall be U.L. "concrete-tight" approved for installation in concrete, and shall allow the placing of conduit without displacing reinforcing bars.
   6. Provide fixture-supporting device in outlet boxes for surface mounted fixtures as required.
   7. Provide solid gang boxes for three or more switches, for mounting behind a common device plate.
   8. Provide barriers for all 277 volt devices, between line voltage and low voltage devices and where more than one device is installed in an outlet box.

B. Surface Outlet Boxes
   1. Surface mounted outlet boxes, cast iron Type FS or FD, with threaded hubs as required. Box interior dimensions and interior volume capacity not less than required for "press steel boxes", and "sheet steel boxes". Provide plugs in all unused openings. Provide vyeatherproof gaskets for all exterior boxes.

2.02 PULL BOXES

A. Sizes as indicated on the drawings and in no case of less size or material thickness than required by the governing code. Exercise care in locating underground pull boxes to avoid installation in drain water flow areas.
   1. General purpose sheet steel pull boxes: Install only in dry protected locations with removable screw covers. Manufacturer's standard baked enamel finishes.
   2. Weatherproof sheet steel pull boxes: Fabricate of code gauge, hot-dip galvanized steel with gasketed weathertight cover of same material. Manufacturer's standard baked exterior enamel finish.

2.03 SWITCHES

A. Provide circuit switches totally enclosed, Bakelite or composition base, toggle type with 277 volt A.C. rating for full capacity or contacts for incandescent or fluorescent lamp loads. Switch ratings shall be 20 ampere only. Color as selected by OWNER'S REPRESENTATIVE. Switches controlling circuits connected to emergency power shall be red.

B. Where switches are mounted in multiple gang assembly and are operating at 277 volts and/or 277 volts and 120 volts mounted in same outlet box, there shall be a barrier installed between each switch.

C. Switches – Specification Grade Commercial Series
   1. Single Pole Switches

Make	Toggle Type 20 Amps	Lock Type 20Amps
Hubbell	#CS1221	#CS1221-L

2. Double Pole Switch
   Hubbell

7. Ground Fault Circuit Interrupter (GFCI)
   Hubbell GFST15I, or GFST20I

2.05 RECEPTACLES

A. All receptacles in flush type outlet boxes shall be installed with a bonding jumper to connect the box to the receptacle ground terminal. Grounding through the receptacle mounting straps is not acceptable. The bonding jumper shall be sized in accordance with the branch circuit protective device as tabulated herein under "Grounding". Bonding jumper shall be attached at each outlet to the back of the box using drilled and tapped holes and washer head screws 6-32 or larger (except isolated ground receptacles). For receptacles in surface mounted outlet boxes direct metal-to-metal contact between receptacle mounting strap (if it is connected to the grounding contacts) and outlet box may be used. Color as selected by OWNER'S REPRESENTATIVE. Receptacles connected to emergency power circuits shall be red.

B. Duplex convenience receptacles shall be grounding type, 120 volt, 15 ampere, and shall have two current carrying contacts and one grounding contact which is internally connected to the frame. Outlet shall accommodate standard parallel blade cap and shall be side wired:
   1. Hubbell, Specification Grade Commercial Series, Ivory, or equal.

D. Weatherproof receptacle: Ground fault type duplex receptacle, mounted in a flush hinged door enclosure with lock and key. Enclosure shall be a P & S #4600 with a #1591F46 receptacle. On exposed conduit runs, weatherproof ground fault type receptacle as hereinbefore specified, installed in "FS" condulet with one of the following spring door type covers:
   1. Hubbell, Specification Grade Commercial Series, or equal.

E. Special outlets shall be as indicated on the drawings.

2.06 PLATES

Provide plates for every switch, receptacle, telephone, computer, television and other device outlets. All plates shall be 0.040" stainless steel, Type 302 alloy composed of 18% chromium and 8% nickel. Plates shall be manufactured by P & S, Hubbell, Leviton or General Electric only.

2.07 VANDALPROOF FASTENINGS

Provide approved vandalproof type screws, bolts, nuts where exposed to sight throughout the project. Screws for such items as switch plates, receptacle plates, fixtures, communications equipment, fire alarm, blank covers, wall and ceiling plates to be spanner head stainless steel, tamperproof type. Provide OWNER with six (6) screwdrivers for this type.

2.08 STRUCTURAL AND MISCELLANEOUS STEEL

Structural and miscellaneous steel used in connection with electrical work and located out-of-doors or in damp locations, to be hot-dip galvanized unless otherwise specified. Included are underground pull box covers and similar electrical items. Galvanizing averages 2.0 ounce per square foot and conforms to ASTM A123.

2.09 FLASHING ASSEMBLIES

Provide Semco Fig. #1100-4 lead flashing assemblies at all roof penetrations. Seal the joint between flashing and pipe with waterproofing compound.

2.10 RELAYS, CONTACTORS, AND TIMESWITCHES

A. Individual Control Relays (HV/AC Plumbing of the Control Functions)

1. Individual control relays shall have convertible contacts rated a minimum of 10 amperes, 600 volts regardless of usage voltage. Coil voltage, number and type of contacts shall be verified and supplied to suit the specific usage as shown in the wiring diagrams and/or schedules on the electrical and mechanical drawings. Coil control circuit shall be independently fused, sized to protect coil. Relays shall be installed on prefabricated mounting strips. Each relay shall have a surge suppressor to limit coil transient voltages. Furnished in the NEMA Type I enclosure unless indicated otherwise.
2. The following relays are approved:

Manufacturer	IYQg
Arrow Hart	IMP
General Electric	Class CR 2811
I.T.E.	Class J10
Square D Co.	Class 8501, Type A
Westinghouse	Bul. 16-321, Type NH
Allen Bradley	Approved Equal

B. Contactors and/or Relays

1. Contactors and/or relays for control of lighting shall be 600 volt A.C., electrically operated, mechanically held units, open type for panel mounting with number of poles and of size as indicated on the drawings. Provide auxiliary control relay for operation of each contactor and/or relay with a two-wire control circuit.
2. Contactors and/or relays shall be mounted in panelboards in barriered section under separate hinged lockable doors or in contactor and/or relay cabinets as called for on the drawings. Contactors and/or relays shall be installed on Lord sound absorbing rubber mounts.
3. Contactors and/or relays shall be Automatic Switch Co. Bulletin #920 Series for 2 and 3 pole, Automatic Switch Co. Bulletin 917 Series with poles as indicated on drawings. Coil control circuit shall be independently fused, sized to protect coil.
4. Contactors and/or relays shall be equipped with a switch, in the proper configuration, to disconnect the control circuit controlling 'the coil of the respective device. Control circuit disconnect switch shall be labeled showing function of device.

C. Timeswitches

1. All timeswitches shall have synchronous motor drive for operation on 120 or 277 volts, 60 Hertz, A.C. and shall be furnished with a ten-hour, spring-driven, reserve-power motor. Contacts shall be rated 40A per pole.
   a. Exterior lighting timeswitches for control of individual circuits or electrically operated relays shall have astronomic dial and shall be Tork 7000ZL Series or approved equal by Paragon or Intermatic.
   b. Interior lighting timeswitches for control of individual circuits or electrically operated relays shall be Tork 7000 Series or approved equal by Paragon or Intermatic.
   c. Timeswitches for control of air conditioning or plumbing equipment shall have seven day dial and shall be Tork WL Series or approved equal by Paragon or Intermatic.
2. All timeswitches shall be mounted in separate section in top of panelboards under separate lockable door unless otherwise indicated on drawings. Clear opening for timeswitch shall be a minimum of 12" x 12".

D. Contactors and/or Relays/Timeswitch Cabinet

1. Contactors, relays, and/or timeswitches not indicated to be mounted in electrical panels shall be mounted in a cabinet, size as required, with hinged lockable door keyed same as panelboards. Construction of cabinet shall be similar to terminal cabinets.
2. Each contactor, relay or timeswitch mounted in the contactor cabinet shall be barriered in its own compartment, and shall be installed on Lord sound absorbing mounts.
3. Contactor cabinets shall be of the same manufacturer as the panelboards.
4. Where relays and/or contactors occupy the same enclosure as timeswitches they shall have a clear acrylic shield installed over each relay or contactor to guard line exposed parts from accidental contact by nonauthorized personnel.

2.11 DISCONNECTS (SAFETY SWITCHES)

Disconnect switches shall be rated 600 volt A.C., NEMA Type HD, quick-make, quick-break, h.p.-rated, fused Class "R", in NEMA Type I enclosure, lockable with number of poles and amperage as indicated on the drawings. Provide neutral bus and conductor landing lugs, size to match conductors shown on drawings. Where enclosure is indicated W.P. (weatherproof) switches shall be raintight NEMA Type 3R enclosure, lockable. Maximum voltage, current and horsepower rating clearly marked on the switch enclosure and switches having dual element fuses shall have rating indicated on the nameplate.

2.13 WIREWAY

A. General

Unobstructed lay in type, metal wireway, fittings and connectors U.L. listed for use as wireway and auxiliary gutter. Length, elbows and "T-S" as shown on drawings. Minimum cross-section size 4 inches X 4 inches, but not less then shown on the drawings. Suitable for mounting in any position orientation.

B. Construction

1. Minimum metal gauge shall not be less then 14 gage.
2. Cover shall be hinged entire length of cover. Cover shall be held in the closed position with bolts and nuts.
3. Provide spring nuts on all hardware fastener penetrations into the interior of the wireway to protect against wire insulation damage.
4. The inside of 90-degree corners in the wireway shall be a 45-degree bevel.
5. Grounding continuity between wireway sections and fittings shall be continuous the entire length of the wireway.

C. Finish

1. Indoor non-raintight, rust inhibitor phosphatizing base coating and baked enamel finish, manufacturer's standard color.
2. Raintight or outdoor-galvanized metal, with corrosion resistant phosphate primer and baked enamel finish, manufacturer's standard color, Nema 3R construction.
3. All hardware shall be plated to prevent corrosion.

PART 3 EXECUTION

3.01 GROUNDING (ADDITIONAL REQUIREMENTS)

A. Grounding shall be executed in accordance with all applicable codes and regulations, both of the State of California, and local authorities having jurisdiction, and in compliance with DSA.

B. Each pull box or any other enclosure in which several ground wires are terminated shall be equipped with a ground bus secured to the interior of the enclosure. The bus shall have a separate lug for each ground conductor. No more than one conductor shall be installed per lug.

C. The maximum resistance to ground shall not exceed 5 ohms.

3.02 OUTLET AND JUNCTION BOXES

A. Accurately place boxes and securely fastens to structural members. Where outlets are shown at same location but at different mounting heights, install outlets in one vertical line. Where outlets are shown at same location and mounting height, mount outlets as close together in a horizontal row as possible. Where the outlet boxes for switches and receptacles are shown at the same location and mounting height, mount in common outlet box with barriers between devices. Provide single piece multigang cover plate for close mounted outlet boxes. Where switches are shown on wall adjacent to hinge side of doors, box shall be installed to clear door when door is fully opened.

B. Flush mounted boxes shall be attached to two studs or structure members by means of metal supports.

C. Boxes above accessible ceilings shall be attached to structural members. Where boxes are suspended, they shall be supported independently of conduit system by means of hanger rods and/or preformed steel channels. Boxes shall be supported independently of all piping, ductwork, equipment, ceiling hanger wires and suspended ceiling grid system.

D. Surface mounted outlets shall be attached to concrete or masonry walls by means of expansion shields.

E. Floor boxes shall be installed level with finish floor and within adjustable limits of floor ring. Where outlets are shown at same or adjacent location, use multigang boxes.

F. Outlet Box Horizontal and Vertical Separation: Outlet boxes and device outlet rings installed flush in walls shall be horizontally and vertically separated by not less than 24 inches (edge of box to edge of box) from device outlet boxes and rings in common wall surfaces located on the opposite (back) side of the same wall.
   1. Where the separation cannot be maintained, provide a solid backing behind and completely enclosing each outlet box.
   2. The backing shall extend the width of the wall cavity (i.e. between "studs" or masonry cells) behind the box and 12 inches above and below the outlet box centerline, completely enclosing the outlet box.
   3. The backing shall consist of the following:
      a. 5/8 inch thick gypsum board anchored in place for "stud" wall construction.
      b. Solid "mortar" to completely fill the outlet box "cell" behind the box in masonry construction.

G. In fire rated walls and ceilings provide fire rated "box-wrap" around the outside of each outlet box placed in fire rated wall or ceiling inside the wall, to maintain the fire rating of wall with the installed outlet boxes.

H. Plug-in type receptacle installation orientation:
   1. The "ground-pin" shall face "up" at the receptacle top location {double duplex) 4-plex, individual and vertically mounted individual duplex receptacles.
   2. The "neutral-blade" shall face "up" at the receptacle top location on horizontally mounted duplex receptacles.

3.06 WIREWAY INSTALLATION

Wireway hangers shall provide clamp type, hanger rod type, direct bolted bracket type from ceiling or walls as indicated on the drawings and required for field installation locations. Supports shall be installed a minimum of 5 ft. on center.

END OF SECTION

SECTION 26 05 30
CONDUIT AND WIRE

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other sections for work related to those other sections and required to be included as work under this section.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS (ADDITIONAL REQUIREMENTS)

A. Submit product data sheets for all wire, supports, conduit, fittings and splicing materials.

B. Submit material list for all conduit and conduit fittings.

C. Submit details and structural engineering calculations for conduit support systems.

PART 2 - PRODUCTS

2.01 CONDUIT

A. General
   1. The interior surfaces of conduits and fittings shall be continuous and smooth, with a constant interior diameter. Conduits and conduit fittings shall provide conductor raceways of fully enclosed circular cross section. The interior surfaces of conduits and fittings shall be without ridges, burrs irregularities or obstructions. Conduits and fittings of the same type shall be of the same uniform weight and thickness.
   2. Type of conduit, type of conduit fittings and conduit supports shall be suitable for the conditions of use and the conditions of location of installation, based on the manufacturer's recommendations and based on applicable codes.
   3. All fittings for metal conduit shall be suitable for use as a grounding means, pursuant to the applicable code requirements. All metal conduit and metal conduit fittings shall provide 3 second duration ground fault current carrying ratings, when installed and connected to the respective conduit, as follows:
      a. RMC and EMT conduit fittings.
         1) 0.75 inch through 1.5 inch conduit/fitting size - 10,000 ampere RMS.
         2) 2.0 inch and larger conduit/fitting size - 20,000 ampere RMS.
      b. FMC and LTFMC Conduit Fittings
         1) 0.75 inch through 1.25-inch conduit/fitting size-1,000 ampere RMS (without external bonding jumper).
         2) 1.5 inch through 4.0-inch fitting size-10,000 ampere RMS with bonding jumper.
   4. Protective corrosion resistant finish for metal conduit fabricated from steel and metal conduit fittings fabricated from steel, shall be as follows:
      a. Clean all metal surfaces (including metal threads) with acid bath "pickle" prior to coating, to remove dirt, oil and prepare surfaces for galvanizing.
      b. Hot-dip galvanized zinc coating on all interior and exterior steel surfaces. Minimum finish zinc coating thickness shall not be less than 0.002 inches.
      c. Threads shall be hot-dip zinc coated after machine fabrication.
      d. Exterior metal surfaces shall be finished with clear organic polymer topcoat layer, after galvanizing.

e. The inner metal surfaces of conduit fittings shall be finished with a lubricating topcoat after galvanizing, to facilitate conductor pulling through the conduit/fitting.

5. Threads for metal conduit and metal conduit fittings shall be taper-pipe-thread, National Pipe Standards (NPS) and shall comply with ANSI-B1.20.1.
6. Metal conduit termination connector fittings shall be provided with a manufacturer installed, insulating throat bushing inside the fitting. The bushing shall protect the wire conductor insulation from cutting, nicks and abrasion during conductor installation and electrical load "cycling" after installation is complete. The bushing shall comply with UL 94V-0 flammability.
7. Provide conduit bonding/grounding jumper from metal enclosures with "concentric ring" knockouts, to positively ground/bond each respective conduit(s) to the metal enclosure.
9. The conduit and fittings shall be watertight and airtight without cracks and pinholes.

B. Rigid Metal Conduit (RMC)
1. Rigid metal, round tubing, machine threaded at both ends.
   a. The conduit and conduit fittings shall comply with the requirements for an equipment grounding conductor, pursuant to applicable codes.
2. RMC raceway types shall be as follows:
   a. Rigid galvanized steel conduit (RGS), minimum yield strength shall be 35,000 PSI. Shall comply with NEMA standard 5-19 (latest revision); ANSI C80.1 and ANSI-C80.4 (latest revision); UL 514-B and UL 6 (latest revisions); National Pipe Standard Specification (latest revision).
   b. Intermediate steel conduit (IMC). Shall comply with NEMA Standard 5-19 (latest revision) ANSI-C80.6 (latest revision); UL 2142 (latest revision).
3. RMC fittings:
   a. Fittings shall be compatible with RGS and IMC.
   b. Fittings shall be rated "liquid tight".
   c. Fittings imbedded in concrete shall be rated "liquid tight" and "concrete tight".
   d. Connectors and couplings for terminating, connecting and coupling to RMC conduit shall be threaded metal.
   e. Fittings shall comply with ANSI C80.4 and ANSI C33-84 (latest revision); NEMA FB1 (latest revision); UL 514 (latest revision).
   f. Conduit seal fittings:
      1) Conduit seals shall prevent the passage of gasses, liquids and vapors past the location of the seal installation in the conduit.
      2) Conduit seals shall be suitable for installation in both vertical and horizontal conduit locations.
      3) Conduit seals shall be visible and accessible for inspection after installation is complete.
      4) Conduit seals shall be rated for the following locations:
         a) Wet locations
         b) Classified hazardous location materials NEC Class 1 Division 1.
         c) Temperature ranges from 0 [minus 20] degrees centigrade through 90 degrees centigrade.
      5) Conduit seals, sealing compound and sealing compound dam shall be the products of the same manufacturer.
4. RMC fittings as manufactured by:
   a. For threaded enclosure, termination connection.
      1) Thomas & Betts - 106 Series bonding locknut, 5302 series sealing ring with stainless steel retainer.
   b. For non-threaded enclosure, termination connector.

1) Thomas & Betts - 370 Series watertight threaded sealing hub, 106 series threaded bonding lock nut, Sta-Con Series enclosure bonding jumper and 3870 Series threaded ground bushing.
2) Emerson-OZ/Gedney-CHMT/CHT watertight threaded hub with bonding locknut and GH50G Series enclosure bonding jumper.

c. For RMC to RMC conduit-to-conduit coupling
1) Thomas & Betts/Erickson - 674 (threaded) Series
2) Emerson-OZ/Gedney Type TPC (threaded) Series
3) Threaded RMC conduit couplings, product of the same manufacturer as the RMC conduit.

d. For RMC Conduit Seals
1) Emerson-OZ/Gedney-EYA and EYAM (threaded) Series
2) Appleton-EYF and EYM (threaded) Series

C. Electrical Metallic Tubing (EMT)
1. Rigid metal round tubing, "thin wall" steel construction, with non-threaded ends.
a. The conduit and conduit fittings shall comply with the requirements for an equipment grounding conductor pursuant to applicable codes.
b. The conduit shall be watertight and airtight without cracks and pinholes.
2. EMT shall be allowed for conduit size ranges from 0.75-inch through 2.0-inch. EMT is not allowedfor exterior locations, including under covered walks, shelters, or roof overhangs. EMT is not allowed less than ten (10) feet above FF, not in concrete, not underground, and not in runs longer than 100'.
3. Comply with ANSI C80.3, C80.4, and ANSI C33.98 (latest revisions); UL 594 and UL 797 (latest revisions); CEC Section 12500 (latest revision).
4. EMT fittings:
a. Connectors and couplings for terminating, connecting and coupling to EMT conduit shall be non-threaded steel fabrication.
b. EMT termination connector fittings shall be as follows:
1) Set screw type "concrete tight" when installed in dry interior locations.
2) Compression types "raintight" and "concrete tight" when installed in wet or damp locations, outdoors and in concrete or masonry construction.
c. Fittings shall comply with ANSI C33.84 (latest revision); UL 514 (latest revision); NEMA FB-1.
5. EMT fittings as manufactured by:
a. For threaded and non threaded enclosure, termination connector
1) Thomas & Betts-TC721A (set screw type) Series (with locknuts).
2) Emerson-OZ/Gedney-TC500I (set screw type) Series (with locknuts).
3) Thomas & Betts-5123 (compression type) Series (with 2 locknuts).
4) Emerson-OZ/Gedney-TC600I (compression type) Series (with locknut).
5) Thomas & Betts-4240 (compression type) Series (90 degree angle with locknut).
6) Emerson-OZ/Gedney-TWL (compression type) Series (90 degree angle with locknut).
b. Fo· EMT to EMT conduit-to-conduit coupling:
1) Thomas & Betts-TK121A (set screw type) Series (with locknut).
2) Emerson-OZ/Gedney-5000 (set screw type) Series (with locknut).
3) Thomas & Betts-5120 (compression type) Series.
4) Emerson-OZ/Gedney-TC600 (compression type) Series.
c. Fo· EMT to RMC conduit to conduit combination coupling:
1) Thomas & Betts-HT221 (set screw type) Series.
2) Emerson-OZ/Gedney-ESR (set screw type) Series.
3) Thomas & Betts-530 (compression type) Series.
4) Emerson-OZ/Gedney-ETR (compression type) Series.

D. Flexible Metal Conduit (FMC)
1. Round flexible conduit, fabricated from a single continuous steel strip. The steel shall be factory formed into continuous interlocking convolutions to form a complete lock between

steel strips and provide raceway flexibility.

2. Metal to metal grounding contact shall be maintained throughout the length of the FMC conduit.
3. FMC shall be used only for making motor connections, conduit drop from remote junction boxes to fixtures installed above the suspended ceiling, and as specifically noted on the drawings. FMC shall not be used for runs longer than 8 feet; at any exposed locations; for any conduit size larger than 1-1/4".
4. FMC shall comply with ANSI-C.33.84 and ANSI C33.92; NEMA FB-1; CEC 12-1100.
5. FMC Fittings
   a. FMC fittings shall be malleable iron construction or steel construction.
   b. Fitting shall automatically cause the FMC raceway throat opening to be centered with respect to the fitting throat opening.
   c. Straight and angled connector termination fittings shall be threaded on one end and shall include a threaded locknut, suitable for connection to threaded and unthreaded enclosures.
   d. The attachment of the fittings to FMC shall be angled saddle type, to engage and interlock with the FMC spiral groove, and shall be unaffected by vibration. Direct bearing screw type fittings shall not be used.
   e. Direct FMC conduit-to-FMC conduit coupling of FMC shall not be permitted.
   f. Shall comply with ANSI C33.9, and ANSI C33.92 (latest revision); NEMA FB1 (latest revision); U.L. 514.
6. FMC fittings as manufactured by:
   a. Straight Termination Connectors
      1) Thomas & Betts-3110 Series (with locknut)

      45 & 90 Degree Angle Connectors
      Thomas & Betts-3130 Series (with locknut)
   b. FMC to EMT conduit combination coupling:
      1) Thomas & Betts 503TB Series.

E. Liquid Tight Flexible Metal Conduit (LTFMC)
1. The metal conduit core of LTFMC shall comply with the same requirements as FMC conduit, with the addition of a thermoplastic exterior flexible jacket over the metal core.
2. The exterior jacket shall be positively locked to the metal core to prevent jacket "sleeving".
3. The LTFMC shall be rated for installation and operating service temperatures of between minus 20 degrees centigrade through plus 90 degrees centigrade.
4. The LTFMC jacket shall be suitable for continuous exposure to sunlight, rainwater, water vapor, mineral oils and liquid solvents, without penetrating into the conduit and without deteriorating the jacket.
5. LTFMC sizes from 0.75-inch through 1.25-inches shall include an additional internal ground conductor, fabricated by the manufacturer, as an integral part of the conduit core.
6. Direct LTFMC conduit-to-LTFMC conduit coupling of LTFMC shall not be permitted.
7. LTFMC shall be allowed for conduit size ranges from 0.75-inch through 4.0-inches.
8. In addition to the requirements for FMC conduit, LTFMC shall also comply with ANSI C-33.84 (latest revision); NEMA-FB1 (latest revision); CEC 12-1400 (latest revision).
9. LTFMC fittings
   a. Fittings shall include an external mechanical ground/bond wire connector.
   b. The attachment of the fitting to LTFMC shall be threaded compression type onto the conduit core with locknut and liquid tight jacket compression seal. The fitting shall automatically prevent "sleeving" of the jacket.
   c. Straight and angled termination connector fittings shall be threaded on one end and shall include locknut suitable for connection to threaded and unthreaded enclosures.
10. LTFMC fittings as manufactured by:
    a. Termination connector fittings:

Straight	45 and 90 Degree Angle Connectors
1) Thomas & Betts-5331 GR Series.	Thomas & Betts-5341GR and 5351GR Series.
2) Appleton-STB Series; STN-L Series for use with preformed"knockouts".	Appleton-STB-L Series; STN-L Series for use with preformed "knockouts".

3) Emerson- OZ/Gedney-4QSeries. Emerson-OZ/Gedney-4Q Series

b. LTFMC to RMC conduit to conduit combination coupling fittings:
   1) Thomas & Betts-5271 GR Series.
   2) Emerson-OZ/Gedney-4Q Series

H. Expansion Joint, Deflection Joint and Seismic Joint Conduit Fittings
   1. Expansion Conduit Fitting - Fitting shall provide for a minimum of 2-inches straight line movement between two connecting conduits in each direction (total 4-inches conduit expansion and contraction) parallel to the respective conduit lengths. Fitting shall be watertight.

2. Deflection Conduit Fitting - Fitting shall provide for a minimum of 30 degrees angular deflection movement ("Shear" deflection) between two connecting conduits, in any direction perpendicular to the length of the respective conduits. Fitting shall be watertight.
3. Combination Expansion/Deflection Conduit Fitting - Fitting shall provide the combined "expansion" and "deflection" movement capacity between two connecting conduits as described for separate "expansion" and "Deflection" conduit fittings. Fitting shall be approved for installation concealed in both masonry/ concrete construction and exposed non-masonry/concrete construction. Fitting shall be watertight.
4. Fittings shall comply with UL.
5. Fittings as manufactured by:
   a. Conduit expansion fittings exposed or concealed locations as manufactured by:
      1) Emerson-OZ/Gedney – AXB-8 Series for RMC conduit.
      2) Emerson-OZ/Gedney - TX Series for EMT conduit.
      3) Appleton – AXB or XJ8 Series for RMC conduit and EMT conduits. Provide RMC to EMT combination conduit coupling fittings for each end of the expansion fitting.
   b. Combination expansion/deflection conduit fittings exposed or concealed conduit locations as manufactured by:
      1) Emerson-OZ/Gedney - AXDX Series for RMC conduit.
      2) Emerson-OZ/Gedney - AXDX Series for EMT conduit.
      3) Appleton-DX Series for RMC conduit.
      4) Provide RMC to EMT combination conduit coupling fittings for each end of the expansion/deflection fitting.
   c. Conduit expansion/deflection fittings for FMC and LTFMC conduit.
      1) Provide a minimum of 12-inches of "slack" LTFMC in each FMC or LTFMC conduit at building and structure seismic or expansion joint conduit crossings.
      2) Note: Each FMC "slack" expansion/deflection location, shall be considered as not less than a 90 degree conduit bend location, for compliance with the maximum quantity of conduit bends allowed in a raceway.
6. Conduit fitting bonding jumper:
   a. The grounding/bonding path of metal conduit shall be maintained by the fitting.
   b. Provide a bonding jumper at each expansion, deflection and combination expansion deflection conduit fitting.
   c. The jumper shall be a bare flexible copper "braid". The copper braid electrical current carrying capacity shall be equal to the metal conduit.
   d. Provide a factory terminated ground clamp on each end of the braid with adjusting steel conduit grounding clamps and connect to each respective conduit end.
   e. The jumper braid length shall be 8-inches longer than the respective conduit fitting.
   f. Bonding jumper for FMC and EMT fittings as manufactured by:
      1) Emerson-OZ/Gedney – BJ and BJE Series
      2) Appleton – BJ/XJ Series

I. Conduit Bodies Conduit Fitting
1. Conduit bodies shall provide conductor access with a removable conduit body cover and wiring area enclosed in metal housing. The conduit body shall facilitate pulling conductors.
2. In-line form "C" conduit bodies shall be prohibited.
3. The interior space "length" of 90 degree "elbow" conduit bodies shall not be less than six (6) times the diameter size of the largest conduit connecting to the conduit body.
4. Conduit body covers shall be removable, gasketed; watertight "domed" metal covers "Mogul-Type" with threaded screw attachment to the conduit body.
5. Lubricated, reusable, wire roller guards inside the conduit body shall protect wire from insulation damage during wire "pulling".
6. Conduit body fittings shall comply with UL 514.
7. Conduit bodies as manufactured by:
   a. For RMC Conduit
      1) Hubbell/Killark – LB/Mogul (90-degree elbow) Series – threaded body.

2) Emerson-OZ/Gedney - LB 6X/Mogul (90 degree elbow) Series - threaded body.
3) Appleton – NEC6X-LB/Mogul (90 degree elbow) Series - threaded body.

b. For EMT Conduit
1) Same as for RMC conduit. Provide EMT to RMC conduit combination coupling fitting for each outlet body connection.

2.03 CONDUIT SUPPORTS

A. General
1. Conduit Supports, hangers and fasteners for metal conduit shall be steel, hot dip zinc galvanized.

3. Threaded hardware shall be continuous, free running threads.
4. Conduit support systems, including support channels, pipe clamps, braces, anchors, hardware, fasteners, shall be sized to support the full capacity circuit conductors weight, plus the installed conduit weight, plus the conduit fitting weight and support hardware weight, plus a 300% additional weight capacity safety factor.
5. Provide lock washer at each "bolted"/threaded connection.
6. Conduit supports, fasteners, channels, braces, hardware, anchors, pipe clamps, and hangers as manufactured by Unistrut or Kindorf.
7. Supports shall be free of "BURRS" and sharp edges.
8. Metal supports cut in the field shall be zinc galvanized after cutting to prevent rust.

B. Conduit Hangers
1. Threaded steel hanger rods.
a. Hanger rods smaller than 0.375-inches in diameter shall not be used for support of individual conduits.
b. Hanger rods smaller than 0.5-inches in diameter shall not be used for support of multiple conduits.
2. Conduit hanger wires shall be not less than 12-gauge steel.
3. Conduit hangers shall attach to structure fasteners with steel "Clevis" or "Swing" hangers and shall provide a minimum of 45 degrees of angular movement in any direction at the point of the conduit hanger attachment to the structure fasteners.
4. Conduits individually suspended by conduit hangers shall fasten to the respective hangers with "Clevis" type pipe hangers. The pipe hangers shall be steel, adjustable to fit conduit size and shall completely enclose the conduit circumference.

C. Conduit Support Channels
1. "C" channels shall be factory preformed with a minimum 12 gauge thickness metal. The channel shall be factory "punched" with regularly spaced slotted holes for fastener attachments along the length of the channel.

2. The "C" channel shall not deflect more than 0.1 inches between channel supports at maximum installed design load, including required safety factor.
3. Channels shall comply with ANSI-1008 (latest revision) and ASTM-A569 latest revision).
4. Channels shall provide "turned lips" at longitudinal edges to hold (lock-in) fasteners.
5. Conduit support channels suspended from conduit hangers shall attach to conduit hangers with treaded connections. Provide a minimum of two hangers (trapeze style) connected to each channel.
6. Non-suspended conduit support channels shall connect to structure fasteners with threaded connectors.

D. Fasteners, Seismic Earthquake Rated
1. Channel fasteners:
   a. Channel fasteners shall "prelocate" and lock into the channel "turned lips" and channel "walls".
   b. A separate metal strap shall "tie" each conduit to each channel with conduit channel fasteners.
2. Structure fasteners:
   a. Structure fasteners for wall and floor mounted conduit attachments shall attach to existing masonry and concrete structures with structure fasteners using drilled, mechanical, expansion shield anchors.
   b. Structure fasteners for wall and floor mounted conduit attachments shall attach to new masonry and concrete structures with structure fasteners using steel threaded inserts precast into the structures.
   c. Structure fasteners shall center the support load above or below the beam flanges and reduce torsion-rotation forces exerted on the structural beam. Attach to steel structural members with "swing-beam clamps", with set-locking screw structure fasteners.
      1) Beam clamps shall include integral safety rod, strap or "J"-hook to secure the attachment clamp to the beam flanges on both sides of the beam, with integral hanger rod attachment.
      2) Or double-ended beam clamp to secure the attachment clamp to the beam flanges on both sides of the beam, with integral hanger rod attachment.
   d. Structure fasteners for wall and floor mounted conduit attachments shall attach to wood structural members with flush "through-bolted" wood beam/wood framing stud structure fasteners.
   e. Structure fasteners for wall mounted conduit attachments shall attach to steel framing studs and steel structural elements with spot welded steel structure fasteners or drilled and bolted structure fasteners.

E. Brace Connectors
1. Provide lateral brace connectors to resist horizontal, lateral and vertical movement of suspended conduits during seismic earthquakes.
2. The braces shall connect from each conduit support, attach as close to the conduit as possible, and attach to fixed rigid, nonsuspended building "main" structural elements with fixed anchoring.
3. Brace attachment connectors and fasteners shall be rigid preformed steel channels or flexible #10 gauge steel hanger wire.
4. Connect and attach the brace connectors to fixed structural elements in the same manner as conduit support hangers. The connection of braces to structural elements shall be independent of the conduit support hanger structure fasteners.

2.04 ELECTRICAL POWER WIRE AND CABLE

A. General
1. All wire and cable shall be single-conductor, annealed copper, insulated 600 volt, #12AWG minimum unless specifically noted otherwise on the drawings.

2. Conductors #10AWG and smaller shall be solid. Conductors #8AWG and larger shall be stranded.
3. Insulation of conductor connected to circuit protection devices required to be "100%" rated, shall be 90 degree centigrade rated insulation.
4. Insulation of conductors installed outdoors, on grade or underground, insulation shall be rated for wet locations.
5. Insulation of conductors installed outdoors, installed exposed to the sun, installed in exposed conduits, insulation shall be rated for high-temperature 90 degrees centigrade.
6. Insulation of branch circuit conducts installed in light fixtures, insulation shall be rated for 90 degrees centigrade.
7. Conductor exposed to oil, insulation and jacket shall be oil resistant, complying with "Oil Resistant-1" and "Oil Resistant-2" UL 83.

B. Conductor Insulation
1. 600 Volt AC and/or DC insulated conductors installed entirely inside conduits, or enclosed inside wireways, or enclosed inside raceways, insulation shall be rated as follows.
2. Indoor above Grade locations either concealed or exposed.
   a. Dual rated THHN and THWN
   b. Individually rated THHN-2
   c. Individually rated THWN-2
   d. XHHW-2
3. Outdoor above Grade either concealed or exposed.
   a. XHHW-2
   b. THWN-2
   c. THW-2
4. Outdoor below Grade or outdoor on Grade.
   a. XHHW-2
   b. THWN-2
   c. THW-2
5. All other enclosed raceway locations not described above.
   a. XHHW-2
   b. THWN-2
   c. THW-2
7. 600 Volt AC and/or DC insulated conductors installed in open cable tray or open wireway or exposed insulation also shall be rated for exposed install locations.

C. Insulation Color Coding and Identification
1. The following color code for branch circuits:
   a. Neutral . . . White (Tape feeder neutrals with white tape near connections)
   b. Normal Power:

120/208 Volt	480/277 Volt	Ground
Green	Ground	Green
Phase A Black	Phase A	Brown
Phase B Red	Phase B	Orange
Phase C Blue	Phase C	Yellow

   c. Isolated ground insulation shall be green with a longitudinal yellow stripe.

2. When individual neutral conductors are shown for each branch circuit, the color code for the neutral conductors shall be as follows:
   a. 120/208 volt; Phase A - White with Black stripe; Phase B - White with Red stripe; Phase C - White with Blue stripe.
   b. 277/480 volt; Phase A - White with Brown stripe; Phase B - White with Orange stripe; Phase C - White with Yellow stripe.
3. Feeders identified as to phase or leg in each, switchboard, switchgear, panelboard and junction location with printed identifying tape.
4. Fire alarm conductors: Use 600-volt, type THHN-2/THWN-2 conductors and color-coded

per equipment manufacturer's recommendations and approved and listed for use on fire alarm systems by the State Fire Marshal.

5. Color coding for mechanical and plumbing control wiring shall be an agreed upon color code between the Mechanical/Plumbing CONTRACTOR and the Electrical CONTRACTOR, and color code shall be submitted to the DISTRICT'S REPRESENTATIVE in writing for approval prior to installation.

D. Panel feeders shall be copper:
   1. Wire size shown on the drawings is for copper conductors, unless specifically indicated otherwise.
   2. If the conductor termination is to be made on a bus bar or similar flat surface, a Burndy Type YA-A HYPLUG compression terminal intended for the specific conductor size, factory filled with oxide inhibitor compound shall be used. Terminal must be installed using a hydraulic compression tool equipment with a die head for the particular terminal used. Only Burndy Hypress tools shall be used for compression.
   3. If the conductor termination is to be made into a circuit breaker or similar insert compartment it shall be terminated by use of a Burndy AYP HYPLUG compression connector intended for the specific conductor size, factory filled with oxide inhibitor compound. Connector must be installed using only Burndy Hydraulic compression tool specifically approved for each respective connector.
   4. Connector aid shall be used for all terminations and connections. Connector aid shall be Burndy Pentrox A, NO-OX-1D Grade "A".
   5. When an aluminum lug is terminated to a copper bus with a steel or copper stud or bolt, place aluminum lug on stud or bolt followed by a flat steel washer, a Belleville washer, and steel or copper nut, in that order.

2.06 FLEXIBLE CORDS AND PORTABLE CABLES

A. General
   1. Multi-conductor insulated flexible cable with jacket rated extra heavy duty, extra hard-use and high abuse duty; ozone, sunlight, grease, oil resistant-UL 83 and water resistant; rated for indoor/outdoor use.
   2. Quantity of conductors and conductor sizes as indicated on the drawings but in no case less than five 16AWG.
   3. Characteristics:
      a. Conductors - stranded copper, soft annealed conforming to ASTM-B-174 and ASTM-B-172. 600 volt individually insulated and color-coded. Separate green insulated ground conductor. Aluminum conductors shall not be permitted for cords and cables.
      b. Insulation - rubber conforming to UL 62; temperature range plus 105 Centigrade to minus 50 Centigrade.
      c. Flame resistance shall conform with MSHA-P123-103.
      d. Jacket - black for equipment connections and yellow for outlet connections. Rated for temperature range plus 105 Centigrade to minus 50 Centigrade, water, sunlight and ozone resistant. Permanently mark jacket a minimum of 40-inches on center with rated voltage, manufacturer's name, wire/insulation type, AWG conductor size and quantity (minimum 24-inches on center).

PART 3 - EXECUTION

3.02 GROUNDING

A. Grounding shall be executed in accordance with all applicable codes and regulations, both of the State and local authorities having jurisdiction.

B. Where nonmetallic conduit is used in the distribution system, the CONTRACTOR shall install the proper sized copper ground wire in the conduit with the feeder for use as an equipment ground. The electrical metallic raceway system shall be grounded to this ground wire.

C. The maximum ground/bond resistance to the grounding electrode shall not exceed 1 ohms from any location in the electrical system. The maximum ground resistance of the grounding electrode to earth shall not exceed 5 ohms.

D. Ground/Bond Conductors
   1. Provide an additional, dedicated, green insulation equipment ground/bond wire inside each conduit type and raceway as follows. Size the ground/bond conductors to comply with CEC/NEC requirements. The metal conduit or raceway shall not be permitted to serve (function) as the only (exclusive) electrical ground return path:
      a. All types of nonmetallic conduit and all types of non-metallic raceways including but not limited to: RNMC - Rigid Nonmetallic Conduit.
      b. FMC - Flexible Metal Conduit.
      c. LTFMC - Liquid Tight Flexible Metal Conduit.
      d. Metal and non-metal raceways.
      e. RMC - Rigid Metal Conduit.
      f. EMT - Electrical Metal Tubing.
   2. The equipment ground/bond wire shall be continuous from the electrical circuit source point of origin to the electrical circuit end termination utilization point as follows:
      a. Every conduit and raceway path containing any length of the above identified conduits or raceway.
      b. Every conduit path and raceway path connected to any length of the above-identified conduits and raceways.
   3. The equipment ground/bond wire shall be sized as follows, but in no case smaller than indicated on the drawings. Install equipment ground/bond wire in each conduit/raceway, with the respective phase conductors:
      a.

Feeder, Subfeeders & Branch Circuit Protection	Min. Equipment Ground Wire Size
15 Amp	#12
20 Amp	#12
30 to 60Amp	#10
70 to 100 Amp	#8
101 to 200 Amp	#6
201 to 400 Amp	#2
401 to 600 Amp	#1
801 to 1000 Amp	2/0
1001 to 1200 Amp	3/0
1201 to 1600 Amp	4/0
1601 to 2000 Amp	250 MCM
2001 to 2500 Amp	350 MCM
2501 to 4000 Amp	500 MCM

   5. Splices in ground/bond wires shall be permitted only at the following locations:
      a. Ground buses with listed and approved ground lugs.
      b. Where exothermic welded ground/bond wire splices are provided.
   6. Provide ground/bond wire jumpers for conduit fittings with ground lugs, expansion and deflection conduit fittings at conduit fittings connecting between metallic and non-metallic raceways and to bond metal enclosures to conduit fittings with ground lugs.

E. Where conductors are run in parallel in multiple raceways, the grounding conductor shall be run in parallel. Each parallel equipment-grounding conductor shall be sized on the basis of the ampere rating of the overcurrent device protecting the circuit conductors in the raceway. When conductors are adjusted in size to compensate for voltage drop, grounding conductors, where required, shall be adjusted proportionately in size.

F. Ground conductors for branch circuit wiring shall be attached at each outlet to the back of the box using drilled and tapped holes and washer head screws, 6-32 or larger.

G. Each panelboard, switchboard, pull box or any other enclosure in which several ground wires are terminated shall be equipped with a ground bus secured to the interior of the enclosure. The bus shall have a separate lug for each ground conductor. No more than one conductor shall be installed per lug.

3.03 CONDUIT

A. General
   1. The sizes of the conduits for the various circuits shall be as indicated on the drawings, but not less than the conduit size required by code for the size and quantity of conductors to be

installed in the conduit.

2. Conduits shall be installed concealed from view. Install conduits concealed in walls, concealed below floors and concealed above ceilings, except as specifically noted otherwise.
   a. Conduits shall not be installed in concrete floors.
3. The following systems shall be considered as circuits 100 volts and less, all other circuits shall be considered to be over 100-volts (power circuits) unless specifically noted otherwise: Fire alarm, energy management control, telephone, public address, data, computer, television, intercom, intrusion alarm and nurse call.
4. Conduits shall be provided complete with conduit bends, conduit fittings, outlet boxes, pullboxes, junction boxes, conduit anchors/supports, grounding/bonding for a complete and operating conductor/wire raceway system.
5. Metal and nonmetal conduits shall be provided mechanically continuous between termination connection points. Metal conduit shall be provided electrically continuous between termination connection points.
6. Individual conduit paths and home runs shown on the drawings shall be maintained as separate individual conduits for each homerun and path.
7. Conduits, conduit fittings and installation work occurring in classified hazardous materials locations shall comply with applicable code Class 1 Division 1 requirements, unless specifically noted otherwise.
8. Transitions between conduits constructed of different materials and occurring in above grade locations shall be allowed only at outlet boxes, junction boxes, pull boxes, and equipment enclosures unless specifically indicated otherwise. Provide outlet boxes and junction boxes.
9. Metal conduit terminating to nonmetal enclosures; terminating into metal enclosures with "concentric.ring" knockouts; terminating into metal enclosures with knockout reducing washers, including but not limited to equipment housings, outlet boxes, junction boxes, pull boxes, cable trenches, manholes, shall be provided with a ground/bonding lug integrated with the conduit termination conductor fitting construction, by the fitting manufacturer. The lug shall provide for connection of a grounding/bonding conductor (insulated or uninsulated). The grounding lug shall be located on the fitting, inside the termination enclosure.
10. The type of conduit, type of conduit fittings, and type of conduit supports and method of conduit installation shall be suitable for the conditions of use and conditions of location of installation based on the manufacturer's recommendations; based on the applicable codes and based on the requirements of the contract documents.

B. RMC Installation Locations

RGS, IMC conduits and RGS, IMC fittings shall be installed in the following locations:

1. Embedded in floors, walls, ceilings, roofs, foundations, and footings constructed with concrete.
2. Embedded in walls and foundations constructed with brick and masonry.
3. Interior of buildings, within 9-feet of finish floor lines for exposed conduit locations.
4. Exterior of building for exposed conduit locations.
5. Damp or wet locations, exposed or concealed locations.
6. Exposed on roofs.
7. In hazardous materials areas and locations; below hazardous materials areas and locations; above hazardous materials areas and locations.
8. Exposed on utility service poles, for pole risers less than 9-feet above finish grade.
9. RMC conduit and RMC fittings may be installed in any location where EMT and FMC conduit is permitted to be installed.

D. EMT Installation Locations

EMT conduit and EMT fittings may be installed in the following locations, for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials"; only dry locations:

1. Concealed in hollow non masonry/non-concrete, metal stud frame and wood stud frame walls and floors.
2. Concealed above ceilings.
3. Exposed inside interior enclosed crawl spaces.

4. Exposed interior locations placed 10-feet or higher above finished floors (except as described in paragraph below at lower heights).
5. Exposed on walls and ceilings (any height) in the following dedicated function areas, interior enclosed room locations:
   a. Indoor enclosed electrical equipment rooms and closets.
   b. Indoor enclosed data and telecommunication terminal rooms and closets.
   c. Indoor enclosed HVAC equipment rooms and closets.
6. Any location where FMC is described to be installed, except as the final connection to rotating or vibrating equipment.

E. FMC Installation Locations

FMC conduit and FMC fittings may be installed in the following locations for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials"; only dry, interior locations:

1. Concealed in hollow non-masonry metal stud frame and wood stud frame fully enclosed walls.
2. Concealed above fully enclosed ceiling spaces.
3. FMC conduit shall be installed in continuous lengths between termination points. FMC shall not be "spliced" or coupled directly to FMC or any other conduit type under any circumstance.
4. The maximum continuous length of FMC that shall be installed between termination end points is 8-feet. Circuits requiring continuous conduit lengths exceeding 8-feet between termination end points shall be installed using either RMC or EMT conduits. FMC lengths shorter than 16-inches are prohibited.
5. The minimum size FMC conduit shall be as shown on the drawings but not be less than the following:
   a. FMC lengths of six feet or less, minimum FMC conduit size shall be 0.75-inch.

F. LTFMC Installation Locations

LTFMC conduit and LTFMC fittings shall be installed in the following locations for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials":

1. Final electrical connection to vibrating or rotating equipment; control and monitoring devices mounted on vibrating and rotating equipment including the following. Minimum conduit length shall not be less than 24-inches:
   a. Motor, engines, boilers, solenoids, and valves.
   b. Fixed mounted "shop" (manufacturing) production equipment.
   c. Fixed mounted food preparation equipment and "kitchen" equipment.
2. All locations where exposed flexible conduit connections are required, both indoor and outdoor.
3. Final connection to indoors electrical transformers. Minimum conduit length shall not be less than 24-inches; maximum conduit length shall not exceed 72-inches.
4. Do not install LTFMC located in environmental air plenums.

I. Conduit Installation

1. Conduit Supports
   a. Securely and rigidly support all raceways/conduits from the building structure. Raceways/Conduits shall be supported independent of all piping, air ducts, equipment ceiling hanger wires, and suspended ceiling grid systems. Secure conduit to structural element by means of UL listed and approved hangers, fasteners, "C" channels and pipe clamps.
   b. Provide conduit supports spaced along the length of the conduit as follows:
      1) RMC and EMT conduit, maximum not to exceed 96-inches on center; within 24-inches of each conduit bend and conduit termination location.
      2) FMC and LTFMC conduit, maximum not to exceed 24-inches on center; within 6-inches of each conduit bend and conduit termination location.
   c. Suspended conduit methods:
      1) Individual, suspended raceways/conduits separated by more than 12-inches from any other conduit and suspended from ceilings and roofs shall be supported as follows:
         a) Conduits smaller than 1.5-inches by means of hanger rods or hanger wires.

b) Conduits 1.5-inches and larger by means of hanger rods.
c) The conduit shall attach to the hangers with pipe clamps.

2) Suspended raceways/conduits positioned within 24 inches of any other conduit shall be grouped and supported by hanger rods using trapeze type conduit support channels ("C" channels). Conduits shall individually attach to common channels side-by-side, with pipe clamps.

d. Non-suspended conduit methods:
1) Individual raceway/conduits placed against wall/ceiling/floors, placed inside hollow wall/ceiling construction or structure framing (i.e., "dry- wall" or plaster hollow wall construction), shall be secured by means of individual pipe clamps and fasteners attached to the framing studs or other structural members and the conduit/raceway.
2) Provide common "C" channel supports for all multiple raceway/conduits placed against vertical or horizontal surfaces and positioned within 24-inches of other raceways/conduits. Attach channels to the framing studs or other structural members. Attach the conduits/raceway individually to common channels, side-by-side, with pipe clamps.
3) The use of toggle bolts is prohibited.

e. Conduit rising from floor for motor connection shall be independently supported if extending over 18-inch above floor. Support shall not be to a motor or ductwork, which may transmit vibrations.

f. Provide conduit anchoring, conduit support and conduit bracing systems conforming to Earthquake Seismic Zone 4 requirements. The conduit support/ anchoring system capacity shall include the weight of the conduits, conduit fittings, conduit supports and conductors/wires/cables installed in the conduits plus a 300% safety factor. Submit shop-drawing details showing each typical conduit anchor, conduit support and conduit brace location. Submit structural calculations performed by and signed by a Professional Structural Engineer (P.E.) with a P.E. license, registered in the state of California, U.S.A.

2. Conduit separation:
a. Conduit installed underground or below building slab without full concrete encasement: Shall be separated from adjacent conduits of identical systems (i.e. signal to signal, data to data, power to power, control to control etc.) by a minimum of 3-inches. Conduits of non-identical systems (i.e. signal to power; data to power; power to control; signal to control, etc.) shall be separated by a minimum of 12-inches.

b. Conduit installed underground with full concrete encasement; shall be separated from adjacent conduits of similar systems (100 volt and less) by a minimum of 2-inches; conduits for non power systems (100 volts and less to ground) shall be separated by a minimum of 6-inches from power circuits (over 100 volts to ground); conduits for power circuits shall be separated from adjacent conduits of similar power systems (over 100 volts to ground) by a minimum of 3-inches.

c. Separation of conduits entering termination points or crossing other conduits may be reduced as required within 60-inches of the termination or crossing points.

d. Conduits containing Utility Company service circuits (i.e. electrical power, telephone, or cable television) shall be separated a minimum of 12-inches from all other utilities and conduits, with or without concrete encasement; metallic or non-metallic conduit, above grade or underground conduit locations.

e. Conduits shall be separated from hot water piping, exhaust flues/chimneys, steam piping, boilers, furnaces, ovens by a minimum of 12-inches.

3. Conduit stubs:
a. Branch circuit and telephone conduits turned up from floor at the following locations shall terminate each conduit in a flush conduit coupling at the floor and then extend into partition or to equipment. Refer to DISTRICT'S REPRESENTATIVE'S drawings for location of walls and partitions.
1) Interior demountable partitions.
2) Below, into or adjacent to equipment not installed directly adjoining to a wall.
3) Up from below the floor into hollow stud frame walls.

b. From each panel, and signal cabinet which is wall mounted, stub up from top of the panel/cabinet a minimum of (3) three 1-inch conduits to the nearest accessible ceiling spaces or other accessible location. Where the floor below the panel is accessible or is a ceiling space, stub an additional (3) three 1-inch conduits from the bottom of the

panel into the accessible space below the panel. Cap conduits for future use.

c. Conduits stubbed underground outside of building line for future use shall be terminated a minimum of five feet clear (whichever distance is greater) of building or adjacent concrete walks and AC paving. The stubout conduit shall be capped. Provide concrete monuments, 6-inches by 6-inches by 15-inches deep, buried flush with grade over the capped ends. The face of monument shall be furnished with 3-inch square brass plates securely mounted and engraved with the number and size of conduits and type of service (i.e., "POWER", "TEL.", etc.).

d. Conduits stubbed into ceiling or floor spaces from outlets for telephone, video, computer/data or television shall be provided with an insulated throat bushing, on the end of each conduit stubout.

e. Conduit stubouts from outlet boxes and equipment located in hollow stud walls, into ceiling and floor spaces, shall be EMT or RMC conduit. The stubouts shall terminate into the ceiling and floor spaces with a conduit termination connector fitting.

f. Empty conduit stubs into building spaces and equipment shall be individually identified with a "ID-tag" located at each end of the conduit. The ID-tag shall state the origination point and termination point of the respective conduit (i.e., "from PNL-A/to Room #121"; "from outlet #24/to outlet #17 in Room #120"; etc.).

g. Provide a conduit termination fitting with insulated throat bushing and mechanical ground lugs at each conduit "stub-up" location.

6. Raceway/Conduits, which are installed at this time and left empty for future use, shall have 0.25-inch diameter polyvinyl rope left in place for future use. The pull rope shall be 500-pound minimum tensile strength. Provide a minimum of 5-feet of slack at each end of pull ropes.

7. Unless otherwise restricted by structural drawings and specifications, the maximum size conduit permitted in concrete slab on-grade, walls, ceilings and roofs constructed of masonry or concrete shall not be greater than 20% of the concrete/masonry thickness. Conduits installed in these locations shall not cross.
   a. Conduits shall not be installed in cast-in-place concrete floors.

8. Provide openings in building structures for conduit penetrations:
   a. New construction shall be provided with conduit sleeves, to provide conduit penetrations.
   b. Existing construction shall be drilled (core drill masonry and concrete) and provide conduit sleeves installed after drilling, to provide conduit penetrations.
   c. Where the structure penetrations for underground conduits penetrating through foundations will not comply with the (restriction/penetration) shown in the Contract Documents, install the conduits below and clear of the foundation lowest point.

9. Conduit bends risers and offsets:
   a. The minimum bend radius of "factory or field" fabricated conduit bends shall not be less than the following. The bend radius shall be measured at the surface, inside radius of the conduit wall:
      1) FMC and LTFMC conduit - conduit minimum bend radius 12-times the conduit diameter.
      2) RMC and EMT conduit minimum bend radius - conduit for power circuits over 100 volts and less than 600 volts, 8-times conduit diameter. Conduit for power circuits over 600 volt, 12-times conduit diameter. Conduit for low voltage, signal and fiber optic circuits, 10-times conduit diameter.
      3) RNMC conduit - conduit minimum bend radius 36-times the conduit diameter. Under building reduce minimum bend radius to 10-times the conduit diameter. Conduit bends and offsets in RNMC with less than 36-times conduit diameter bend/offset radius, shall be RNMC PVC schedule 80 or PVC coated RGS.
      4) Conduits for utility company conductors. Conduit minimum bend radius shall comply with the respective utility company requirements.
   b. Bends and offsets in conduits shall be kept to an absolute minimum. The total summation of all bends and offsets permitted in a conduit segment, occurring between two conduit termination/ connection end points, shall not exceed the following, including conduit fittings:
      1) RMC and EMT conduit - 360 angular degrees
      2) FMC and LTFMC conduit - 180 angular degrees
      3) RNMC conduit - 270 angular degrees

c. Each field fabricated conduit offset, bend and elbow which are not the standard product of the raceway/conduit manufacturer shall be mandrel tested. The test shall be conducted after the conduit installation is complete and prior to pulling-in any wire, in the same manner as for underground conduits.

d. Factory manufactured angle connector conduit fittings shall be installed in exposed conduit locations only. Installation in locations normally concealed from view shall not be permitted. Not more than one (1) factory manufactured angle connector shall be permitted in any length of conduit between conduit termination end points.

e. RNMC conduit risers from below grade shall be PVC coated RGS. Conduit risers, bends or offsets entering into a building shall be PVC coated RGS.

f. If three (3) or more conduit-bends of the same conduit size and same conduit material type, installed, as part of the contract work, fail to comply with the required minimum conduit bend radius or conduit angular degree limits. The following corrective actions shall occur:

1) The CONTRACTOR shall remove all the non-complying conduit bends and the respective wire in the conduit from the project site. Provide new conduit and wire, complying with the contract documents.

2) Where the conduit bends similar to the non-complying conduit bends are installed concealed in walls, floors, above ceilings or below grade, the Contractor shall expose the conduit bends to allow visual observation.

3) The CONTRACTOR shall remove the non-complying conduit bends and dispose off the project site. The CONTRACTOR shall provide new conduit bends and conductors complying with the contract documents.

4) All the costs to correct the deficient material and work along with costs to repair the direct, indirect, incidental damages and contract delays shall be the sole responsibility of the CONTRACTOR and shall be included in the bid price.

10. Expansion joint, deflection joint and seismic joint fittings.

a. Provide a conduit expansion fitting for each conduit length and conduit type as follows (Note - The installation of specified combination expansion/deflection fittings at seismic joints shall satisfy this spacing requirement also):

	Conduit Type	Conduit	Fitting Length Spacing
1)	RMC and EMT	Exposed exterior locations	200-feet
2)	RMC and EMT	Interior weather protected locations	400 feet

b. Provide a conduit combination expansion/deflection fitting for each conduit, crossing the following elements:

1) At each building or non-building structure seismic joint.

2) At each building on non-building structure expansion joint.

3) At each conduit penetration of a "sound-rated" wall, floor or ceiling.

11. Provide two (2) locknuts and an insulated throat bushing at each metal conduit terminating at enclosures, including but not limited to outlet boxes, junction boxes, terminal cabinets, switchgear, transformers, switchboards, distribution panels and panelboards.

12. Provide metallic or plastic closure caps on all conduit ends during construction, until installation of conductors in the respective conduit.

13. Conduit run exposed, shall be run at right angles or parallel to the walls or structures. All changes in directions, either horizontally or vertically, shall be made with conduit outlet bodies as manufactured by Crouse Hinds, OZ or equal. Conduits run on exposed beams or trelliswork shall be painted to match surrounding surfaces.

14. Conduit exposed on roof:

a. Conduits installed exposed on roofs shall be limited on the project and be approved by Architect beforehand. When approved, they shall be installed on conduit sleepers. Place the conduit sleepers a maximum 5-foot on center along the entire length of the conduit; under conduit expansion/deflection fittings; under each junction box and within 24- inches of each conduit bend.

b. Provide a conduit support "C" channel continuous along the top length of the sleeper and rigidly bolted to the sleeper. Conduits shall be loosely fastened to each sleeper "C" channel with pipe clamps to allow for relative movement between the sleeper and conduit.

c. Conduits shall not block or interfere with roof hatches, doors, ventilation openings, dampers, equipment access panels/doors, roof water drainage.

e. Conduit sleepers shall be fabricated, MIFAB C-Port Rubber Support or MIRO

Industries with Polycarbonate base, or equal. Sleeper length shall extend a minimum of 9-inches past the conduits attached to the sleeper, but in no case shall the length of the sleeper be less than 24- inches.

f. Provide a pad under each sleeper, sleepers shall not be installed in direct contact with the roofing. Sleeper pads shall extend a minimum of 6 inches past each side of the sleeper. The sleeper pad shall be semirigid mineral surfaced composition board, not less than 0.375-inch thickness, bituminous impregnated, manufactured for application on the specific roofing material. Remove roofing "ballast" (gravel) under pad, prior to installation of sleeper pad. Do not puncture roof membrane.

g. Position the "length" of the conduit sleepers' perpendicular to the roof slope, to prevent obstruction of roof drainage water flow. Where the conduit routing prevents placing the conduit sleeper parallel to the roof slope, provide two separate sleeper pads for the conduit sleeper, with a continuous 3-inches wide water drainage gap between the sleepers. Align the water drainage gap to allow unimpeded water travel along the roof slope drainage flow line between the pads.

15. Rigid steel conduit or electrical metallic tubing shall not be strapped or fastened to equipment subject to vibration or mounted on shock absorbing bases.

16. RMC conduit threads:
    a. Machine cut threads on RMC conduit required for field fabrication shall comply with NPS and ANSI-
    B1.20.1.
    b. The length of bare metal exposed during thread fabrication shall be completely covered by conduit couplings and fittings. Additionally, the thread length shall insure that conduit joints will reach "torque" tightness and become secure before conduit ends "butt" together and before conduit ends "butt" into the "shoulders" of other conduit fittings.
    c. Running threads or right/left handed threads shall not be used to connect RMC.

18. Tighten each conduit fittings and fitting appurtenance, to the "torque" (allowable tolerance 5%) value recommended by the fitting manufacturer and applicable code. If three (3) or more conduit fittings are found to not be in compliance with the manufacturer's "torque"
    (tightness) recommendations, the following corrective actions shall occur:
    a. The CONTRACTOR shall tighten "re-torque" the defective fittings and all similar conduit fittings installed as part of the contract documents in the presence of the District's Representative.
    b. If the respective conduit fittings similar to the deficient "torque tightness" fittings are installed concealed in walls, floors, above ceilings or below grade, the CONTRACTOR shall expose the fitting, to allow retightening each similar conduit fitting to the manufacturers recommended "torque" values.
    c. All the cost to repair the direct, indirect, incidental damages and contract delays resulting from complying with these requirements shall be the sole responsibility of the CONTRACTOR and shall be included in the bid price.

J. Conduit Seals
1. Provide conduit seal fittings at each location where a conduit transitions or passes through the following areas and where indicated on the drawings:
    a. Refrigerated areas.
    b. Temperature control rooms including warming rooms, steam rooms, saunas etc.
    c. Classified hazardous material areas.
    d. Water intrusion areas.
2. Provide conduit seals on each conduit entering a building from a below grade area located outside the building (i.e., basement, vault etc.) and connecting to the following types of equipment
    a. Transformers
    b. Panelboards
    c. Motor control centers
    d. Switchboards
    e. Switchgear
    f. Motors
    g. Terminal cabinets

h. Terminal backboards
i. Cable trenches

3. Conduit seals shall be installed in locations where the fitting is visible and accessible.

K. Nailing Shields
1. Provide "nail" shields where FMC conduit and conductors not installed in a conduit are installed through wood stud and wood frame construction. The nail shield shall provide a barrier resistant to "nailing" fasteners through the stud, and penetrating into the FMC and conductors.
2. The nail shields shall be flat nominal 1.5-inch x 3-inches, 14-gauge steel, and hot dip zinc galvanized with "nailing spurs".
3. Provide nailing shields on the front face and rear face of each FMC penetration. The shield shall be centered on each penetration through the respective framing, stud framing blocking, and stud framing plates.

L. Conduit Bodies
1. Conduit bodies shall be installed in exposed conduit locations only or above accessible ceilings.
2. Conduit bodies shall be accessible for removing body cover and pulling wire through the conduit body.
3. Conduit bodies shall not be installed inside enclosed walls.

M. Preparation of Reuse of Existing Conduits
1. Prepare existing conduits shown to be reused as part of contract work as follows: Complete the required work prior to installing any conductors or cables in respective existing conduits.
a. "Rod" out existing raceways to be used under this contact, with approved test and flexible mandrels to remove all obstructions to clear debris from inside conduits.
b. Use test mandrels at least 12-inches long, 0.25-inches less than diameter of duct at center, tapering to 0.5-inches less than duct size at ends.
2. If test mandrels cannot be pulled through raceways, CONTRACTOR shall perform the following to clear the existing raceways:
a. Force rigid or semi-rigid rods through the raceways to clear the obstructions from one to both ends of the raceway.
b. Force a power driven rotating router device through the conduit from one or both ends of raceways. Device shall incorporate small diameter cutting blades. Repeat the "router" process in incremental stages to a cutting blade diameter approximately ⅛-inch smaller than the raceway inside diameter.
3. After clearing the raceway of obstructions, pull a test mandrel or brush through the raceway to clear the remaining debris from the raceway.

3.04 WIRE AND CABLE

A. Branch circuit and fixture joints for #10AWG and smaller wire shall be made with UL-approved connectors listed for 600 volts, approved for use with copper and/or aluminum wire. Connector to consist of a cone-shaped, expandable coil spring insert, insulated with a nylon shell and two (2) wings placed opposite each other to serve as a built-in wrench or shall be molded one-piece as manufactured by 3M-"Scotchlok".

B. Branch circuit joints of #8AWG and larger shall be made with screw pressure connectors made of high strength structural aluminum alloy and UL-approved for use with both copper and/or aluminum wire as manufactured by Thomas & Betts. Joints shall be insulated with plastic splicing tape, tapered half-lapped and at least the thickness equivalent to 1.5-times the conductor insulation. Tapes shall be fresh and of quality equal to Scotch.

C. Use UL listed pulling compound for installation of conductors in conduits.

D. Correspond each circuit to the branch number indicated on the panel schedule shown on the drawings except where departures are approved by the DISTRICT'S REPRESENTATIVE or the DISTRICT'S Representative.

E. All wiring, including low voltage, shall be installed in conduit.

F. Control wiring to conform to the wiring diagrams shown on the mechanical drawings and the

manufacturer's wiring diagrams.

G. All splices in exterior pull boxes and light poles shall be cast resins encapsulated.
   1. Power conductor splices - 3M Scotchcast Series 82/85/90; Plymouth or equal.
   2. Control and signal circuits 3M Scotchcast series 8981 through 8986, Plymouth or equal.

H. Neatly group and lace all wiring in panelboards, motor control centers and terminal cabinets with plastic ties at 3-inch on centers. Tag all spare conductors.

3.07 TESTING

A. Testing Conduit and Conduit Bends

The CONTRACTOR shall demonstrate the usability of all underground raceways, and field fabricated conduit bends installed as part of this contract.

1. A round tapered segmented semi-rigid mandrel with a diameter approximately ¼-inch smaller than the diameter of the raceway, shall be pulled through each new raceway.
2. The mandrel shall be pulled through after the raceway installation is completed. Conduits which stubout only, may have the mandrel pulled after the concrete encasement is completed, but prior to completing the backfill.
3. DISTRICT'S REPRESENTATIVE shall witness the raceway testing for usability. A Representative of the Respective Utility Company shall witness the raceway testing where applicable.
4. CONTRACTOR shall repair/replace any conduit and conduit bend provided under this contract which will not readily pass the mandrel during this test.

END OF SECTION

SECTION 26 24 16
BRANCH CIRCUIT PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other specification sections and drawings for related work required to be included as work under Division 26.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS (ADDITIONAL REQUIREMENTS)

A. Provide submittal data for all new circuit breakers to be installed in existing panelboards.

PART 2 - PRODUCTS

2.01 PANELBOARDS

A. All panelboards are existing – to remain.

B. The existing panelboards shall be modified and upgraded as indicated on the Drawings. The upgrades and modifications shall include (but shall not be limited to) the addition/removal of circuit breakers, new cover plates, etc. – as noted.

C. Furnish and install new circuit breakers in spaces indicated, complete with all required mounting hardware, cover plates, etc.

D. The Contractor shall prepare a ***new*** neatly typewritten schedule with number or name of room or area, or load served by each ***new and existing*** panelboard circuit. Do not 'mark-up' the existing schedule. Prepare a complete new schedule indicating all new and existing branch circuits as described above.

2.03 PANEL CIRCUIT BREAKERS, CIRCUIT PROTECTION DEVICES

A. New circuit breakers installed in existing panelboards shall match the existing characteristics of the existing circuit breakers (in the same panelboard) as noted on the drawings and as required.

C. Configuration
   1. Circuit breakers shall be arranged in the panels so that the breakers of the proper trip settings and numbers correspond to the numbering in the panel schedules on the drawings.
   2. Circuit numbers of breakers shall be black-on-white micarta tabs or other previously approved method. Circuit number tabs, which can readily be changed from front of panel, will not be accepted. Circuit number tabs shall not be attached to or be a part of the breaker.
   3. Panelboard circuit protection devices shall be bolt on type for connection to panel bus. Removable and installable without disturbing adjacent devices.
   5. Where 2-pole or 3-pole breakers occur in the panels, they shall be common trip units. Single pole breakers with tie-bar between handles will not be accepted.

D. Lock-Off and Lock-On
   1. All circuit breakers shall be pad-lockable in the "off" position.
   2. Where branch circuit breakers supply the power to motors and signal systems, the breakers shall also be furnished with lockout clips, mounted in the "on" position. The breakers shall be able to trip automatically with lockout clips in place.
   4. Locking facilities shall be riveted or mechanically attached to the circuit breaker (submit sample for approval. Other means of attachment shall not be accepted without prior written

approval of the District's Representative.

PART 3 - EXECUTION

3.01 MOUNTING

A. All panelboards are existing as indicated on the drawings.

3.03 UPGRADE OF EXISTING PANELBOARDS

B. As indicated on the Drawings, certain existing panelboards shall be modified and upgraded with new circuit breakers. These modifications include the addition and/or removal of individual circuit breakers for new and revised loads.

C. Furnish and install updated schedule for upgraded and revised panelboards as specified in this section.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment necessary for, and incidental to, performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other specification sections and drawings for related work required to be included as work under Division 26.
   2. General provisions and requirements for electrical work.

PART 2 - PRODUCTS

2.01 GENERAL

A. Division 240000 HVAC/Plumbing
   Refer to Division 260000 Mechanical and Plumbing Contract Documents and shop drawings for additional electrical work and material requirements.
   1. Provide all control devices including timeswitches, relays, auxiliary contacts, voltage transformers, and interlocks.
   2. Provide all raceways, conduit wire, circuits, outlets, and interconnections of starters as required for HVAC and Plumbing systems.

B. Special Considerations
   1. Mount all auxiliary relays and timeswitches in an isolated compartment inside motor control equipment unless otherwise indicated.
   2. Whether or not shown on mechanical and plumbing Contract Documents and/or control schedules, where motors are controlled by external devices (i.e., thermostats, relays, float or pressure switches, etc.) or interlocked with other motors, provide each magnetic motor starter with a "Hand-Off-Auto" selector switch in starter cover. Other magnetic motor starters provide a "Start-Stop" push-button station in starter cover.
   3. Motor starters, motor controllers and circuit feeder tap devices for motor circuits shall be rated and labeled for control of all electric motor design types A, B, C, D, and E pursuant to the requirements of the NEC

2.02 MANUAL MOTOR STARTERS

A. Provide flush or surface mounting manual motor starters with number of poles and size of thermal overload heaters as required for the motor being controlled (equipped with overload heaters, one (1) for each motor lead). Back boxes shall be supplied with all flush mounting starters, whether they are toggle type requiring only a 4-inch square outlet box or the larger type requiring a special box. Provide cover designed to accept the particular unit.

B. Unless otherwise noted on the drawings, all manual starters for single phase motors, smaller than 1 h.p. shall be the compact toggle type. Manual starters for all single phase motors, 1 to 5 h.p. and all three phase motors up to 5 h.p. shall be the heavy-duty type.

C. Where manual motor starter is shown with pilot light, the pilot light shall be installed in a separate outlet box adjacent to the starter outlet with engraved nameplate to indicate function of pilot light. Pilot lights shall be push-to-test style.

PART 3 - EXECUTION

3.01 MOTOR CONTROL CENTER AND INDIVIDUAL COMBINATION MOTOR STARTERS

A. Install motor control equipment in accordance with manufacturer's written instructions and

applicable portions of NEMA "Standards of Installations" for switchboards and motor control centers and individual motor starters.

3.03 SETTINGS AND ADJUSTMENTS

A. Program and set control function sequences, time delays, and protective device settings for correct system operation.

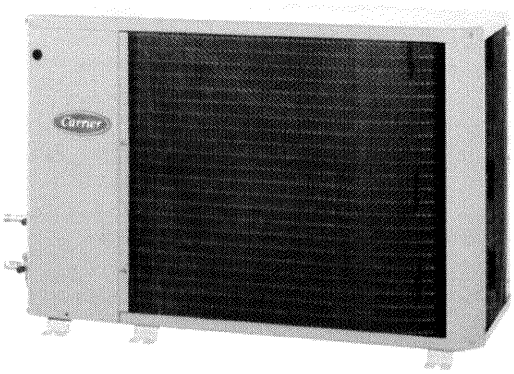
B. Test all timing, control sequences and motor rotation direction for proper operation. Correct deficiencies and retest until proper operation is confirmed.

END OF SECTION

25HHA4
Performance™ Series Heat Pump with Puron® Refrigerant 1–1/2 to 5 Nominal Tons

Carrier turn to the experts

Product Data



Puron. Performance SERIES

Carrier Heat Pumps with Puron® refrigerant provide a collection of features unmatched by any other family of equipment. The 25HHA4 has been designed utilizing Carrier's Puron refrigerant. This environmentally sound refrigerant allows you to make a responsible decision in the protection of the earth's ozone layer.

NOTE: Ratings contained in this document are subject to change at any time. Always refer to the AHRI directory (www.ahridirectory.org) for the most up–to–date ratings information.

INDUSTRY LEADING FEATURES / BENEFITS

Energy Efficiency

- 14 – 15 SEER/11.5 – 12.5 EER/8.2 – 8.5 HSPF (Based on tested combinations)

Sound

- Levels as low as 69 dBA

Design Features

- Small footprint
- WeatherArmor™ cabinet
  - — All steel cabinet construction
  - — Mesh coil guard

Reliability, Quality and Toughness

- Scroll compressor
- Factory–supplied filter drier
- High pressure switch
- Low pressure switch
- Accumulator
- Line lengths up to 250' (76.2 m)
- Low ambient operation (down to –20°F/–28.9°C with low ambient accessories)

MODEL NUMBER NOMENCLATURE

1	2	3	4	5	6	7	8	9	10	11	12	13
N	N	A	A	A/N	N	N	N	A/N	A/N	A/N	N	N
2	5	H	H	A	4	1	8	A	0	0	3	0
Product Series		Product Family	Product Type	Major Series	SEER	Cooling Capacity		Variations	Open	Open	Voltage	Minor Series
25=HP		H = HP	H = Horizontal Discharge		4 = 14 SEER			A=Standard	0=Not Defined	0=Not Defined	3=208/230–1 5=208/230–3 6=460/3	0, 1, 2...

Puron

AHRI CERTIFIED www.ahridirectory.org

Use of the AHRI Certified TM Mark indicates a manufacturer's participation in the program For verification of certification for individual products, go to www.ahridirectory.org.

c UL us

PHYSICAL DATA

UNIT SIZE – SERIES	18–30	24–30	30–30	36–30, 50, 60	48–30, 50, 60	60–30, 50, 60
COMPRESSOR TYPE	Scroll					
REFRIGERANT	Puron® (R–410A)					
Control	TXV (Puron Hard Shutoff)					
Charge lb (kg)	6.72 (3.05)	7.67 (3.48)	12.07 (5.47)	12.32 (5.59)	10.95 (4.97)	11.82 (5.36)
COND FAN	Propeller Type, Direct Drive					
Air Discharge	Horizontal					
Air Qty (CFM)	1285	1285	2615	2615	2785	2785
Motor HP	1/12	1/12	1/4	1/4	1/4	1/4
Motor RPM	800	800	800	800	800	800
COND COIL						
Face Area (Sq ft)	5.8	7.3	12.1	12.1	14.1	14.1
Fins per In.	20	20	20	20	20	20
Rows	2	2	2	2	2	2
Circuits	3	3	6	5	6	6
VALVE CONNECT. (In. ID)						
Vapor	5/8	3/4	3/4	7/8	7/8	7/8
Liquid	3/8					
REFRIGERANT TUBES* (In. OD)						
Rated Vapor*	5/8	3/4	3/4	7/8	7/8	1 1/8
Max Liquid Line†	3/8					

* Units are rated with 25 ft (7.6 m) of lineset length. See Vapor Line Sizing and Cooling Capacity Loss table when using other sizes and lengths of lineset.
Note: See unit Installation Instruction for proper installation.

† See *Liquid Line Sizing For Cooling Only Systems with Puron Refrigerant* tables.

VAPOR LINE SIZING AND COOLING CAPACITY LOSS

LONG LINE APPLICATION: An application is considered "Long line" when the total equivalent tubing length exceeds 80 ft. (24.38 m) or when there is more than 20 ft. (6.09 m) vertical separation between indoor and outdoor units. These applications require additional accessories and system modifications for reliable system operation. The maximum allowable total equivalent length is up to 250 ft. (76.2 m). The maximum vertical separation is 200 ft. (60.96 m) when outdoor unit is above indoor unit, and up to 80 ft. (24.38 m) when the outdoor unit is below the indoor unit. Refer to Accessory Usage Guideline below for required accessories. See Longline Application Guideline for required piping and system modifications. Also, refer to the table below for the vapor tube diameters based on the total length to minimize the cooling capacity loss.

Unit Nominal Size (Btuh)	Maximum Liquid Line Diameters (In.) OD	Vapor Line Diameters (In.) OD	Cooling Capacity Loss (%) Total Equivalent Line Length ft. (m)							
			Standard Application		Long Line Application Requires Accessories					
			26–50 (7.9–15.2)	51–80 (15.5–24.4)	81–100 (24.7–30.5)	101–125 (30.8–38.1)	126–150 (38.4–45.7)	151–175 (46.0–50.3)	176–200 (53.6–60.0)	201–225 (61.3–68.6)	226–250 (68.9–76.2)
18,000 1–Stage Puron HP	3/8	1/2	1	2	3	4	6	7	8	9	10
		5/8	0	0	1	1	1	2	2	3	3
24,000 1–Stage Puron HP		5/8	0	1	1	2	3	3	4	4	5
		3/4	0	0	0	0	1	1	1	1	1
30,000 1–Stage Puron HP		5/8	1	2	3	3	4	5	6	7	8
		3/4	0	0	1	1	1	2	2	2	3
		7/8	0	0	0	0	1	1	1	1	1
36,000 1–Stage Puron HP		5/8	1	2	4	5	6	7	9	10	11
		3/4	0	0	1	1	2	2	3	3	4
		7/8	0	0	0	0	1	1	1	1	2
48,000 1–Stage Puron HP		3/4	0	1	2	3	4	5	5	6	7
		7/8	0	0	1	1	2	2	2	3	3
60,000 1–Stage Puron HP		3/4	1	2	4	5	6	7	9	10	11
		7/8	0	1	2	2	3	4	4	5	5
		1–1/8	0	0	0	1	1	1	1	1	1

Applications in this area are long line. Accessories are required as shown recommended on Long Line Application Guidelines

Applications in this area may have height restrictions that limit allowable total equivalent length, when outdoor unit is below indoor unit See Long Line Application Guidelines

ACCESSORIES

KIT NUMBER	KIT NAME	Unit Size (Voltage/Series)											
		018 (30)	024 (30)	030 (30)	036 (30)	036 (50)	036 (60)	048 (30)	048 (50)	048 (60)	060 (30)	060 (50)	060 (60)
KAACH1701AAA	Crankcase Heater	X	X	S	S	S	S						
KAACH1601AAA	Crankcase Heater							X	X		X	X	
KAACH1901AAA	Crankcase Heater									X			X
KAACS0201PTC	PTC Start Assist	X	X	X	X			X			X		
KAAFT0101AAA	Evaporator Freeze Stat	X	X	X	X	X	X	X	X	X	X	X	X
KAATD0101TDR	Time Delay Relay	X	X	X	X	X	X	X	X	X	X	X	X
KHAIR0201AAA	Isolation Relay	X	X	X	X	X	X	X	X	X	X	X	X
KSALA0301410	Low Ambient Kit	X	X	X	X	X	X	X	X	X	X	X	X
KSALA0801AAA	MotorMaster® 230v	X	X	X	X	X		X		X	X		X
KSALA0901AAA	MotorMaster® 460v						X		X			X	
53DS–900–––070	Wind Baffle	X											
53DS–900–––087	Wind Baffle		X										
53DS–900–––071	Wind Baffle			X	X	X	X						
53DS–900–––088	Wind Baffle							X	X	X	X	X	X
53DS–900–––077	Wall Mounting Kit	X	X										
53DS–900–––078	Wall Mounting Kit			X	X	X	X	X	X	X	X	X	X
KSASH2301COP	Sound Blanket Kit			X	X	X	X						
KSASH2401COP	Sound Blanket Kit							X	X	X	X	X	X
KHALS0401LLS	Solenoid Valve Kit	X	X	X	X	X	X	X	X	X	X	X	X
KSAHS1501AAA	Capacitor Relay Start Assist	X	X	X	X			X			X		
KSACY0101AAA	Cycle Protector	X	X	X	X	X	X	X	X	X	X	X	X

X = Accessory

ACCESSORY THERMOSTATS

PART NUMBER	DESCRIPTION
TP-WEM01	Côr™ Thermostat
TP-PRH01-A	edge™ Programmable Relative Humidity Thermostat
TP-PHP01	edge™ Programmable Thermostat
TP-NRH01	edge™ Non-Programmable Relative Humidity Thermostat
TP-NHP01	edge™ Non-Programmable Thermostat
TC-WHS01	Wi-Fi® Thermostat
TC-PHP01	Programmable Thermostat
TC-NHP01	Non-Programmable Thermostat
TCSNHP01	Non-Programmable Standard Screen Thermostat

THERMOSTAT ACCESSORIES

PART NUMBER	DESCRIPTION	THERMOSTATS USED WITH
TP-EXP	edge™ EXP® Card	Programmable edge™ thermostats
TSTATCCSEN01-B	Outdoor Air Temperature Sensor	TP-Pxx, TP-Nxx
TSTATXXCNV10	Thermostat Conversion Kit (4 to 5 wire) - 10 pack	All Carrier® branded thermostats
TX-MBP01	Medium Decorative Backplate	TC-Nxx
TX-LBP01	Large Decorative Backplate	TP-Pxx, TP-Nxx, TC-Pxx

ACCESSORY USAGE GUIDELINE

Accessory	REQUIRED FOR LOW–AMBIENT COOLING APPLICATIONS (Below 55°F / 12.8°C)	REQUIRED FOR LONG LINE APPLICATIONS* (Over 80 ft. / 24.38 m)	REQUIRED FOR SEA COAST APPLICATIONS (Within 2 miles / 3.22 km)
Ball Bearing Fan Motor	Standard	Standard	Standard
Compressor Start Assist Capacitor and Relay	Yes	Yes	No
Crankcase Heater	Yes	Yes	No
Evaporator Freeze Thermostat	Yes	No	No
Isolation Relay	Yes	No	No
Liquid Line Solenoid Valve	No	See Long–Line Application Guideline	No
MotorMaster® Controller	Yes	No	No

* For tubing line sets between 80 and 200 ft. (24.38 and 60.96 m) and/or 20 ft. (6.09 m) vertical differential, refer to Residential Split–System Longline Application Guideline.

Accessory Description and Usage (Listed Alphabetically)

1. Ball–Bearing Fan Motor

A fan motor with ball bearings which permits speed reduction while maintaining bearing lubrication.

Usage Guideline:

Required on all units when using MotorMaster®

2. Compressor Start Assist – Capacitor and Relay

Start capacitor and relay gives a "hard" boost to compressor motor at each start up.

Usage Guideline:

Required for reciprocating compressors in the following applications:

Long line

Low ambient cooling

Hard shut off expansion valve on indoor coil

Liquid line solenoid on indoor coil

Required for single–phase scroll compressors in the following applications:

Long line

Low ambient cooling

Suggested for all compressors in areas with a history of low voltage problems.

3. Crankcase Heater

An electric resistance heater which mounts to the base of the compressor to keep the lubricant warm during off cycles. Improves compressor lubrication on restart and minimizes the chance of liquid slugging.

Usage Guideline:

Required in low ambient cooling applications.

Required in long line applications.

Suggested in all commercial applications.

4. Evaporator Freeze Thermostat

An SPST temperature–actuated switch that stops unit operation when evaporator reaches freeze–up conditions.

Usage Guideline:

Required when low ambient kit has been added.

5. Isolation Relay

An SPDT relay that switches the low–ambient controller out fo the outdoor fan motor circuit when the heat pump switches to heating mode.

Usage Guideline:

Required on all heat pumps where low–ambient kit has been added.

6. Liquid–Line Solenoid Valve (LLS)

An electrically operated shutoff valve which stops and starts refrigerant liquid flow in response to compressor operation. It is to be installed at the outdoor unit to control refrigerant off cycle migration in the heating mode.

Usage Guideline:

An LLS is required in all long line heat pump applications to control refrigerant off cycle migration in the heating mode. See Long Line Guideline.

7. Low Pressure Switch Kit

Factory installed added compressor protection against loss of refrigerant. It cuts out the system at 50 PSI and allows operation again at 95 PSI. Used for commercial or "harsh" environment applications for extra protection..

8. MotorMaster Low–Ambient Controller

A fan–speed control device activated by a temperature sensor, designed to control condenser fan motor speed in response to the saturated condensing temperatures down to −20°F (−28.9°C), it maintains condensing temperature at −100°F +/− 10°F (37.8°C + −6°C).

Usage Guideline:

A MotorMaster Low–Ambient Controller must be used when cooling operation is used at outdoor temperatures below 55°F (12.8°C).

Suggested for all commercial applications.

9. Time Delay Relay

An optional accessory for systems that do not have an integral blower time delay.

ELECTRICAL DATA

UNIT SIZE – voltage,series	V/PH	OPER VOLTS* MAX	OPER VOLTS* MIN	COMPR LRA	COMPR RLA	FAN FLA	MCA	MAX FUSE** or CKT BRK AMPS
18–30				48.0	9.0	0.50	11.8	20
24–30				58.3	12.8	0.50	16.5	25
30–30	208/230/1	253	197	64.0	12.8	1.20	17.2	30
36–30				77.0	14.2	1.20	19.0	30
48–30				117.0	21.8	1.45	28.8	50
60–30				144.2	25.5	1.45	33.4	50
36–50				71.0	9.3	1.20	12.8	20
48–50	208/230/3	253	197	83.1	13.7	1.45	18.6	30
60–50				110.0	17.1	1.45	22.9	40
36–60				38.0	5.6	0.60	7.6	15
48–60	460/3	506	414	41.0	6.2	0.80	8.6	15
60–60				52.0	7.8	0.80	10.6	15

LEGEND:

FLA – Full Load Amps
HACR – Heating, Air Conditioning, Refrigeration
LRA – Locked Rotor Amps
NEC – National Electrical Code
RLA – Rated Load Amps (compressor)

* Permissible limits of the voltage range at which the unit will operate satisfactorily
** Time–Delay fuse.
Complies with 2007 requirements of ASHRAE Standards 90.1

A–WEIGHTED SOUND POWER (dBA)

Unit Size	Standard Rating (dBA)	Typical Octave Band Spectrum (dBA, without tone adjustment) 125	250	500	1000	2000	4000	8000
18	70	53.5	59.5	61.5	65.5	59.5	55.5	46.0
24	69	53.0	63.0	63.0	62.5	59.0	54.0	50.5
30	72	58.0	61.0	64.0	66.5	64.0	63.5	57.0
36	71	60.5	60.5	64.0	65.5	64.0	62.0	56.5
48	73	60.0	59.0	65.0	68.0	64.0	61.0	55.5
60	74	70.0	62.0	65.0	66.0	64.5	64.0	57.5

NOTE: Tested in accordance with AHRI Standard 270–08 (not listed in AHRI).

A–WEIGHTED SOUND POWER (dBA) WITH ACCESSORY SOUND SHEILD

Unit Size	Standard Rating (dBA)	Typical Octave Band Spectrum (dBA, without tone adjustment) 125	250	500	1000	2000	4000	8000
18	N/A	–	–	–	–	–	–	–
24	N/A	–	–	–	–	–	–	–
30	71	57.5	61.0	63.5	65.5	63.0	63.5	57.0
36	70	59.5	60.5	63.0	64.5	63.0	61.5	56.0
48	72	56.5	59.5	63.5	67.5	64.0	60.5	55.0
60	72	62.0	60.5	64.5	65.0	64.0	63.5	54.5

NOTES:
Tested in accordance with AHRI Standard 270–08 (not listed in AHRI).
Accessory sound shield will not accommodate unit sizes 18 and 24.

CHARGING SUB–COOLING (TXV–TYPE EXPANSION DEVICE)

UNIT SIZE–SERIES	REQUIRED SUBCOOLING °F (°C)
18	12 (6.7)
24	14 (7.8))
30	11 (6.1)
36	14 (7.8)
48	11 (6.1)
60	12 (6.7)

DIMENSIONS – ENGLISH

UNIT	SERIES	ELECTRICAL CHARACTERISTICS				A	B	C	D	E	F	G	H	J	K	L	M	N	P	OPERATING WEIGHT(lbs)	SHIPPING WEIGHT(lbs)	SHIPPING DIMENSIONS (L x W x H)
25HHA418	0	X	O	O	O	25 1/8"	36 15/16"	14 9/16"	16"	23 7/16"	17 3/16"	17 1/8"	22 1/16"	13"	6 5/8"	11 1/4"	5/8"	2 7/8"	4 15/16"	150	170	42 15/16" X 18" X 28 1/8"
25HHA424	0	X	O	O	O	31 1/8"	36 15/16"	14 9/16"	16"	23 7/16"	17 3/16"	23 1/8"	28 1/16"	14"	6 3/4"	11 5/8"	3/4"	2 7/8"	4 15/16"	161	181	42 15/16" X 18" X 34 1/8"
25HHA430	0	X	O	O	O	37 1/8"	44 1/2"	17 1/16"	18 7/16"	30 1/2"	19 5/8"	29 1/8"	34 1/16"	13 11/16"	8 1/8"	15 7/8"	3/4"	3 3/8"	5 1/2"	196	226	50 1/2" X 20 1/2" X 40 1/8"
25HHA436	0	X	O	X	X	37 1/8"	44 1/2"	17 1/16"	18 7/16"	30 1/2"	19 5/8"	29 1/8"	34 1/16"	13 11/16"	8 1/8"	15 7/8"	7/8"	3 3/8"	5 1/2"	197	227	50 1/2" X 20 1/2" X 40 1/8"
25HHA448	0	X	O	X	X	43 1/8"	44 1/2"	17 1/16"	18 7/16"	30 1/2"	19 5/8"	35 1/8"	40 1/16"	14 1/2"	8 1/2"	18 7/8"	7/8"	3 3/8"	5 1/2"	246	276	50 1/2" X 20 1/2" X 46 1/8"
25HHA460	0	X	O	X	X	43 1/8"	44 1/2"	17 1/16"	18 7/16"	30 1/2"	19 5/8"	35 1/8"	40 1/16"	14 1/2"	8 1/2"	18 7/8"	7/8"	3 3/8"	5 1/2"	258	288	50 1/2" X 20 1/2" X 46 1/8"
		208-230-1-60	230-1-60	208/230-3-60	460-3-60																	

X = YES
O = NO

1. CLEARANCE REQUIREMENTS: SINGLE UNIT APPLICATIONS: WITH COIL FACING WALL: ALLOW 6 IN. MINIMUM CLEARANCE ON COIL SIDE AND COIL END AND 20 IN. MINIMUM CLEARANCE ON FAN SIDE. WITH FAN FACING WALL: ALLOW 8 IN. MINIMUM CLEARANCE ON FAN SIDE AND 6 IN. ON COIL END AND 20 IN. MINIMUM CLEARANCE ON COIL SIDE. MULTI-UNIT APPLICATIONS: ALLOW 24 IN. MINIMUM CLEARANCE BETWEEN FAN AND COIL SIDES OF MULTIPLE UNITS. ARRANGE UNITS SO DISCHARGE OF ONE DOES NOT ENTER INLET OF ANOTHER.WHEN TWO UNITS ARE INSTALLED END TO END WITH THE COIL ENDS FACING EACH OTHER ALLOW 12 IN. MINIMUM CLEARANCE BETWEEN UNITS. COMPRESSOR END SERVICE CLEARANCE: ALLOW 24 IN. MINIMUM CLEARANCE ON COMPRESSOR END WHEN UNITS ARE STACKED OR THERE IS LESS THAN 40 IN. OF CLEARANCE ABOVE THE TOP OF THE UNIT. IF THERE IS 40 IN. CLEARANCE ABOVE UNIT AND THE TOP PANEL IS ACCESSIBLE FOR REMOVAL ALLOW 8 IN. MINIMUM CLEARANCE ON COMPRESSOR END FOR SERVICE.

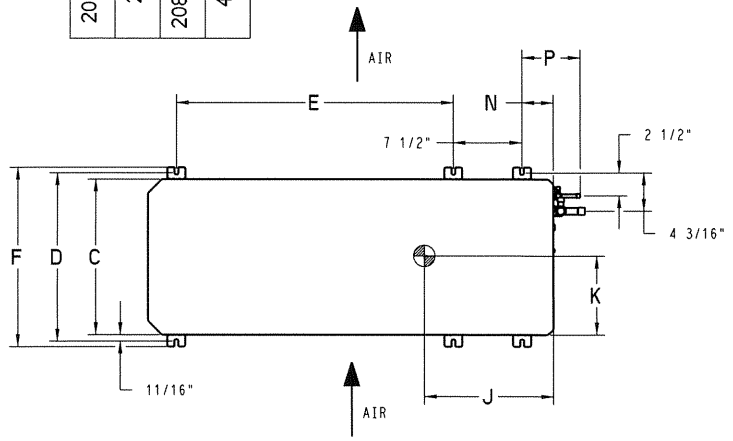
   IMPORTANT: WHEN INSTALLING SINGLE OR MULTIPLE UNITS IN AN ALCOVE, ROOF WELL, OR PARTIALLY ENCLOSED AREA, ENSURE THERE IS ADEQUATE VENTILATION TO PREVENT RECIRCULATION OF DISCHARGE AIR.

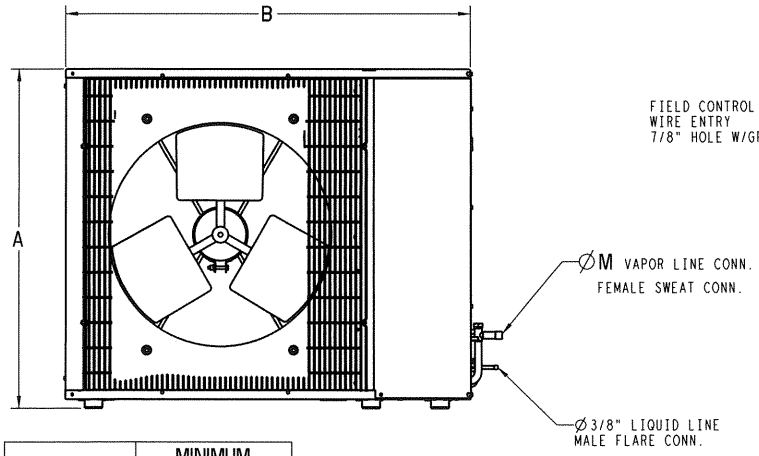
2. MINIMUM OUTDOOR OPERATING AMBIENT IN COOLING MODE IS 55°F, MAX. 125°F.

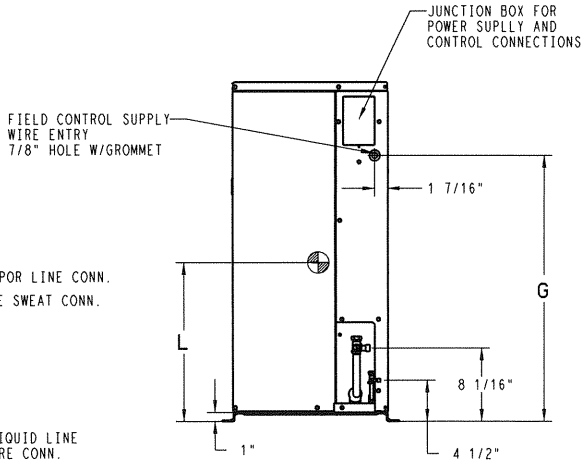
3. SERIES DESIGNATION IS THE 13TH POSITION OF THE UNIT MODEL NUMBER.

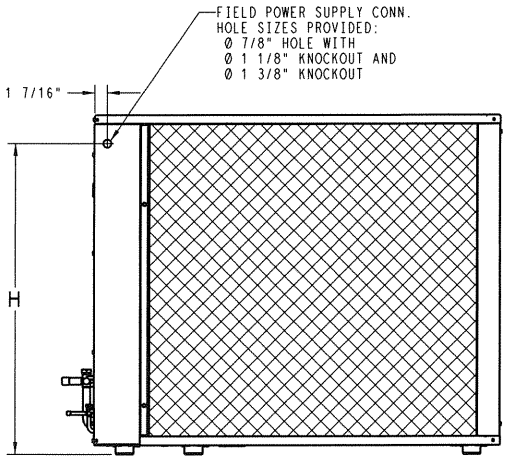
4. CENTER OF GRAVITY

5. ALL DIMENSIONS ARE IN "INCHES" UNLESS NOTED.







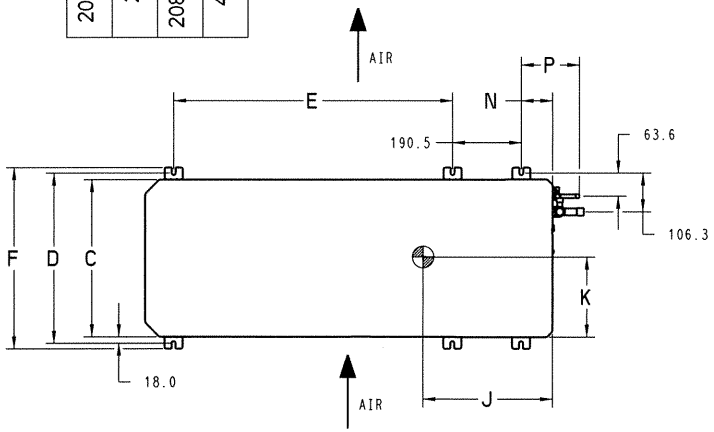


UNIT SIZE	MINIMUM MOUNTING PAD DIMENSIONS
18,24	23" X 42"
30,36,48,60	24" X 50"

DIMENSIONS – SI

UNIT	SERIES	ELECTRICAL CHARACTERISTICS				A	B	C	D	E	F	G	H	J	K	L	M	N	P	OPERATING WEIGHT(KG)	SHIPPING WEIGHT(KG)	SHIPPING DIMENSIONS (L x W x H)
25HHA418	0	X	O	O	O	638.0	938.0	370.0	406.0	595.5	436.0	435.2	559.8	330.2	168.3	285.8	15.9	73.0	126.2	68.0	77.1	1090.2 X 457.7 X 714.3
25HHA424	0	X	O	O	O	790.4	938.0	370.0	406.0	595.5	436.0	587.6	712.2	355.6	171.5	295.3	19.1	73.0	126.2	73.0	82.1	1090.2 X 457.7 X 866.7
25HHA430	0	X	O	O	O	942.8	1130.0	433.0	469.0	774.5	499.0	740.0	864.6	347.7	206.4	403.2	19.1	86.0	139.2	88.9	102.5	1282.7 X 520.7 X 1019.1
25HHA436	0	X	O	X	X	942.8	1130.0	433.0	469.0	774.5	499.0	740.0	864.6	347.7	206.4	403.2	22.2	86.0	139.2	89.4	103.0	1282.7 X 520.7 X 1019.1
25HHA448	0	X	O	X	X	1095.2	1130.0	433.0	469.0	774.5	499.0	892.4	1017.0	368.3	215.9	479.4	22.2	86.0	139.2	111.6	125.2	1282.7 X 520.7 X 1171.5
25HHA460	0	X	O	X	X	1095.2	1130.0	433.0	469.0	774.5	499.0	892.4	1017.0	368.3	215.9	479.4	22.2	86.0	139.2	117.0	130.6	1282.7 X 520.7 X 1171.5
		208-230-1-60	230-1-60	208/230-3-60	460-3-60																	

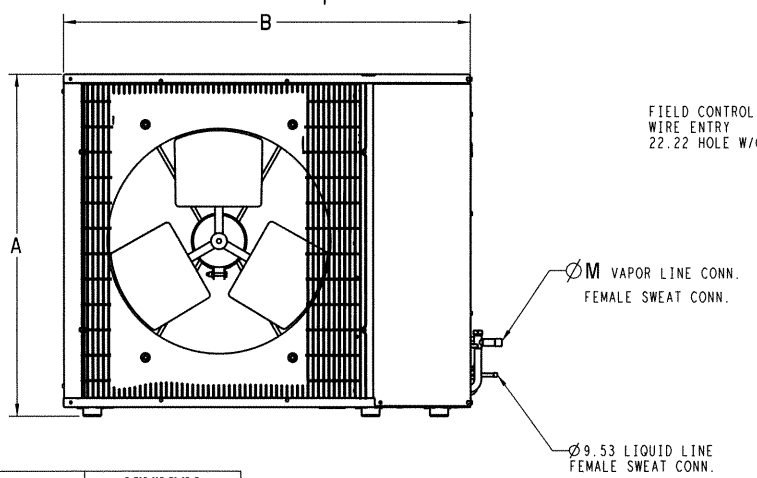
X = YES
O = NO

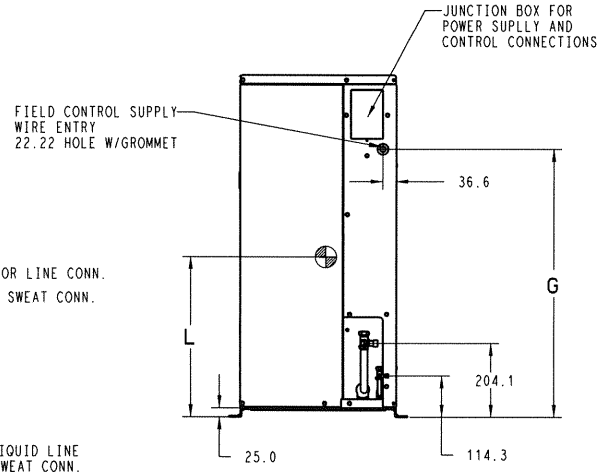


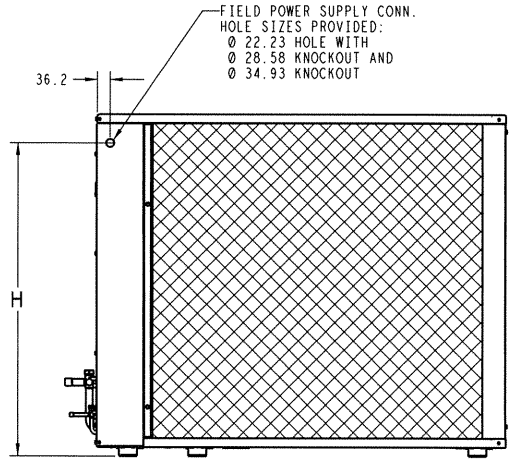
1. CLEARANCE REQUIREMENTS: SINGLE UNIT APPLICATIONS: WITH COIL FACING WALL: ALLOW 152.4 mm MINIMUM CLEARANCE ON COIL SIDE AND COIL END AND 504 mm MINIMUM CLEARANCE ON FAN SIDE. WITH FAN FACING WALL: ALLOW 203.2 mm MINIMUM CLEARANCE ON FAN SIDE AND 152.4 mm ON COIL END AND 504.0 mm MINIMUM CLEARANCE ON COIL SIDE. MULTI-UNIT APPLICATIONS: ALLOW 609.6 mm MINIMUM CLEARANCE BETWEEN FAN AND COIL SIDES OF MULTIPLE UNITS. ARRANGE UNITS SO DISCHARGE OF ONE DOES NOT ENTER INLET OF ANOTHER.WHEN TWO UNITS ARE INSTALLED END TO END WITH THE COIL ENDS FACING EACH OTHER ALLOW 304.8 mm MINIMUM CLEARANCE BETWEEN UNITS. COMPRESSOR END SERVICE CLEARANCE: ALLOW 609.6 mm MINIMUM CLEARANCE ON COMPRESSOR END WHEN UNITS ARE STACKED OR THERE IS LESS THAN 1016 mm OF CLEARANCE ABOVE THE TOP OF THE UNIT. IF THERE IS 1016 mm CLEARANCE ABOVE UNIT AND THE TOP PANEL IS ACCESSIBLE FOR REMOVAL ALLOW 203.2 mm MINIMUM CLEARANCE ON COMPRESSOR END FOR SERVICE.

   IMPORTANT: WHEN INSTALLING SINGLE OR MULTIPLE UNITS IN AN ALCOVE, ROOF WELL, OR PARTIALLY ENCLOSED AREA, ENSURE THERE IS ADEQUATE VENTILATION TO PREVENT RECIRCULATION OF DISCHARGE AIR.

2. MINIMUM OUTDOOR OPERATING AMBIENT IN COOLING MODE IS 12.8°C, MAX. 51.7°C.
3. SERIES DESIGNATION IS THE 13TH POSITION OF THE UNIT MODEL NUMBER.
4. CENTER OF GRAVITY
5. ALL DIMENSIONS ARE IN "MM" UNLESS NOTED.

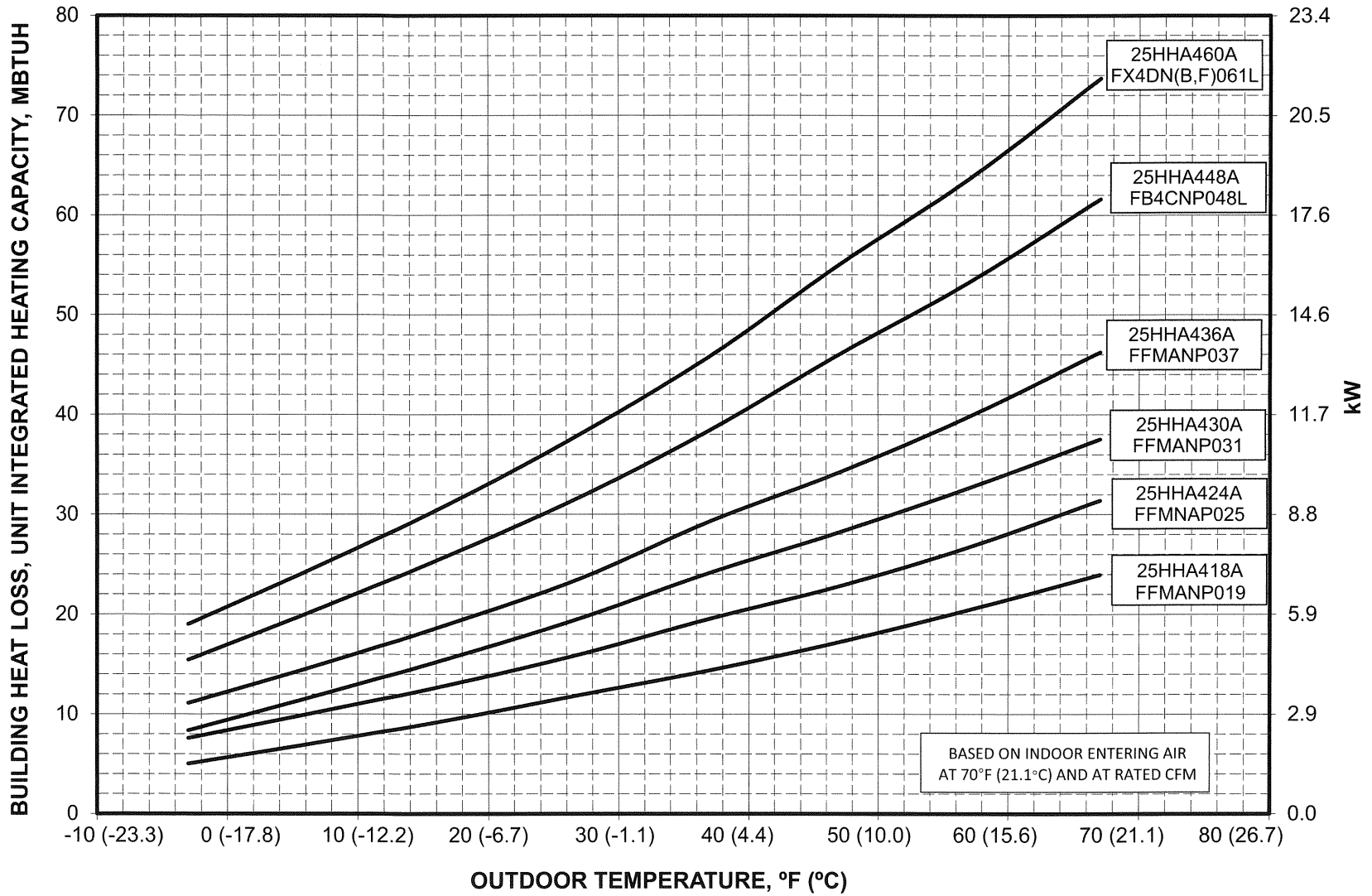






UNIT SIZE	MINIMUM MOUNTING PAD DIMENSIONS
18,24	584.2 X 1066.8
30,36,48,60	609.6 X 1270.0

BALANCE POINT WORKSHEET



TESTED AHRI COMBINATION RATINGS*

NOTE: Ratings contained in this document are subject to change at any time.

For AHRI ratings certificates, please refer to the AHRI directory www.ahridirectory.org

Additional ratings and system combinations can be accessed via the Carrier database at: www.MyCarrierRatings.com

For performance data at specific application &/or design conditions with various indoor unit combinations, the equipment performance calculator can be accessed at : http://rpmob.wrightsoft.com/

Model Number	Indoor Coil Model Number	Furnace Model Number	Cooling Capacity	EER	SEER	High Temp		HSPF	Low Temp	
						Capacity 47°F (8°C)	COP		Capacity 17°F (−8°C)	COP
25HHA418A**30	FFMANP019		18,000	11.5	14	17,200	3.80	8.2	10,400	2.48
25HHA424A**30	FFMANP025		23,400	11.5	14	22,800	3.74	8.2	13,800	2.50
25HHA430A**30	FFMANP031		28,800	12.5	15	28,200	4.02	8.5	17,500	2.62
25HHA436A**30	FFMANP037		34,200	12.0	14	34,200	3.94	8.5	21,000	2.60
25HHA436A**50	FFMANP037		34,200	12.0	14	34,200	3.94	8.5	21,000	2.60
25HHA436A**60	FFMANP037		34,200	12.0	14	34,200	3.94	8.5	21,000	2.60
25HHA448A**30	FB4CNP048L		45,500	11.5	14	46,000	3.66	8.2	29,000	2.56
25HHA448A**50	FB4CNP048L		45,500	11.5	14	46,000	3.66	8.2	29,000	2.56
25HHA448A**60	FB4CNP048L		45,500	11.5	14	46,000	3.66	8.2	29,000	2.56
25HHA460A**30	FX4DN(B,F)061L		55,000	11.5	14	55,000	3.78	8.2	33,600	2.62
25HHA460A**50	FX4DN(B,F)061L		55,000	11.5	14	55,000	3.78	8.2	33,600	2.62
25HHA460A**60	FX4DN(B,F)061L		55,000	11.5	14	55,000	3.78	8.2	33,600	2.62

EER — Energy Efficiency Ratio

SEER — Seasonal Energy Efficiency Ratio

TXV — Thermostatic Expansion Valve

NOTES:

1. Ratings are net values reflecting the effects of circulating fan motor heat. Supplemental electric heat is not included.
2. Tested outdoor/indoor combinations have been tested in accordance with DOE test procedures for central air conditioners. Ratings for other combinations are determined under DOE computer simulation procedures.
3. Determine actual CFM values obtainable for your system by referring to fan performance data in fan coil or furnace coil literature.
4. Do not apply with capillary tube coils as performance and reliability are significantly affected.

DETAILED COOLING CAPACITIES

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Sens‡	125 (51.7) Total System KW**
25HHA418A**30 Outdoor Section With FFMANP019 Indoor Section																			
	72 (22.2)	21.77	11.33	1.24	20.66	10.90	1.40	19.51	10.46	1.57	18.30	10.01	1.75	17.02	9.54	1.96	15.68	9.06	2.19
	67 (19.4)	19.71	13.86	1.23	18.70	13.43	1.38	17.64	12.99	1.55	16.54	12.54	1.73	15.37	12.07	1.94	14.15	11.58	2.17
525	63 (17.2)	18.24	13.32	1.22	17.30	12.89	1.37	16.31	12.45	1.53	15.28	11.99	1.72	14.19	11.52	1.92	13.05	11.04	2.15
	62 (16.7)	17.90	16.38	1.22	17.00	15.96	1.37	16.05	15.52	1.53	15.09	15.01	1.72	14.22	14.22	1.92	13.29	13.29	2.16
	57 (13.9)	17.35	17.35	1.21	16.63	16.63	1.37	15.87	15.87	1.53	15.06	15.06	1.72	14.20	14.20	1.92	13.27	13.27	2.16
	72 (22.2)	22.25	11.92	1.26	21.10	11.49	1.41	19.88	11.04	1.58	18.62	10.59	1.77	17.29	10.11	1.98	15.91	9.62	2.21
	67 (19.4)	20.16	14.81	1.24	19.11	14.37	1.40	18.00	13.92	1.57	16.85	13.47	1.75	15.64	12.99	1.96	14.38	12.49	2.19
600	63 (17.2)	18.67	14.21	1.24	17.69	13.77	1.39	16.66	13.32	1.55	15.58	12.86	1.74	14.46	12.38	1.94	13.28	11.88	2.17
	62 (16.7)	18.38	17.69	1.23	17.47	17.25	1.39	16.60	16.60	1.55	15.73	15.73	1.74	14.80	14.80	1.94	13.81	13.81	2.18
	57 (13.9)	18.16	18.16	1.23	17.39	17.39	1.39	16.57	16.57	1.55	15.71	15.71	1.74	14.78	14.78	1.94	13.79	13.79	2.18
	72 (22.2)	22.63	12.49	1.27	21.42	12.05	1.43	20.17	11.60	1.60	18.87	11.13	1.79	17.50	10.65	2.00	16.07	10.16	2.23
	67 (19.4)	20.52	15.72	1.26	19.42	15.28	1.41	18.28	14.83	1.58	17.10	14.36	1.77	15.85	13.88	1.97	14.56	13.37	2.20
675	63 (17.2)	19.01	15.06	1.25	17.99	14.62	1.40	16.93	14.16	1.57	15.82	13.69	1.75	14.66	13.20	1.96	13.46	12.69	2.19
	62 (16.7)	18.87	18.87	1.25	18.06	18.06	1.40	17.19	17.19	1.57	16.27	16.27	1.76	15.28	15.28	1.97	14.24	14.24	2.20
	57 (13.9)	18.85	18.85	1.25	18.03	18.03	1.40	17.16	17.16	1.57	16.24	16.24	1.76	15.26	15.26	1.96	14.22	14.22	2.20

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Sens‡	125 (51.7) Total System KW**
25HHA424A**30 Outdoor Section With FFMANP025 Indoor Section																			
	72 (22.2)	28.58	14.75	1.68	27.22	14.23	1.87	25.78	13.70	2.09	24.23	13.12	2.32	22.56	12.51	2.58	20.77	11.87	2.87
	67 (19.4)	25.98	18.17	1.63	24.74	17.65	1.82	23.40	17.10	2.03	21.96	16.51	2.27	20.41	15.89	2.53	18.76	15.23	2.82
700	63 (17.2)	24.11	17.49	1.60	22.95	16.97	1.79	21.70	16.41	2.00	20.34	15.81	2.24	18.88	15.19	2.50	17.32	14.52	2.80
	62 (16.7)	23.68	21.57	1.60	22.57	21.05	1.79	21.38	20.49	2.00	20.13	19.94	2.24	18.94	18.94	2.51	17.66	17.66	2.80
	57 (13.9)	23.03	23.03	1.59	22.13	22.13	1.78	21.15	21.15	2.00	20.08	20.08	2.24	18.91	18.91	2.51	17.63	17.63	2.80
	72 (22.2)	29.13	15.49	1.72	27.73	14.97	1.91	26.22	14.42	2.13	24.61	13.83	2.36	22.88	13.21	2.62	21.03	12.56	2.90
	67 (19.4)	26.50	19.36	1.66	25.20	18.83	1.86	23.81	18.27	2.07	22.32	17.68	2.31	20.73	17.05	2.57	19.02	16.39	2.85
800	63 (17.2)	24.61	18.60	1.63	23.40	18.06	1.83	22.09	17.50	2.04	20.69	16.90	2.27	19.19	16.27	2.54	17.58	15.59	2.83
	62 (16.7)	24.27	23.23	1.63	23.14	22.67	1.82	22.03	22.03	2.04	20.89	20.89	2.28	19.64	19.64	2.55	18.29	18.29	2.84
	57 (13.9)	24.01	24.01	1.63	23.05	23.05	1.82	22.00	22.00	2.04	20.86	20.86	2.28	19.61	19.61	2.55	18.26	18.26	2.84
	72 (22.2)	29.55	16.19	1.76	28.10	15.66	1.95	26.55	15.10	2.16	24.89	14.51	2.40	23.11	13.89	2.65	21.21	13.23	2.94
	67 (19.4)	26.89	20.50	1.70	25.55	19.97	1.89	24.12	19.40	2.11	22.60	18.81	2.34	20.97	18.17	2.60	19.23	17.49	2.89
900	63 (17.2)	24.99	19.66	1.67	23.74	19.12	1.86	22.40	18.55	2.07	20.97	17.95	2.31	19.43	17.30	2.57	17.79	16.60	2.86
	62 (16.7)	24.83	24.83	1.66	23.84	23.84	1.86	22.73	22.73	2.08	21.53	21.53	2.32	20.22	20.22	2.58	18.80	18.80	2.88
	57 (13.9)	24.83	24.83	1.66	23.81	23.81	1.86	22.70	22.70	2.08	21.50	21.50	2.32	20.19	20.19	2.58	18.78	18.78	2.88

See notes on pg. 13

DETAILED COOLING CAPACITIES (CONT.)

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Capacity MBtuh† Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Capacity MBtuh† Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Capacity MBtuh† Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Capacity MBtuh† Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Capacity MBtuh† Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Capacity MBtuh† Sens‡	125 (51.7) Total System KW**
25HHA430A30 Outdoor Section With FFMANP031 Indoor Section**																			
	72 (22.2)	35.68	17.88	1.86	33.43	17.10	2.05	31.12	16.32	2.26	28.69	15.50	2.51	26.11	14.65	2.78	23.35	13.76	3.09
	67 (19.4)	32.54	22.42	1.87	30.52	21.65	2.06	28.40	20.86	2.28	26.19	20.04	2.52	23.85	19.19	2.80	21.34	18.27	3.11
875	63 (17.2)	30.26	21.54	1.88	28.41	20.79	2.07	26.46	20.00	2.29	24.39	19.18	2.53	22.20	18.31	2.81	19.89	17.39	3.12
	62 (16.7)	29.91	26.93	1.88	28.23	28.08	2.07	26.61	26.61	2.29	24.86	24.86	2.53	22.99	22.99	2.80	20.94	20.94	3.11
	57 (13.9)	29.67	29.67	1.88	28.17	28.17	2.07	26.57	26.57	2.29	24.82	24.82	2.53	22.96	22.96	2.80	20.91	20.91	3.11
	72 (22.2)	36.23	18.82	1.88	33.89	18.03	2.07	31.51	17.24	2.29	29.00	16.41	2.53	26.34	15.55	2.80	23.51	14.63	3.11
	67 (19.4)	33.09	23.97	1.90	30.99	23.19	2.09	28.80	22.39	2.30	26.52	21.55	2.55	24.12	20.67	2.82	21.59	19.69	3.13
1000	63 (17.2)	30.81	23.00	1.90	28.88	22.23	2.10	26.86	21.42	2.31	24.72	20.57	2.56	22.50	19.68	2.83	20.18	20.07	3.14
	62 (16.7)	30.86	30.86	1.90	29.25	29.25	2.10	27.52	27.52	2.31	25.67	25.67	2.55	23.69	23.69	2.82	21.51	21.51	3.13
	57 (13.9)	30.82	30.82	1.90	29.21	29.21	2.10	27.48	27.48	2.31	25.63	25.63	2.55	23.66	23.66	2.82	21.49	21.49	3.13
	72 (22.2)	36.64	19.72	1.91	34.23	18.92	2.10	31.79	18.11	2.31	29.23	17.28	2.55	26.50	16.40	2.83	23.60	15.48	3.14
	67 (19.4)	33.51	25.48	1.92	31.35	24.68	2.11	29.09	23.85	2.33	26.78	22.99	2.57	24.36	22.04	2.85	21.98	21.98	3.15
1125	63 (17.2)	31.23	24.39	1.93	29.25	23.60	2.12	27.17	22.77	2.34	25.00	21.89	2.58	22.78	20.92	2.86	20.60	20.60	3.17
	62 (16.7)	31.80	31.80	1.93	30.09	30.09	2.12	28.26	28.26	2.33	26.32	26.32	2.57	24.24	24.24	2.85	21.96	21.96	3.15
	57 (13.9)	31.76	31.76	1.93	30.05	30.05	2.12	28.22	28.22	2.33	26.29	26.29	2.57	24.21	24.21	2.85	21.94	21.94	3.15

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Capacity MBtuh† Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Capacity MBtuh† Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Capacity MBtuh† Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Capacity MBtuh† Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Capacity MBtuh† Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Capacity MBtuh† Sens‡	125 (51.7) Total System KW**
25HHA436A30 Outdoor Section With FFMANP037 Indoor Section**																			
	72 (22.2)	41.22	20.81	2.31	39.23	20.08	2.55	37.15	19.33	2.83	34.92	18.53	3.13	32.56	17.71	3.48	30.04	16.84	3.88
	67 (19.4)	37.36	25.73	2.29	35.55	25.00	2.53	33.64	24.24	2.80	31.63	23.45	3.11	29.48	22.63	3.46	27.20	21.76	3.86
1050	63 (17.2)	34.58	24.71	2.27	32.91	23.98	2.52	31.14	23.22	2.79	29.27	22.44	3.09	27.28	21.61	3.44	25.15	20.73	3.84
	62 (16.7)	34.03	30.64	2.27	32.44	29.92	2.52	30.80	29.14	2.79	29.18	29.18	3.09	27.56	27.56	3.44	25.80	25.80	3.85
	57 (13.9)	33.32	33.32	2.27	32.02	32.02	2.51	30.63	30.63	2.79	29.14	29.14	3.09	27.52	27.52	3.44	25.76	25.76	3.85
	72 (22.2)	41.98	21.85	2.35	39.91	21.11	2.60	37.72	20.34	2.88	35.42	19.54	3.18	32.97	18.70	3.53	30.36	17.81	3.93
	67 (19.4)	38.06	27.42	2.33	36.17	26.68	2.58	34.20	25.92	2.85	32.11	25.12	3.16	29.90	24.28	3.51	27.54	23.38	3.90
1200	63 (17.2)	35.26	26.28	2.32	33.52	25.55	2.56	31.68	24.78	2.83	29.74	23.98	3.14	27.69	23.14	3.49	25.49	22.23	3.89
	62 (16.7)	34.91	32.97	2.32	33.32	33.32	2.56	31.87	31.87	2.84	30.26	30.26	3.14	28.54	28.54	3.50	26.65	26.65	3.90
	57 (13.9)	34.72	34.72	2.32	33.32	33.32	2.56	31.82	31.82	2.84	30.22	30.22	3.14	28.50	28.50	3.50	26.62	26.62	3.90
	72 (22.2)	42.44	22.61	2.39	40.30	21.87	2.64	38.06	21.09	2.91	35.70	20.28	3.22	33.20	19.42	3.57	30.54	18.53	3.96
	67 (19.4)	38.48	28.68	2.37	36.56	27.94	2.62	34.53	27.16	2.89	32.40	26.35	3.19	30.15	25.49	3.54	27.76	24.57	3.94
1315	63 (17.2)	35.68	27.45	2.36	33.88	26.71	2.60	32.01	25.93	2.87	30.03	25.12	3.17	27.93	24.25	3.52	25.72	23.32	3.93
	62 (16.7)	35.66	35.66	2.36	34.19	34.19	2.60	32.63	32.63	2.87	30.96	30.96	3.18	29.15	29.15	3.53	27.19	27.19	3.94
	57 (13.9)	35.62	35.62	2.36	34.15	34.15	2.60	32.59	32.59	2.87	30.92	30.92	3.18	29.11	29.11	3.53	27.16	27.16	3.94

See notes on pg. 13

DETAILED COOLING CAPACITIES (CONT.)

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Sens‡	125 (51.7) Total System KW**
25HHA448A**30 Outdoor Section With FB4CNP048L Indoor Section																			
	72 (22.2)	55.58	28.52	3.24	52.71	27.44	3.60	49.67	26.31	3.99	46.46	25.13	4.42	43.04	23.90	4.91	39.43	22.61	5.45
	67 (19.4)	50.82	35.33	3.22	48.24	34.27	3.57	45.50	33.14	3.96	42.57	31.95	4.39	39.46	30.71	4.87	36.16	29.39	5.42
1400	63 (17.2)	47.29	34.06	3.21	44.94	33.00	3.55	42.44	31.89	3.93	39.73	30.71	4.36	36.85	29.47	4.85	33.78	28.14	5.40
	62 (16.7)	46.47	41.90	3.20	44.21	40.79	3.55	41.81	39.57	3.92	39.28	38.16	4.36	36.75	36.75	4.85	34.20	34.20	5.41
	57 (13.9)	44.97	44.97	3.20	43.16	43.16	3.54	41.20	41.20	3.92	39.05	39.05	4.35	36.71	36.71	4.85	34.16	34.16	5.40
	72 (22.2)	56.50	29.84	3.29	53.50	28.73	3.65	50.34	27.58	4.04	47.02	26.39	4.48	43.48	25.13	4.96	39.77	23.83	5.50
	67 (19.4)	51.70	37.50	3.27	49.01	36.42	3.62	46.14	35.26	4.01	43.11	34.04	4.44	39.90	32.75	4.93	36.51	31.38	5.47
1600	63 (17.2)	48.16	36.09	3.26	45.70	35.00	3.60	43.07	33.86	3.98	40.27	32.65	4.41	37.29	31.36	4.90	34.15	29.97	5.45
	62 (16.7)	47.45	44.71	3.26	45.13	43.45	3.60	42.70	42.70	3.98	40.37	40.37	4.42	37.87	37.87	4.91	35.16	35.16	5.46
	57 (13.9)	46.68	46.68	3.25	44.73	44.73	3.60	42.62	42.62	3.98	40.32	40.32	4.41	37.83	37.83	4.91	35.13	35.13	5.46
	72 (22.2)	57.23	31.12	3.34	54.12	29.99	3.71	50.87	28.83	4.10	47.43	27.61	4.53	43.81	26.34	5.01	40.00	25.01	5.55
	67 (19.4)	52.40	39.64	3.32	49.60	38.51	3.68	46.64	37.31	4.06	43.52	36.05	4.49	40.23	34.70	4.98	36.78	33.24	5.52
1800	63 (17.2)	48.85	38.06	3.31	46.28	36.94	3.65	43.57	35.76	4.04	40.68	34.50	4.47	37.63	33.15	4.95	34.43	31.67	5.50
	62 (16.7)	48.35	47.90	3.31	46.06	46.06	3.65	43.82	43.82	4.04	41.39	41.39	4.47	38.75	38.75	4.96	35.91	35.91	5.52
	57 (13.9)	48.09	48.09	3.31	46.02	46.02	3.65	43.78	43.78	4.04	41.35	41.35	4.47	38.72	38.72	4.96	35.88	35.88	5.52

Evaporator Air CFM	EWB °F (°C)	CONDENSER ENTERING AIR TEMPERATURES °F (°C) 75 (23.9) Capacity MBtuh† Total	75 (23.9) Sens‡	75 (23.9) Total System KW**	85 (29.4) Capacity MBtuh† Total	85 (29.4) Sens‡	85 (29.4) Total System KW**	95 (35) Capacity MBtuh† Total	95 (35) Sens‡	95 (35) Total System KW**	105 (40.6) Capacity MBtuh† Total	105 (40.6) Sens‡	105 (40.6) Total System KW**	115 (46.1) Capacity MBtuh† Total	115 (46.1) Sens‡	115 (46.1) Total System KW**	125 (51.7) Capacity MBtuh† Total	125 (51.7) Sens‡	125 (51.7) Total System KW**
25HHA460A**30 Outdoor Section With FX4DN(B,F)061L Indoor Section																			
	72 (22.2)	71.53	37.82	3.89	68.08	36.52	4.29	64.42	35.16	4.76	60.48	33.71	5.29	56.24	32.16	5.90	51.76	30.56	6.59
	67 (19.4)	65.68	47.25	3.85	62.56	45.95	4.25	59.23	44.58	4.71	55.66	43.13	5.25	51.76	41.55	5.86	47.62	39.88	6.55
1750	63 (17.2)	61.40	45.63	3.82	58.54	44.34	4.22	55.47	42.98	4.68	52.16	41.52	5.21	48.55	39.94	5.82	44.67	38.26	6.52
	62 (16.7)	60.35	56.38	3.81	57.59	55.02	4.21	54.66	53.49	4.68	51.60	51.60	5.21	48.60	48.60	5.82	45.33	45.33	6.52
	57 (13.9)	58.88	58.88	3.80	56.63	56.63	4.21	54.21	54.21	4.67	51.52	51.52	5.21	48.54	48.54	5.82	45.28	45.28	6.52
	72 (22.2)	72.60	39.66	3.96	69.02	38.35	4.36	65.21	36.95	4.82	61.14	35.48	5.35	56.77	33.92	5.96	52.16	32.28	6.65
	67 (19.4)	66.73	50.32	3.91	63.47	48.98	4.32	60.02	47.58	4.78	56.30	46.08	5.31	52.30	44.46	5.92	48.05	42.73	6.61
2000	63 (17.2)	62.44	48.48	3.88	59.46	47.16	4.29	56.27	45.76	4.75	52.83	44.26	5.28	49.11	42.64	5.89	45.13	40.88	6.58
	62 (16.7)	61.58	60.29	3.88	58.75	58.75	4.28	56.09	56.09	4.75	53.22	53.22	5.28	50.04	50.04	5.90	46.58	46.58	6.59
	57 (13.9)	61.06	61.06	3.87	58.64	58.64	4.28	56.03	56.03	4.75	53.16	53.16	5.28	49.99	49.99	5.89	46.53	46.53	6.59
	72 (22.2)	73.40	41.42	4.02	69.69	40.08	4.42	65.78	38.67	4.88	61.60	37.18	5.41	57.12	35.59	6.02	52.43	33.95	6.71
	67 (19.4)	67.50	53.24	3.98	64.14	51.88	4.38	60.57	50.43	4.84	56.77	48.88	5.37	52.69	47.20	5.98	48.38	45.35	6.67
2250	63 (17.2)	63.23	51.19	3.95	60.13	49.83	4.35	56.84	48.39	4.81	53.33	46.85	5.34	49.52	45.15	5.95	45.49	43.27	6.64
	62 (16.7)	62.93	62.93	3.95	60.36	60.36	4.35	57.57	57.57	4.82	54.54	54.54	5.35	51.19	51.19	5.97	47.57	47.57	6.66
	57 (13.9)	62.86	62.86	3.94	60.29	60.29	4.35	57.51	57.51	4.82	54.48	54.48	5.35	51.14	51.14	5.96	47.53	47.53	6.66

† Total and sensible capacities are net capacities. Blower motor heat has been subtracted.

‡ Sensible capacities shown are based on 80°F (27°C) entering air at the indoor coil. For sensible capacities at other than 80°F (27°C), deduct 835 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air for each degree below 80°F (27°C), or add 835 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air per degree above 80°F (27°C).

** System kw is total of indoor and outdoor unit kilowatts.

EWB — Entering Wet Bulb

NOTES:

1. Detailed cooling capacities are based on indoor and outdoor unit at the same elevation per AHRI standard 210/240–2008. If additional tubing length and/or indoor unit is located above outdoor unit, a slight variation in capacity may occur.
2. When the required data falls between the published data, interpolation may be performed. Extrapolation is not an acceptable practice.

HEAT PUMP HEATING PERFORMANCE

INDOOR AIR EDB °F (°C)	CFM	OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																					
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
		Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA418A30 Outdoor Section With FFMANP019 Indoor Section**																							
65 (18.3)	525	5.18	4.77	1.03	7.27	6.68	1.08	9.73	8.87	1.13	11.98	10.64	1.18	14.44	13.14	1.23	17.27	17.27	1.29	20.50	20.50	1.38	24.08	24.08	1.47
	600	5.26	4.84	1.04	7.38	6.78	1.08	9.87	9.00	1.13	12.12	10.76	1.16	14.64	13.32	1.21	17.54	17.54	1.26	20.83	20.83	1.34	24.29	24.29	1.42
	675	5.34	4.91	1.05	7.47	6.86	1.08	9.97	9.09	1.12	12.24	10.87	1.16	14.81	13.47	1.19	17.75	17.75	1.25	21.03	21.03	1.31	24.26	24.26	1.38
70 (21.1)	525	4.94	4.54	1.08	7.03	6.46	1.13	9.27	8.45	1.18	11.76	10.45	1.24	14.17	12.90	1.29	16.94	16.94	1.35	20.10	20.10	1.44	23.70	23.70	1.55
	600	5.02	4.62	1.09	7.14	6.56	1.13	9.41	8.58	1.18	11.90	10.57	1.22	14.37	13.07	1.27	17.20	17.20	1.33	20.44	20.44	1.41	23.94	23.94	1.49
	675	5.10	4.69	1.09	7.23	6.65	1.14	9.56	8.72	1.18	12.03	10.68	1.21	14.53	13.22	1.25	17.41	17.41	1.31	20.69	20.69	1.38	23.99	23.99	1.45
75 (23.9)	525	4.66	4.29	1.13	6.76	6.21	1.19	8.98	8.19	1.24	11.55	10.25	1.30	13.90	12.65	1.35	16.61	16.61	1.42	19.71	19.71	1.51	23.29	23.29	1.63
	600	4.75	4.37	1.14	6.87	6.31	1.19	9.12	8.32	1.23	11.68	10.37	1.28	14.09	12.82	1.33	16.86	16.86	1.39	20.04	20.04	1.47	23.56	23.56	1.56
	675	4.83	4.45	1.14	6.96	6.40	1.19	9.24	8.43	1.23	11.80	10.48	1.27	14.25	12.97	1.32	17.07	17.07	1.37	20.30	20.30	1.45	23.68	23.68	1.52

INDOOR AIR EDB °F (°C)	CFM	OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																					
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
		Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA424A30 Outdoor Section With FFMANP025 Indoor Section**																							
65 (18.3)	700	8.00	7.36	1.42	10.61	9.75	1.49	13.33	12.15	1.54	16.75	14.88	1.60	19.86	18.07	1.64	23.17	23.17	1.70	27.16	27.16	1.79	31.89	31.89	1.92
	800	8.15	7.50	1.43	10.79	9.91	1.50	13.54	12.35	1.54	16.99	15.09	1.59	20.12	18.31	1.62	23.49	23.49	1.67	27.57	27.57	1.75	32.41	32.41	1.87
	900	8.30	7.63	1.44	10.95	10.07	1.51	13.73	12.52	1.55	17.19	15.27	1.59	20.35	18.51	1.61	23.76	23.76	1.65	27.90	27.90	1.73	32.81	32.81	1.84
70 (21.1)	700	7.58	6.97	1.48	10.21	9.39	1.56	12.94	11.80	1.62	15.97	14.19	1.67	19.54	17.79	1.73	22.80	22.80	1.79	26.74	26.74	1.87	31.40	31.40	2.01
	800	7.74	7.12	1.50	10.40	9.56	1.57	13.17	12.00	1.62	16.29	14.47	1.66	19.79	18.01	1.71	23.12	23.12	1.76	27.14	27.14	1.83	31.91	31.91	1.96
	900	7.89	7.26	1.51	10.57	9.71	1.58	13.35	12.17	1.62	16.85	14.96	1.67	20.02	18.22	1.70	23.38	23.38	1.74	27.47	27.47	1.81	32.32	32.32	1.93
75 (23.9)	700	7.14	6.57	1.55	9.78	8.99	1.63	12.54	11.44	1.69	15.52	13.78	1.75	19.22	17.49	1.82	22.44	22.44	1.88	26.31	26.31	1.97	30.89	30.89	2.10
	800	7.30	6.72	1.57	9.98	9.17	1.64	12.76	11.64	1.69	15.79	14.02	1.74	19.46	17.71	1.80	22.74	22.74	1.85	26.70	26.70	1.92	31.40	31.40	2.05
	900	7.44	6.85	1.58	10.14	9.32	1.65	12.96	11.81	1.70	16.03	14.23	1.74	19.68	17.91	1.79	23.00	23.00	1.83	27.03	27.03	1.90	31.81	31.81	2.02

See notes on pg. 16

HEAT PUMP HEATING PERFORMANCE (CONT.)

INDOOR AIR EDB °F (°C)	CFM	OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																							
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
		Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA430A30 Outdoor Section With FFMANP031 Indoor Section**																									
65 (18.3)	875	8.71	8.01	1.63	12.19	11.20	1.70	15.84	14.45	1.77	19.79	17.58	1.84	24.22	22.04	1.93	28.29	28.29	1.99	32.79	32.79	2.07	37.67	37.67	2.16
	1000	8.86	8.15	1.64	12.38	11.38	1.70	16.09	14.67	1.77	20.11	17.86	1.84	24.53	22.32	1.92	28.59	28.59	1.97	33.13	33.13	2.03	38.00	38.00	2.11
	1125	9.02	8.30	1.66	12.59	11.57	1.71	16.33	14.89	1.77	20.85	18.52	1.85	24.79	22.56	1.91	28.83	28.83	1.95	33.38	33.38	2.01	38.22	38.22	2.08
70 (21.1)	875	8.18	7.53	1.70	11.67	10.73	1.77	15.33	13.97	1.84	19.23	17.08	1.92	23.82	21.67	2.02	27.89	27.89	2.09	32.31	32.31	2.16	37.15	37.15	2.25
	1000	8.35	7.68	1.72	11.89	10.93	1.78	15.59	14.21	1.85	19.56	17.37	1.92	24.13	21.95	2.00	28.20	28.20	2.06	32.66	32.66	2.12	37.51	37.51	2.20
	1125	8.50	7.82	1.73	12.08	11.10	1.79	15.81	14.42	1.85	19.81	17.59	1.92	24.36	22.17	1.99	28.43	28.43	2.04	32.93	32.93	2.10	37.74	37.74	2.17
75 (23.9)	875	7.61	7.00	1.78	11.12	10.22	1.85	14.77	13.47	1.92	18.64	16.56	2.00	23.39	21.29	2.11	27.47	27.47	2.18	31.84	31.84	2.26	36.63	36.63	2.35
	1000	7.78	7.16	1.79	11.33	10.41	1.86	15.04	13.71	1.93	18.99	16.87	2.00	23.71	21.57	2.09	27.78	27.78	2.15	32.19	32.19	2.22	36.99	36.99	2.30
	1125	7.94	7.30	1.81	11.50	10.57	1.87	15.27	13.92	1.93	19.25	17.10	2.00	23.97	21.81	2.08	28.04	28.04	2.13	32.46	32.46	2.19	37.24	37.24	2.27

INDOOR AIR EDB °F (°C)	CFM	OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																							
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
		Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA436A30 Outdoor Section With FFMANP037 Indoor Section**																									
65 (18.3)	1050	11.50	10.58	2.02	15.24	14.01	2.10	19.32	17.61	2.17	23.78	21.12	2.25	29.39	26.75	2.36	34.26	34.26	2.46	39.84	39.84	2.58	46.24	46.24	2.73
	1200	11.74	10.80	2.04	15.54	14.28	2.11	19.67	17.93	2.18	24.19	21.49	2.25	29.82	27.13	2.35	34.76	34.76	2.43	40.49	40.49	2.54	47.07	47.07	2.68
	1350	12.00	11.04	2.07	15.83	14.55	2.14	20.00	18.23	2.20	24.58	21.83	2.26	30.16	27.45	2.35	35.20	35.20	2.42	41.03	41.03	2.52	47.76	47.76	2.65
70 (21.1)	1050	10.81	9.95	2.10	14.57	13.39	2.18	18.65	17.00	2.26	23.09	20.50	2.35	28.33	25.78	2.45	33.69	33.69	2.57	39.14	39.14	2.69	45.43	45.43	2.85
	1200	11.10	10.21	2.13	14.90	13.69	2.20	19.03	17.35	2.28	23.53	20.89	2.35	29.28	26.64	2.45	34.20	34.20	2.54	39.79	39.79	2.65	46.23	46.23	2.80
	1350	11.34	10.44	2.16	15.18	13.95	2.23	19.34	17.64	2.29	23.89	21.22	2.36	29.65	26.99	2.45	34.62	34.62	2.53	40.32	40.32	2.63	46.91	46.91	2.77
75 (23.9)	1050	10.08	9.28	2.19	13.85	12.73	2.27	17.94	16.36	2.36	22.37	19.87	2.45	27.34	24.87	2.55	33.12	33.12	2.68	38.45	38.45	2.81	44.63	44.63	2.97
	1200	10.36	9.53	2.21	14.18	13.03	2.29	18.33	16.71	2.37	22.82	20.26	2.45	27.93	25.41	2.54	33.62	33.62	2.66	39.07	39.07	2.77	45.41	45.41	2.92
	1350	10.61	9.76	2.25	14.46	13.29	2.32	18.65	17.01	2.39	23.19	20.59	2.46	28.50	25.93	2.55	34.03	34.03	2.65	39.60	39.60	2.75	46.06	46.06	2.89

See notes on pg. 16

HEAT PUMP HEATING PERFORMANCE (CONT.)

INDOOR AIR		OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																					
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
EDB °F (°C)	CFM	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA448A**30 Outdoor Section With FB4CNP048L Indoor Section																							
65 (18.3)	1400	16.21	14.91	2.77	21.31	19.58	2.89	26.72	24.37	3.01	32.57	28.93	3.14	39.84	36.26	3.33	46.71	46.71	3.52	54.10	54.10	3.71	62.59	62.59	3.93
	1600	16.54	15.21	2.79	21.68	19.93	2.90	27.15	24.76	3.01	33.12	29.41	3.13	40.86	37.18	3.32	47.30	47.30	3.47	54.89	54.89	3.64	63.64	63.64	3.84
	1800	16.82	15.47	2.82	22.01	20.22	2.92	27.53	25.10	3.02	33.58	29.82	3.13	41.31	37.59	3.30	47.82	47.82	3.44	55.54	55.54	3.59	64.50	64.50	3.78
70 (21.1)	1400	15.43	14.20	2.87	20.52	18.85	3.00	25.92	23.63	3.13	31.70	28.15	3.27	38.39	34.93	3.45	46.00	46.00	3.68	53.26	53.26	3.87	61.59	61.59	4.11
	1600	15.76	14.50	2.90	20.89	19.20	3.01	26.37	24.04	3.13	32.24	28.64	3.26	39.29	35.75	3.42	46.58	46.58	3.63	54.04	54.04	3.80	62.61	62.61	4.01
	1800	16.04	14.76	2.93	21.23	19.51	3.03	26.75	24.39	3.14	32.71	29.05	3.26	40.44	36.80	3.44	47.10	47.10	3.60	54.68	54.68	3.75	63.45	63.45	3.95
75 (23.9)	1400	14.58	13.42	2.98	19.66	18.06	3.11	25.08	22.86	3.26	30.81	27.37	3.41	37.32	33.96	3.59	45.27	45.27	3.85	52.45	52.45	4.04	60.60	60.60	4.28
	1600	14.90	13.71	3.01	20.04	18.42	3.13	25.52	23.27	3.26	31.34	27.83	3.40	38.01	34.59	3.56	45.86	45.86	3.79	53.19	53.19	3.96	61.59	61.59	4.18
	1800	15.19	13.98	3.04	20.38	18.73	3.15	25.91	23.63	3.27	31.80	28.25	3.40	38.63	35.15	3.55	46.37	46.37	3.76	53.82	53.82	3.91	62.41	62.41	4.12

INDOOR AIR		OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)																					
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)			47 (8.3)			57 (13.9)			67 (19.4)		
EDB °F (°C)	CFM	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HHA460A**30 Outdoor Section With FX4DN(B,F)061L Indoor Section																							
65 (18.3)	1750	22.65	20.84	3.14	28.50	26.19	3.26	34.87	31.79	3.38	43.02	38.21	3.56	50.31	45.79	3.71	58.30	58.30	3.87	67.89	67.89	4.03	77.66	77.66	4.20
	2000	23.00	21.16	3.16	28.89	26.54	3.27	35.32	32.20	3.38	43.42	38.56	3.54	50.81	46.24	3.67	58.96	58.96	3.82	68.49	68.49	3.95	77.97	77.97	4.10
	2250	23.32	21.46	3.19	29.23	26.86	3.28	35.73	32.57	3.39	43.80	38.91	3.53	51.25	46.64	3.65	59.50	59.50	3.80	68.88	68.88	3.91	78.00	78.00	4.04
70 (21.1)	1750	21.90	20.15	3.28	27.79	25.53	3.41	34.12	31.11	3.54	42.54	37.78	3.73	49.72	45.25	3.88	57.58	57.58	4.04	67.08	67.08	4.22	76.80	76.80	4.39
	2000	22.26	20.48	3.31	28.18	25.90	3.42	34.59	31.54	3.53	42.97	38.16	3.71	50.22	45.70	3.84	58.23	58.23	4.00	67.73	67.73	4.13	77.14	77.14	4.29
	2250	22.58	20.77	3.34	28.54	26.23	3.44	34.98	31.90	3.55	43.31	38.47	3.70	50.65	46.10	3.83	58.78	58.78	3.97	68.13	68.13	4.09	77.22	77.22	4.23
75 (23.9)	1750	21.09	19.41	3.43	27.02	24.83	3.56	33.36	30.41	3.70	41.01	36.42	3.87	49.13	44.71	4.07	56.88	56.88	4.23	66.27	66.27	4.41	75.91	75.91	4.60
	2000	21.45	19.74	3.45	27.43	25.21	3.57	33.81	30.82	3.69	42.41	37.66	3.88	49.60	45.14	4.02	57.51	57.51	4.18	66.93	66.93	4.32	76.30	76.30	4.49
	2250	21.77	20.03	3.48	27.79	25.54	3.59	34.21	31.19	3.71	42.80	38.01	3.88	50.04	45.53	4.01	58.06	58.06	4.15	67.38	67.38	4.27	76.42	76.42	4.42

* The Btuh heating capacity values shown are net integrated values from which the defrost effect has been subtracted. The Btuh heating from supplement heaters should be added to those values to obtain total system capacity.

† The kW values include the compressor, outdoor fan motor, and indoor blower motor. The kW from supplement heaters should be added to these values to obtain total system kilowatts.

NOTE: When the required data falls between the published data, interpolation may be performed. Extrapolation is not an acceptable practice.

EDB — Entering Dry Bulb

GUIDE SPECIFICATIONS
GENERAL

System Description

Outdoor–mounted, air–cooled, split–system heat pump unit suitable for ground or rooftop installation. Unit consists of a scroll–type hermetic compressor, an air–cooled coil, propeller–type condenser fan, and a control box. Unit will discharge supply air horizontally as shown on contract drawings. Unit will be used in a refrigeration circuit to match up to a packaged fan coil or furnace.

Quality Assurance

- Unit will be rated in accordance with the latest edition of AHRI Standard 210.
- Unit will be certified for capacity and efficiency, and listed in the latest AHRI directory.
- Unit construction will comply with latest edition of ANSI/ ASHRAE and with NEC.
- Unit will be constructed in accordance with UL standards and will carry the UL label of approval. Unit will have c–UL approval.
- Unit cabinet will be capable of withstanding Federal Test
  Method Standard No. 141 (Method 6061) 500–hr salt spray test.
- Air–cooled condenser coils will be leak tested and pressure tested
- Unit constructed in ISO9001 approved facility.

Delivery, Storage, and Handling

- Unit will be shipped as single package only and is stored and handled per unit manufacturer's recommendations.

Warranty (for inclusion by specifying engineer)

- U.S. and Canada only.

PRODUCTS

Equipment

- Factory assembled, single piece, air–cooled heat pump unit. Contained within the unit enclosure is all factory wiring, piping, controls, compressor, refrigerant charge Puron® (R–410A), and special features required prior to field start–up.

Unit Cabinet

- Unit cabinet will be constructed of galvanized steel and bonderized.

Fans

- Condenser fan will be direct–drive propeller type, discharging air horizontally.
- Condenser fan motors will be totally enclosed, 1–phase type with class B insulation and permanently lubricated bearings. Shafts will be corrosion resistant.
- Fan blades will be statically and dynamically balanced.
- Condenser fan openings will be equipped with coated steel wire safety guards.

Compressor

- Compressor will be a scroll–type, hermetically sealed.
- Compressor will be mounted on rubber vibration isolators.

Condenser Coil

- Condenser coil will be air cooled.
- Coil will be constructed of aluminum fins mechanically bonded to copper tubes which are then cleaned, dehydrated, and sealed.

Refrigeration Components

- Refrigeration circuit components will include liquid–line front–seating shutoff valve with sweat connections, vapor–line front–seating shutoff valve with sweat connections, system charge of Puron® (R–410A) refrigerant, and compressor oil.
- Unit will be equipped with high–pressure switch, low pressure switch and filter drier for Puron refrigerant.

Operating Characteristics

- The capacity of the unit will meet or exceed _____ Btuh at a suction temperature of _____ °F/°C. The power consumption at full load will not exceed _____ kW.
- Combination of the unit and the evaporator or fan coil unit will have a total net cooling capacity of _____ Btuh or greater at conditions of _____ CFM entering air temperature at the evaporator at _____ °F/°C wet bulb and _____ °F/°C dry bulb, and air entering the unit at _____ °F/°C.
- The system will have a SEER of _____ Btuh/watt or greater at DOE conditions.

Electrical Requirements

- Nominal unit electrical characteristics will be _____ v, single phase, 60 hz. The unit will be capable of satisfactory operation within voltage limits of _____ v to _____ v.
- Nominal unit electrical characteristics will be _____ v, three phase, 60 hz. The unit will be capable of satisfactory operation within voltage limits of _____ v to _____ v.
- Unit electrical power will be single point connection.
- Control circuit will be 24v.

Special Features

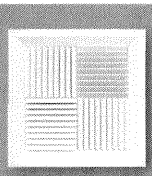
- Refer to section of this literature identifying accessories and descriptions for specific features and available enhancements.

Edition Date: 09/16

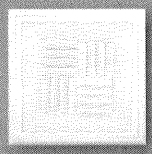
Catalog No: 25HHA4—03PD

Replaces: 25HHA4—02PD

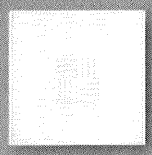
Table of Contents



1240, 51240
These supply, ceiling diffusers feature four hand-removable modular cores. Available in steel or aluminum construction.



1240P, 51240P
These supply, ceiling diffusers feature four hand-removable modular cores that are concealed by a perforated face, outlined by an architectural frame. Available in steel or aluminum construction.



1240PE
This supply, ceiling diffuser features four hand-removable modular cores that are concealed by a perforated face. Available in steel construction only.

1240, 51240
Introduction & Product Description D1-3
Dimensional Information D1-4
Core Part Detail D1-5
Discharge Air Patterns & Reference Charts D1-6
Performance Data D1-8
Engineering Specifications D1-12

1240P, 51240P, 1240PE
Introduction D1-13
Dimensional Information D1-14
Discharge Air Patterns & Reference Chart D1-17
Performance Data D1-19
Engineering Specification D1-23

Introduction: 1240P, 51240P, 1240PE

The Krueger 1240P/51240P/1240PE series of modular core perforated diffusers are one of Krueger's most versatile designs, combining excellent performance with on-the-job flexibility. The 1240P/51240P/1240PE series diffusers exhibit typical isothermal throws of 10' to 15' for 4-way air distribution and 35' to 50' for 1-way air distribution. The perforated face conceals the interior modular cores for an uninterrupted ceiling appearance. The modular cores are factory set for a 4-way air pattern, but may be field adjusted for 1-, 2- or 3-way air patterns. The modular capability makes the 1240P/51240P/1240PE ideal for installations with changing air pattern requirements such as tenant lease spaces.

MODELS

1240P - Modular Core Diffuser with Perforated Face and Architectural Frame, Steel Construction
51240P - Modular Core Diffuser with Perforated Face and Architectural Frame, Aluminum Construction
1240PE - Modular Core Diffuser with Perforated Face and Single Border, Steel Construction

FEATURES

- Hand-removable modular cores.
- Variety of discharge air patterns.

PANEL SIZE

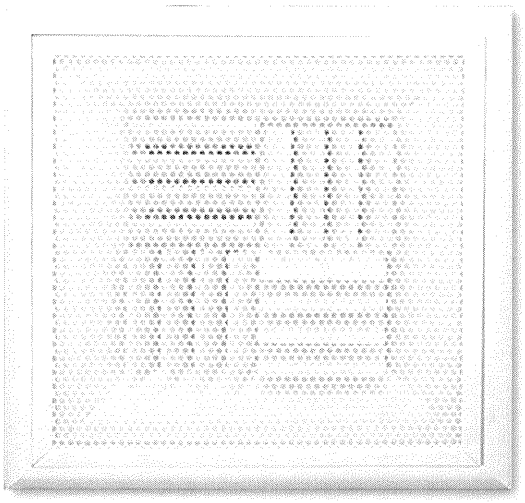
- 24"x24"

ACCESSORIES

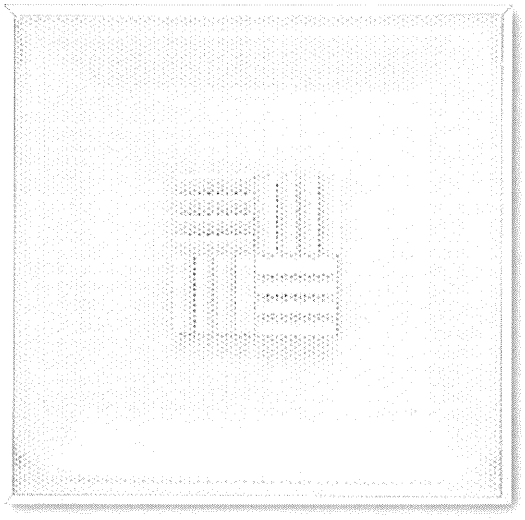
- Damper for 1240P (Model OBD1240, 5OBD1240)
- Damper for 51240P and 1240PE (Model OBD)
- Straightening Grid (Model SSG)

FINISHES

- Standard finish is #44 British White.
- Optional finishes available.

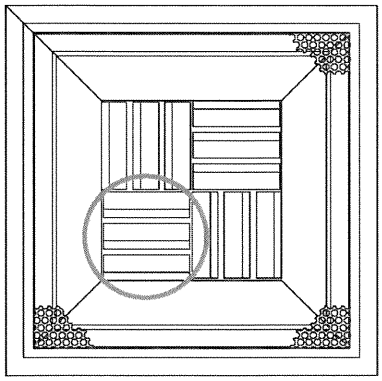


1240P

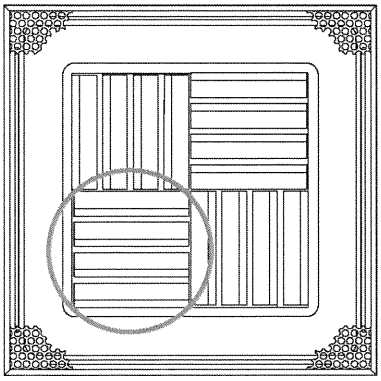


1240PE

1240P, 51240P FACE VIEW



1240PE FACE VIEW



1240P, 51240P, 1240PE

Product Description

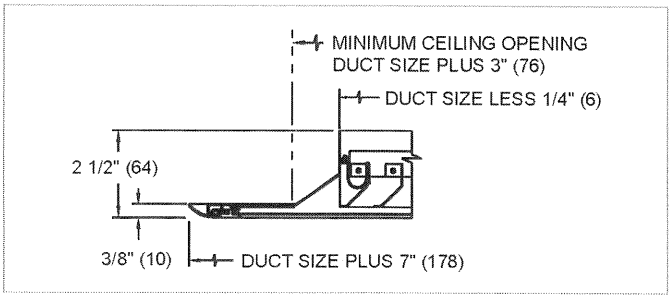
The areas encircled represent one core. Each core represents one quarter section of the diffuser.

EXAMPLE:

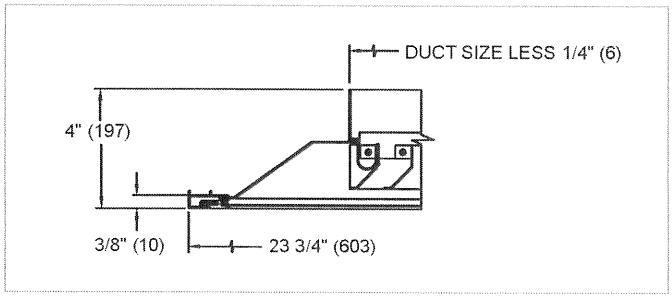
Two core throw will show two of the four cores facing in the same direction. Three core throw will show three of the four cores facing in the same direction. Reference page D1-17 for discharge air patterns.

1240P Frame Styles

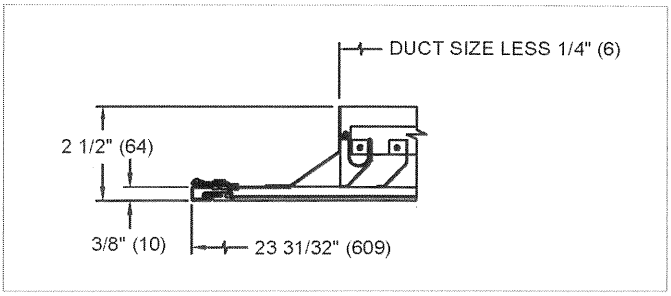
1240P, FRAME 22, SURFACE MOUNT



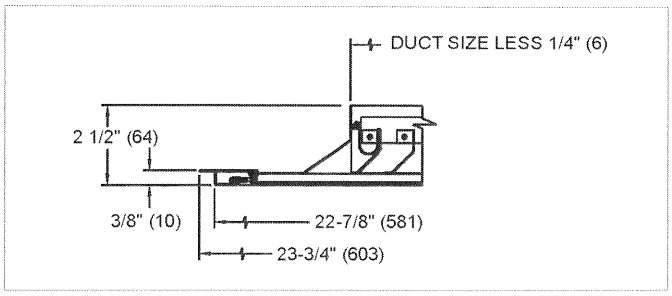
1240P, FRAME 23, LAY-IN T-BAR



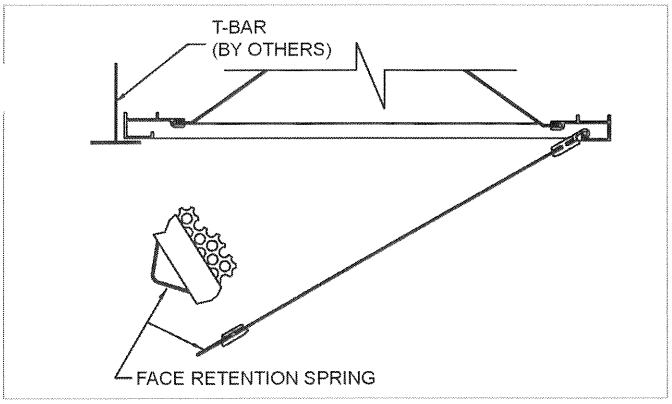
1240P, FRAME 29, CAMLOCK



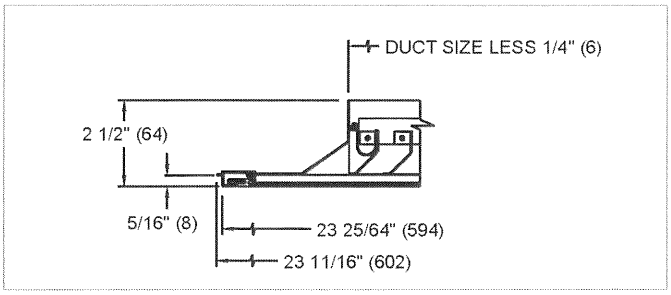
1240P, FRAME 30, DROP FACE



1240P, HINGE DETAIL



1240P, FRAME 98, NARROW-T

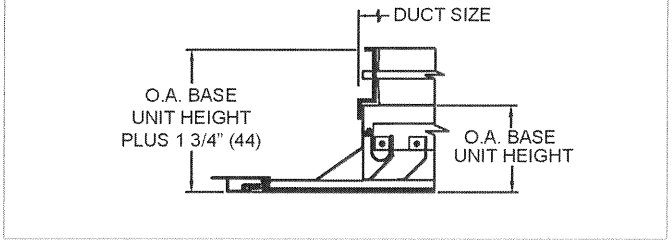


1240P, AVAILABLE NECK SIZES

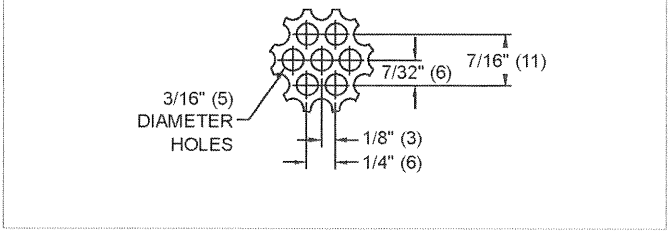
Neck Size	Frame Style				
	Surface Mount	24" x 24" Lay-in Panel			
	F22	F23	F29	F30	F98
6" x 6" (152 x 152)	•	•	•	•	•
8" x 8" (203 x 203)	•	•	•	•	•
10" x 10" (254 x 254)	•	•	•	•	•
12" x 12" (305 x 305)	•	•	•	•	•
14" x 14" (356 x 356)	•	•	•	•	•
16" x 16" (406 x 406)	•	•	•	•	•
18" x 18" (457 x 457)	•	•	•	•	•
20" x 20" (508 x 508)	•				

NOTES: Dimensions in parentheses are mm.
Dot indicates available neck sizes.

1240P, OBD1240/5OBD1240 DETAIL

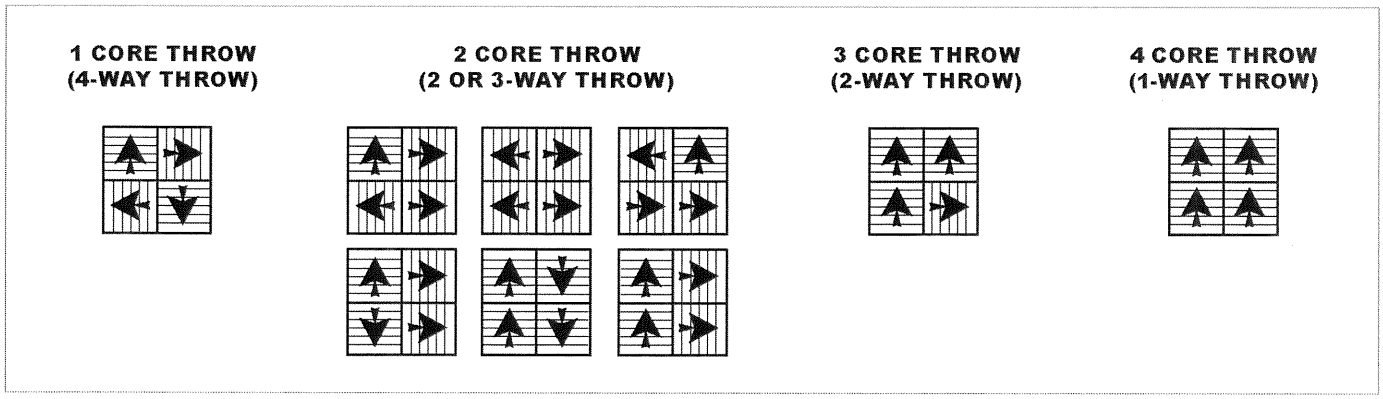


1240P, PERFORATION DETAIL



1240P, 51240P, 1240PE Discharge Air Patterns

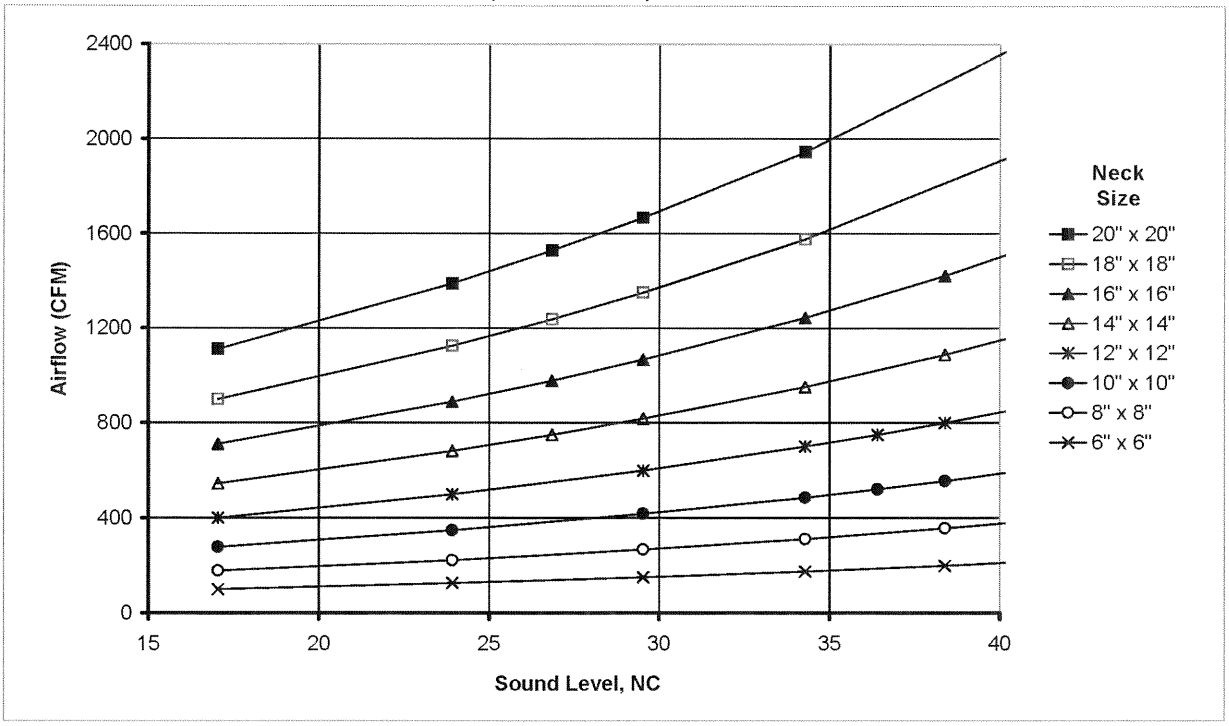
1240P, 51240P, 1240PE, DISCHARGE AIR PATTERNS



NOTE: Reference page D1-3 for core detail.

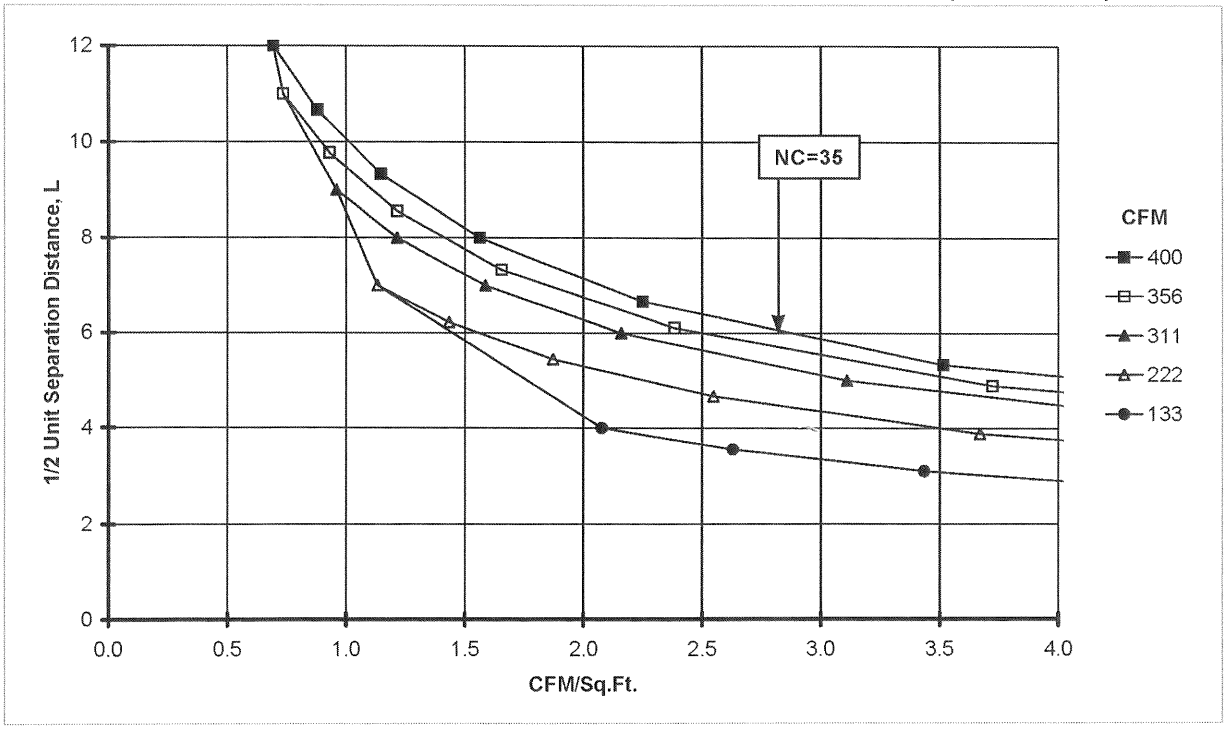
1240P, 51240P, 1240PE Reference Chart

AIRFLOW VS. NC: 1240P, 51240P, 1240PE (NO DAMPER)

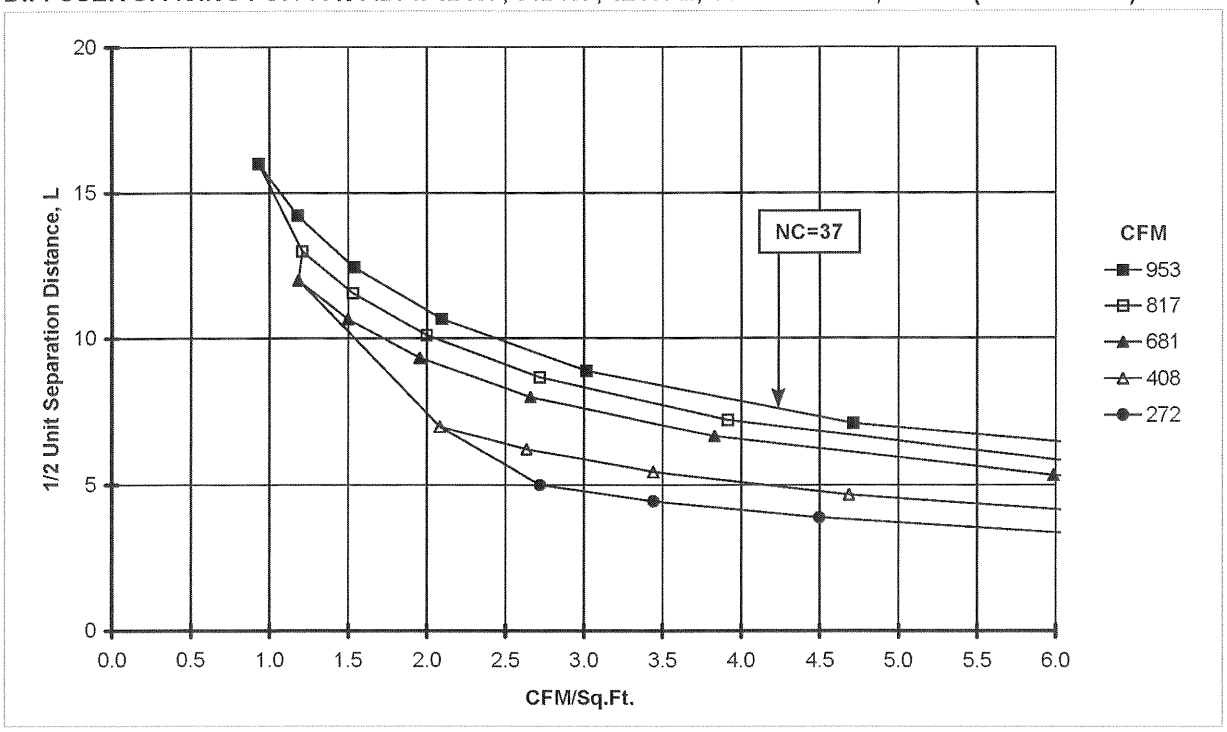


1240P, 51240P, 1240PE Reference Charts

DIFFUSER SPACING FOR 80% ADPI: 1240P, 51240P, 1240PE, 8"x8" NECK, 4-WAY (NO DAMPER)



DIFFUSER SPACING FOR 80% ADPI: 1240P, 51240P, 1240PE, 14"x14" NECK, 4-WAY (NO DAMPER)



NOTES: Charts are at 20 BTUH/ft² loads. See the Engineering section of this catalog for instructions on how to read these charts and additional ADPI information.

1240P, 51240P, 1240PE Performance Data: Horizontal Throw

IP/METRIC DATA: 1240P, 51240P, 1240PE, 1-CORE (NO DAMPER)

	IP Data						Metric Data											
	Neck Vel	Air Flow	Ps	Pt	1-Core 4-Way Throw	NC	Neck Vel	Air Flow	Ps	Pt	1-Core 4-Way Throw	Octave Band, dB					
	FPM	CFM	"WG	"WG	ft		m/s	L/s	Pa	Pa	m	2	3	4	5	6	7
6" x 6"	300	75	0.009	0.015	1 - 2 - 3	-	1.52	35	2.2	3.6	0.2 - 0.5 - 0.9	26	26	18	-	-	-
	400	100	0.016	0.026	1 - 2 - 4	-	2.03	47	4.0	6.5	0.4 - 0.6 - 1.2	30	31	25	18	-	-
	500	125	0.025	0.041	2 - 3 - 5	12	2.54	59	6.2	10.1	0.5 - 0.8 - 1.5	34	34	30	24	11	-
	600	150	0.036	0.058	2 - 3 - 6	18	3.05	71	9.0	14.6	0.6 - 0.9 - 1.8	37	37	34	29	19	-
	700	175	0.049	0.080	2 - 4 - 7	22	3.56	83	12.2	19.8	0.7 - 1.1 - 2.1	39	39	37	34	26	13
	800	200	0.064	0.104	3 - 4 - 8	27	4.06	94	15.9	25.9	0.8 - 1.2 - 2.4	41	41	40	38	32	20
	900	225	0.081	0.132	3 - 5 - 9	30	4.57	106	20.2	32.8	0.9 - 1.4 - 2.6	43	43	43	41	37	26
	1000	250	0.100	0.162	3 - 5 - 9	33	5.08	118	24.9	40.4	1.0 - 1.5 - 2.7	44	45	45	44	42	31
	1100	275	0.121	0.197	4 - 6 - 9	36	5.59	130	30.2	48.9	1.1 - 1.7 - 2.9	46	46	47	47	46	35
8" x 8"	300	133	0.013	0.019	1 - 2 - 4	-	1.52	63	3.2	4.6	0.3 - 0.6 - 1.2	28	28	22	14	-	-
	400	178	0.023	0.033	2 - 3 - 5	-	2.03	84	5.7	8.2	0.5 - 0.8 - 1.6	32	33	28	22	-	-
	500	222	0.036	0.051	2 - 3 - 7	17	2.54	105	8.9	12.8	0.7 - 1.0 - 2.0	36	36	33	29	17	-
	600	267	0.052	0.074	3 - 4 - 8	23	3.05	126	12.8	18.4	0.8 - 1.2 - 2.4	38	39	37	34	26	13
	700	311	0.070	0.101	3 - 5 - 9	27	3.56	147	17.5	25.1	0.9 - 1.4 - 2.8	41	41	41	39	32	20
	800	356	0.092	0.132	4 - 5 - 11	31	4.06	168	22.8	32.8	1.1 - 1.6 - 3.2	43	43	44	43	38	26
	900	400	0.116	0.167	4 - 6 - 11	35	4.57	189	28.9	41.5	1.2 - 1.8 - 3.4	44	45	46	46	44	32
	1000	444	0.143	0.206	4 - 7 - 12	38	5.08	210	35.7	51.2	1.4 - 2.0 - 3.6	46	47	49	49	48	37
	1100	489	0.173	0.249	5 - 7 - 13	41	5.59	231	43.2	62.0	1.5 - 2.2 - 3.8	47	48	51	52	53	42
10" x 10"	300	208	0.018	0.024	1 - 3 - 5	-	1.52	98	4.5	5.9	0.3 - 0.8 - 1.5	29	30	24	18	-	-
	400	278	0.032	0.042	2 - 3 - 7	14	2.03	131	7.9	10.4	0.6 - 1.0 - 2.0	34	34	30	26	13	-
	500	347	0.050	0.065	3 - 4 - 8	21	2.54	164	12.4	16.3	0.8 - 1.3 - 2.5	37	38	36	33	23	-
	600	417	0.072	0.094	3 - 5 - 10	26	3.05	197	17.8	23.4	1.0 - 1.5 - 3.1	40	40	40	38	31	18
	700	486	0.097	0.128	4 - 6 - 12	31	3.56	229	24.3	31.9	1.2 - 1.8 - 3.6	42	43	43	42	38	25
	750	521	0.112	0.147	4 - 6 - 13	33	3.81	246	27.8	36.6	1.3 - 1.9 - 3.8	43	44	45	44	41	28
	800	556	0.127	0.167	4 - 7 - 13	35	4.06	262	31.7	41.6	1.4 - 2.0 - 4.1	44	45	46	46	44	32
	900	625	0.161	0.212	5 - 8 - 14	39	4.57	295	40.1	52.7	1.5 - 2.3 - 4.3	46	47	49	50	49	37
	1000	694	0.199	0.261	6 - 8 - 15	42	5.08	328	49.5	65.0	1.7 - 2.5 - 4.5	47	48	51	53	53	42
12" x 12"	300	300	0.024	0.030	1 - 3 - 6	-	1.52	142	6.0	7.4	0.4 - 0.9 - 1.8	30	31	26	21	-	-
	400	400	0.043	0.053	2 - 4 - 8	17	2.03	189	10.6	13.1	0.7 - 1.2 - 2.4	35	35	33	29	17	-
	500	500	0.067	0.082	3 - 5 - 10	24	2.54	236	16.6	20.5	1.0 - 1.5 - 3.1	38	39	38	36	27	13
	600	600	0.096	0.118	4 - 6 - 12	30	3.05	283	23.9	29.5	1.2 - 1.8 - 3.7	41	42	42	41	35	22
	700	700	0.131	0.161	5 - 7 - 14	34	3.56	330	32.5	40.2	1.4 - 2.1 - 4.3	43	44	45	45	42	29
	750	750	0.150	0.185	5 - 8 - 15	36	3.81	354	37.4	46.1	1.5 - 2.3 - 4.6	44	45	47	47	45	33
	800	800	0.171	0.211	5 - 8 - 16	38	4.06	378	42.5	52.4	1.6 - 2.4 - 4.9	45	46	48	49	48	36
	900	900	0.216	0.267	6 - 9 - 17	42	4.57	425	53.8	66.4	1.8 - 2.7 - 5.2	47	48	51	53	53	41
	1000	1000	0.267	0.329	7 - 10 - 18	45	5.08	472	66.4	81.9	2.0 - 3.1 - 5.4	48	50	53	56	58	47

NOTES: Throw values are given for terminal velocities of 150, 100, and 50 FPM (0.75, 0.50, and 0.25 m/s). Throw values are given for isothermal conditions. NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. If the diffuser is mounted on an exposed duct, the throw values are 70% of those listed in the table. See Krueger's selection software for performance data not shown.

1240P, 51240P, 1240PE Performance Data: Horizontal Throw

P/METRIC DATA: 1240P, 51240P, 1240PE, 1-CORE (NO DAMPER)

	IP Data						Metric Data											
	Neck Vel	Air Flow	Ps	Pt	1-Core 4-Way Throw	NC	Neck Vel	Air Flow	Ps	Pt	1-Core 4-Way Throw	Octave Band, dB					
	FPM	CFM	"WG	"WG	ft		m/s	L/s	Pa	Pa	m	2	3	4	5	6	7
14" x 14"	200	272	0.014	0.016	1 - 2 - 5	-	1.02	128	3.5	4.1	0.2 - 0.5 - 1.4	25	26	19	11	-	-
	300	408	0.031	0.037	2 - 4 - 7	-	1.52	193	7.8	9.2	0.5 - 1.1 - 2.1	31	32	28	23	-	-
	400	544	0.056	0.065	3 - 5 - 9	20	2.03	257	13.8	16.3	0.8 - 1.4 - 2.8	36	36	34	32	20	-
	500	681	0.087	0.102	4 - 6 - 12	27	2.54	321	21.6	25.5	1.2 - 1.8 - 3.6	39	40	39	38	30	17
	550	749	0.105	0.124	4 - 6 - 13	29	2.79	353	26.1	30.8	1.3 - 2.0 - 3.9	40	41	41	41	35	21
	600	817	0.125	0.147	5 - 7 - 14	32	3.05	385	31.1	36.7	1.4 - 2.1 - 4.3	42	43	43	43	38	25
	700	953	0.170	0.201	5 - 8 - 16	37	3.56	450	42.3	49.9	1.7 - 2.5 - 5.0	44	45	47	48	45	33
	800	1089	0.222	0.262	6 - 9 - 19	41	4.06	514	55.3	65.2	1.9 - 2.8 - 5.7	46	47	50	52	51	39
	900	1225	0.281	0.332	7 - 11 - 20	45	4.57	578	70.0	82.6	2.1 - 3.2 - 6.0	48	49	53	55	57	45
16" x 16"	200	356	0.018	0.020	1 - 2 - 5	-	1.02	168	4.4	5.0	0.2 - 0.5 - 1.6	26	27	20	14	-	-
	300	533	0.040	0.045	2 - 4 - 8	13	1.52	252	9.9	11.2	0.5 - 1.2 - 2.4	32	33	29	25	11	-
	400	711	0.070	0.080	3 - 5 - 11	22	2.03	336	17.5	20.0	1.0 - 1.6 - 3.3	36	37	36	34	23	-
	500	889	0.110	0.125	4 - 7 - 13	29	2.54	420	27.4	31.2	1.4 - 2.0 - 4.1	40	41	41	40	33	20
	550	978	0.133	0.152	5 - 7 - 15	32	2.79	461	33.1	37.8	1.5 - 2.2 - 4.5	41	42	43	43	38	24
	600	1067	0.158	0.181	5 - 8 - 16	34	3.05	503	39.4	45.0	1.6 - 2.4 - 4.9	42	44	45	46	42	29
	700	1244	0.215	0.246	6 - 9 - 19	39	3.56	587	53.6	61.2	1.9 - 2.8 - 5.7	45	46	48	50	48	36
	800	1422	0.281	0.321	7 - 11 - 21	43	4.06	671	70.0	80.0	2.2 - 3.3 - 6.5	47	48	51	54	54	42
	900	1600	0.356	0.407	8 - 12 - 23	47	4.57	755	88.7	101.2	2.4 - 3.7 - 6.9	49	50	54	57	60	48
18" x 18"	100	225	0.005	0.006	0 - 1 - 2	-	0.51	106	1.4	1.5	0.1 - 0.2 - 0.6	16	17	-	-	-	-
	200	450	0.022	0.024	1 - 2 - 6	-	1.02	212	5.4	6.0	0.3 - 0.6 - 1.8	27	27	22	15	-	-
	300	675	0.049	0.055	2 - 5 - 9	15	1.52	319	12.2	13.6	0.6 - 1.4 - 2.7	33	34	31	27	13	-
	400	900	0.087	0.097	4 - 6 - 12	24	2.03	425	21.7	24.2	1.1 - 1.8 - 3.7	37	38	37	36	26	12
	500	1125	0.136	0.152	5 - 8 - 15	31	2.54	531	33.9	37.8	1.5 - 2.3 - 4.6	40	42	42	42	36	22
	550	1238	0.165	0.184	6 - 8 - 17	34	2.79	584	41.0	45.7	1.7 - 2.5 - 5.0	42	43	44	45	40	27
	600	1350	0.196	0.218	6 - 9 - 18	36	3.05	637	48.8	54.4	1.8 - 2.7 - 5.5	43	44	46	48	44	31
	700	1575	0.267	0.297	7 - 11 - 21	41	3.56	743	66.4	74.0	2.1 - 3.2 - 6.4	45	47	50	52	51	39
	800	1800	0.348	0.388	8 - 12 - 24	45	4.06	850	86.8	96.7	2.4 - 3.7 - 7.3	47	49	53	56	57	45
20" x 20"	100	278	0.007	0.007	0 - 1 - 2	-	0.51	131	1.6	1.8	0.1 - 0.2 - 0.7	17	17	-	-	-	-
	200	556	0.026	0.029	1 - 2 - 7	-	1.02	262	6.6	7.2	0.3 - 0.7 - 2.0	27	28	23	17	-	-
	300	833	0.060	0.065	2 - 5 - 10	17	1.52	393	14.8	16.2	0.7 - 1.5 - 3.1	33	34	32	29	16	-
	400	1111	0.106	0.116	4 - 7 - 13	26	2.03	524	26.4	28.8	1.2 - 2.0 - 4.1	38	39	38	37	29	14
	500	1389	0.165	0.181	6 - 8 - 17	33	2.54	655	41.2	45.1	1.7 - 2.5 - 5.1	41	42	43	44	39	25
	550	1528	0.200	0.219	6 - 9 - 18	36	2.79	721	49.8	54.5	1.9 - 2.8 - 5.6	42	44	45	47	43	30
	600	1667	0.238	0.261	7 - 10 - 20	38	3.05	787	59.3	64.9	2.0 - 3.1 - 6.1	44	45	47	49	47	34
	700	1944	0.324	0.355	8 - 12 - 23	43	3.56	918	80.7	88.3	2.4 - 3.6 - 7.1	46	48	51	54	54	41
	800	2222	0.424	0.463	9 - 13 - 27	47	4.06	1049	105.5	115.4	2.7 - 4.1 - 8.1	48	50	54	58	60	48

NOTES: Throw values are given for terminal velocities of 150, 100, and 50 FPM (0.75, 0.50, and 0.25 m/s). Throw values are given for isothermal conditions. NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. If the diffuser is mounted on an exposed duct, the throw values are 70% of those listed in the table. See Krueger's selection software for performance data not shown.

1240P, 51240P, 1240PE Performance Data: Horizontal Throw

IP/METRIC DATA: 1240P, 51240P, 1240PE, 2-, 3-, & 4-CORE (NO DAMPER)

	IP Data					Metric Data				
	Neck Vel	Air Flow	2-Core 3-Way Throw	3-Core 2-Way Throw	4-Core 1-Way Throw	Neck Vel	Air Flow	2-Core 3-Way Throw	3-Core 2-Way Throw	4-Core 1-Way Throw
	FPM	CFM	ft	ft	ft	m/s	L/s	m	m	m
6" x 6"	300	75	2 - 3 - 5	2 - 3 - 7	3 - 5 - 10	1.52	35	0.5 - 0.8 - 1.5	0.7 - 1.1 - 2.1	1.0 - 1.6 - 3.1
	400	100	2 - 3 - 7	3 - 5 - 9	5 - 7 - 14	2.03	47	0.7 - 1.0 - 2.1	0.9 - 1.4 - 2.8	1.4 - 2.1 - 4.1
	500	125	3 - 4 - 8	4 - 6 - 12	6 - 9 - 17	2.54	59	0.9 - 1.3 - 2.6	1.2 - 1.8 - 3.5	1.7 - 2.6 - 5.2
	600	150	3 - 5 - 10	5 - 7 - 13	7 - 10 - 19	3.05	71	1.0 - 1.5 - 3.1	1.4 - 2.1 - 3.8	2.1 - 3.1 - 5.9
	700	175	4 - 6 - 11	5 - 8 - 14	8 - 12 - 21	3.56	83	1.2 - 1.8 - 3.4	1.6 - 2.5 - 4.2	2.4 - 3.6 - 6.4
	800	200	5 - 7 - 12	6 - 9 - 15	9 - 14 - 22	4.06	94	1.4 - 2.1 - 3.6	1.9 - 2.8 - 4.4	2.8 - 4.1 - 6.8
	900	225	5 - 8 - 13	7 - 10 - 16	10 - 15 - 24	4.57	106	1.5 - 2.3 - 3.8	2.1 - 3.2 - 4.7	3.1 - 4.7 - 7.2
	1000	250	6 - 8 - 13	8 - 12 - 16	11 - 17 - 25	5.08	118	1.7 - 2.6 - 4.1	2.4 - 3.5 - 5.0	3.4 - 5.2 - 7.6
	1100	275	6 - 9 - 14	9 - 12 - 17	12 - 19 - 26	5.59	130	1.9 - 2.8 - 4.3	2.6 - 3.7 - 5.2	3.8 - 5.7 - 8.0
8" x 8"	300	133	2 - 3 - 7	3 - 5 - 9	5 - 7 - 14	1.52	63	0.7 - 1.0 - 2.1	0.9 - 1.4 - 2.8	1.4 - 2.1 - 4.1
	400	178	3 - 5 - 9	4 - 6 - 12	6 - 9 - 18	2.03	84	0.9 - 1.4 - 2.7	1.3 - 1.9 - 3.8	1.8 - 2.8 - 5.5
	500	222	4 - 6 - 11	5 - 8 - 15	8 - 11 - 23	2.54	105	1.1 - 1.7 - 3.4	1.6 - 2.4 - 4.7	2.3 - 3.4 - 6.9
	600	267	5 - 7 - 14	6 - 9 - 17	9 - 14 - 26	3.05	126	1.4 - 2.1 - 4.1	1.9 - 2.8 - 5.1	2.8 - 4.1 - 7.9
	700	311	5 - 8 - 15	7 - 11 - 18	11 - 16 - 28	3.56	147	1.6 - 2.4 - 4.5	2.2 - 3.3 - 5.5	3.2 - 4.8 - 8.5
	800	356	6 - 9 - 16	8 - 12 - 19	12 - 18 - 30	4.06	168	1.8 - 2.7 - 4.8	2.5 - 3.8 - 5.9	3.7 - 5.5 - 9.1
	900	400	7 - 10 - 17	9 - 14 - 21	14 - 20 - 32	4.57	189	2.1 - 3.1 - 5.1	2.8 - 4.2 - 6.3	4.1 - 6.2 - 9.6
	1000	444	8 - 11 - 18	10 - 15 - 22	15 - 23 - 33	5.08	210	2.3 - 3.4 - 5.4	3.1 - 4.7 - 6.6	4.6 - 6.9 - 10.2
	1100	489	8 - 12 - 19	11 - 16 - 23	17 - 25 - 35	5.59	231	2.5 - 3.8 - 5.7	3.5 - 4.9 - 6.9	5.1 - 7.5 - 10.7
10" x 10"	300	208	3 - 4 - 8	4 - 6 - 12	6 - 9 - 17	1.52	98	0.9 - 1.3 - 2.6	1.2 - 1.8 - 3.5	1.7 - 2.6 - 5.2
	400	278	4 - 6 - 11	5 - 8 - 15	8 - 11 - 23	2.03	131	1.1 - 1.7 - 3.4	1.6 - 2.4 - 4.7	2.3 - 3.4 - 6.9
	500	347	5 - 7 - 14	6 - 10 - 19	9 - 14 - 28	2.54	164	1.4 - 2.1 - 4.3	2.0 - 2.9 - 5.9	2.9 - 4.3 - 8.6
	600	417	6 - 8 - 17	8 - 12 - 21	11 - 17 - 32	3.05	197	1.7 - 2.6 - 5.1	2.4 - 3.5 - 6.4	3.4 - 5.2 - 9.8
	700	486	7 - 10 - 19	9 - 14 - 23	13 - 20 - 35	3.56	229	2.0 - 3.0 - 5.7	2.7 - 4.1 - 6.9	4.0 - 6.0 - 10.6
	750	521	7 - 11 - 19	10 - 15 - 24	14 - 21 - 36	3.81	246	2.1 - 3.2 - 5.9	2.9 - 4.4 - 7.2	4.3 - 6.5 - 11.0
	800	556	8 - 11 - 20	10 - 15 - 24	15 - 23 - 37	4.06	262	2.3 - 3.4 - 6.0	3.1 - 4.7 - 7.4	4.6 - 6.9 - 11.4
	900	625	8 - 13 - 21	12 - 17 - 26	17 - 26 - 40	4.57	295	2.6 - 3.9 - 6.4	3.5 - 5.3 - 7.9	5.2 - 7.8 - 12.1
	1000	694	9 - 14 - 22	13 - 19 - 27	19 - 28 - 42	5.08	328	2.9 - 4.3 - 6.8	3.9 - 5.9 - 8.3	5.7 - 8.6 - 12.7
12" x 12"	300	300	3 - 5 - 10	5 - 7 - 14	7 - 10 - 20	1.52	142	1.0 - 1.5 - 3.1	1.4 - 2.1 - 4.2	2.1 - 3.1 - 6.2
	400	400	5 - 7 - 14	6 - 9 - 19	9 - 14 - 27	2.03	189	1.4 - 2.1 - 4.1	1.9 - 2.8 - 5.7	2.8 - 4.1 - 8.3
	500	500	6 - 8 - 17	8 - 12 - 23	11 - 17 - 34	2.54	236	1.7 - 2.6 - 5.1	2.4 - 3.5 - 7.0	3.4 - 5.2 - 10.3
	600	600	7 - 10 - 20	9 - 14 - 25	14 - 20 - 39	3.05	283	2.1 - 3.1 - 6.2	2.8 - 4.2 - 7.7	4.1 - 6.2 - 11.8
	700	700	8 - 12 - 22	11 - 16 - 27	16 - 24 - 42	3.56	330	2.4 - 3.6 - 6.8	3.3 - 4.9 - 8.3	4.8 - 7.2 - 12.8
	750	750	8 - 13 - 23	12 - 17 - 28	17 - 26 - 43	3.81	354	2.6 - 3.9 - 7.0	3.5 - 5.3 - 8.6	5.2 - 7.8 - 13.2
	800	800	9 - 14 - 24	12 - 19 - 29	18 - 27 - 45	4.06	378	2.7 - 4.1 - 7.3	3.8 - 5.7 - 8.9	5.5 - 8.3 - 13.6
	900	900	10 - 15 - 25	14 - 21 - 31	20 - 31 - 48	4.57	425	3.1 - 4.6 - 7.7	4.2 - 6.4 - 9.4	6.2 - 9.3 - 14.5
	1000	1000	11 - 17 - 27	15 - 23 - 33	23 - 34 - 50	5.08	472	3.4 - 5.1 - 8.1	4.7 - 7.0 - 9.9	6.9 - 10.3 - 15.3

NOTES: Throw values are given for terminal velocities of 150, 100, and 50 FPM (0.75, 0.50, and 0.25 m/s). Throw values are given for isothermal conditions. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. If the diffuser is mounted on an exposed duct, the throw values are 70% of those listed in the table. See Krueger's selection software for performance data not shown, including octave band data.

1240P, 51240P, 1240PE Performance Data: Horizontal Throw

P/METRIC DATA: 1240P, 51240P, 1240PE, 2-, 3-, & 4-CORE (NO DAMPER)

	IP Data					Metric Data				
	Neck Vel	Air Flow	2-Core 3-Way Throw	3-Core 2-Way Throw	4-Core 1-Way Throw	Neck Vel	Air Flow	2-Core 3-Way Throw	3-Core 2-Way Throw	4-Core 1-Way Throw
	FPM	CFM	ft	ft	ft	m/s	L/s	m	m	m
14" x 14"	200	272	2 - 4 - 8	3 - 5 - 11	5 - 8 - 16	1.02	128	0.6 - 1.2 - 2.4	0.8 - 1.6 - 3.3	1.4 - 2.4 - 4.8
	300	408	4 - 6 - 12	5 - 8 - 16	8 - 12 - 24	1.52	193	1.2 - 1.8 - 3.6	1.6 - 2.5 - 4.9	2.4 - 3.6 - 7.2
	400	544	5 - 8 - 16	7 - 11 - 22	11 - 16 - 32	2.03	257	1.6 - 2.4 - 4.8	2.2 - 3.3 - 6.6	3.2 - 4.8 - 9.7
	500	681	7 - 10 - 20	9 - 14 - 27	13 - 20 - 40	2.54	321	2.0 - 3.0 - 6.0	2.7 - 4.1 - 8.2	4.0 - 6.0 - 12.1
	550	749	7 - 11 - 22	10 - 15 - 28	15 - 22 - 43	2.79	353	2.2 - 3.3 - 6.6	3.0 - 4.5 - 8.6	4.4 - 6.6 - 13.2
	600	817	8 - 12 - 24	11 - 16 - 30	16 - 24 - 45	3.05	385	2.4 - 3.6 - 7.2	3.3 - 4.9 - 9.0	4.8 - 7.2 - 13.8
	700	953	9 - 14 - 26	13 - 19 - 32	19 - 28 - 49	3.56	450	2.8 - 4.2 - 7.9	3.8 - 5.8 - 9.7	5.6 - 8.4 - 14.9
	800	1089	11 - 16 - 28	14 - 22 - 34	21 - 32 - 52	4.06	514	3.2 - 4.8 - 8.5	4.4 - 6.6 - 10.4	6.4 - 9.7 - 15.9
	900	1225	12 - 18 - 30	16 - 24 - 36	24 - 36 - 56	4.57	578	3.6 - 5.4 - 9.0	4.9 - 7.4 - 11.0	7.2 - 10.9 - 16.9
16" x 16"	200	356	2 - 5 - 9	3 - 6 - 12	5 - 9 - 18	1.02	168	0.7 - 1.4 - 2.7	0.9 - 1.9 - 3.8	1.6 - 2.8 - 5.5
	300	533	5 - 7 - 14	6 - 9 - 19	9 - 14 - 27	1.52	252	1.4 - 2.1 - 4.1	1.9 - 2.8 - 5.7	2.8 - 4.1 - 8.3
	400	711	6 - 9 - 18	8 - 12 - 25	12 - 18 - 36	2.03	336	1.8 - 2.7 - 5.5	2.5 - 3.8 - 7.5	3.7 - 5.5 - 11.0
	500	889	8 - 11 - 23	10 - 15 - 31	15 - 23 - 45	2.54	420	2.3 - 3.4 - 6.9	3.1 - 4.7 - 9.4	4.6 - 6.9 - 13.8
	550	978	8 - 12 - 25	11 - 17 - 32	17 - 25 - 50	2.79	461	2.5 - 3.8 - 7.5	3.5 - 5.2 - 9.8	5.1 - 7.6 - 15.1
	600	1067	9 - 14 - 27	12 - 19 - 34	18 - 27 - 52	3.05	503	2.7 - 4.1 - 8.2	3.8 - 5.7 - 10.3	5.5 - 8.3 - 15.8
	700	1244	11 - 16 - 30	14 - 22 - 36	21 - 32 - 56	3.56	587	3.2 - 4.8 - 9.0	4.4 - 6.6 - 11.1	6.4 - 9.7 - 17.0
	800	1422	12 - 18 - 32	17 - 25 - 39	24 - 36 - 60	4.06	671	3.7 - 5.5 - 9.7	5.0 - 7.5 - 11.9	7.4 - 11.0 - 18.2
	900	1600	14 - 20 - 34	19 - 28 - 41	27 - 41 - 63	4.57	755	4.1 - 6.2 - 10.3	5.7 - 8.5 - 12.6	8.3 - 12.4 - 19.3
18" x 18"	100	225	1 - 1 - 5	1 - 2 - 7	1 - 3 - 10	0.51	106	0.2 - 0.4 - 1.5	0.3 - 0.6 - 2.1	0.5 - 1.0 - 3.1
	200	450	3 - 5 - 10	3 - 7 - 14	6 - 10 - 20	1.02	212	0.8 - 1.5 - 3.1	1.0 - 2.1 - 4.2	1.8 - 3.1 - 6.2
	300	675	5 - 8 - 15	7 - 10 - 21	10 - 15 - 31	1.52	319	1.5 - 2.3 - 4.6	2.1 - 3.2 - 6.4	3.1 - 4.7 - 9.3
	400	900	7 - 10 - 20	9 - 14 - 28	14 - 20 - 41	2.03	425	2.1 - 3.1 - 6.2	2.8 - 4.2 - 8.5	4.1 - 6.2 - 12.4
	500	1125	8 - 13 - 25	12 - 17 - 35	17 - 26 - 51	2.54	531	2.6 - 3.9 - 7.7	3.5 - 5.3 - 10.5	5.2 - 7.8 - 15.5
	550	1238	9 - 14 - 28	13 - 19 - 36	19 - 28 - 56	2.79	584	2.8 - 4.2 - 8.5	3.9 - 5.8 - 11.1	5.7 - 8.5 - 17.0
	600	1350	10 - 15 - 30	14 - 21 - 38	20 - 31 - 58	3.05	637	3.1 - 4.6 - 9.3	4.2 - 6.4 - 11.5	6.2 - 9.3 - 17.7
	700	1575	12 - 18 - 33	16 - 24 - 41	24 - 36 - 63	3.56	743	3.6 - 5.4 - 10.2	4.9 - 7.4 - 12.5	7.2 - 10.9 - 19.1
	800	1800	14 - 20 - 36	19 - 28 - 44	27 - 41 - 67	4.06	850	4.1 - 6.2 - 10.9	5.7 - 8.5 - 13.3	8.3 - 12.4 - 20.5
20" x 20"	100	278	1 - 2 - 6	1 - 2 - 8	2 - 4 - 11	0.51	131	0.2 - 0.5 - 1.7	0.3 - 0.7 - 2.4	0.5 - 1.1 - 3.4
	200	556	3 - 6 - 11	4 - 8 - 15	7 - 11 - 23	1.02	262	0.9 - 1.7 - 3.4	1.2 - 2.4 - 4.7	2.0 - 3.4 - 6.9
	300	833	6 - 8 - 17	8 - 12 - 23	11 - 17 - 34	1.52	393	1.7 - 2.6 - 5.1	2.4 - 3.5 - 7.1	3.4 - 5.2 - 10.3
	400	1111	8 - 11 - 23	10 - 15 - 31	15 - 23 - 45	2.03	524	2.3 - 3.4 - 6.9	3.1 - 4.7 - 9.4	4.6 - 6.9 - 13.8
	500	1389	9 - 14 - 28	13 - 19 - 39	19 - 28 - 57	2.54	655	2.9 - 4.3 - 8.6	3.9 - 5.9 - 11.7	5.7 - 8.6 - 17.2
	550	1528	10 - 16 - 31	14 - 21 - 40	21 - 31 - 62	2.79	721	3.1 - 4.7 - 9.4	4.3 - 6.5 - 12.3	6.3 - 9.5 - 18.9
	600	1667	11 - 17 - 34	15 - 23 - 42	23 - 34 - 65	3.05	787	3.4 - 5.1 - 10.3	4.7 - 7.1 - 12.8	6.9 - 10.3 - 19.7
	700	1944	13 - 20 - 37	18 - 27 - 46	26 - 40 - 70	3.56	918	4.0 - 6.0 - 11.3	5.5 - 8.2 - 13.9	8.0 - 12.1 - 21.3
	800	2222	15 - 23 - 40	21 - 31 - 49	30 - 45 - 75	4.06	1049	4.6 - 6.9 - 12.1	6.3 - 9.4 - 14.8	9.2 - 13.8 - 22.7

NOTES: Throw values are given for terminal velocities of 150, 100, and 50 FPM (0.75, 0.50, and 0.25 m/s). Throw values are given for isothermal conditions. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. If the diffuser is mounted on an exposed duct, the throw values are 70% of those listed in the table. See Krueger's selection software for performance data not shown, including octave band data.

1240P, 51240P, 1240PE Suggested Specification & Configuration

1. SERIES: (XXXXXX)
- 1240P - Double Border, Perforated Steel Modular Diffuser
- 51240P - Double Border, Perforated Aluminum Modular Diffuser
- 1240PE - Single Border, Perforated Steel Modular Diffuser

2. WIDTH: SQUARE NECK ONLY (XX) *
6" - 20" in 2" Increments

3. HEIGHT: SQUARE NECK ONLY (XX) *
6" - 20" in 2" Increments

4. FRAME: (XXX) **
- F22 - Surface Mount - Flat
- F23 - Lay-in T-Bar
- F29 - Camlock
- F30 - Drop Face
- F98 - Narrow-T

5. PANEL: (XX)x(XX)
- NONE
- 24"x24"

6. FINISH: (XX)
- 01 - Mill
- 10 - Alumican
- 35 - Black
- 44 - British White

Damper not included in configuration code.
** Neck Size 20"x20" is only available with Frame 22.*
*** Series 1240PE is available in Frame 23 only; maximum neck size is 18"x18".*

1240P, 51240P
The modular core diffuser shall be Krueger model 1240P (steel) or 51240P (aluminum). The diffusers shall have a perforated face with 3/16" diameter holes on 1/4" centers resulting in a 51% free area. The perimeter of the perforated face and backpan shall be an aluminum extrusion resulting in an aesthetic appearance and a removable face. The 1240P and 51240P models shall have a tapered backpan resulting in a square neck. The core of the diffuser shall be made up of 4 independent fixed blade modules that can be easily removed without the use of special tools for 1-, 2-, 3-, or 4-way discharge air pattern adjustments or damper access.

Optional oppose blade damper (OBD) shall be constructed of heavy gage steel. Damper shall be operable from the face of the diffuser.

1240PE
The modular core diffuser shall be Krueger model 1240PE. The diffusers shall have a steel perforated face with 3/16" diameter holes on 1/4" centers resulting in a 51% free area. The 1240PE shall have a steel one piece stamped backpan resulting in a square neck for neck sizes smaller than 16". For neck sizes 16" and larger the diffuser shall have a steel can construction resulting in a square neck. The core of the diffuser shall be made up of 4 independent fixed bladed modules that can be easily removed without the use of special tools for 1-, 2-, 3-, or 4-way discharge air pattern adjustments or damper access.

Optional oppose blade damper (OBD) shall be constructed of heavy gage steel. Damper shall be operable from the face of the diffuser.

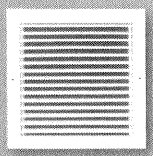
PERFORMANCE
The manufacturer shall provide published (printed or electronic) performance data for the diffuser. Performance data shall include 2 - 7 octave band sound power levels. The diffuser shall be tested in accordance to the data standards at the time of product introduction or ANSI/ASHRAE Standard 70.

FINISH
The paint finish shall be #44 British White and be an anodic acrylic paint, baked at 315°F for 30 minutes. The paint thickness shall be 0.8 – 1.0 mils, gloss at 60° per ASTM D523-89 of 50 – 85%, pencil hardness per ASTM D3363-92A of HB – H, crosshatch adhesion per ASTM D3359-83 of 4B – 5B, impact per ASTM D2794-93 of direct impact >100 in/lb and reverse impact >80 in/lb, salt spray per ASTM B117-9048 of 96 hours, humidity per ASTM D2247-92 of >500 hours and water soak per ASTM D870-92 of 250 hours.

SAMPLE CONFIGURATION: 1240P - 08x08 - F29 - 24X24 - 44

Table of Contents

KRUEGER
Excellence in Air Distribution

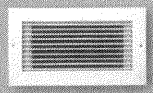


S80/S580
These fixed-blade return grilles feature 3/4" blade spacing. Deflection will be fixed at 35° or 0°. Available in aluminum or steel construction.

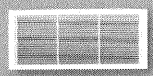
S85/S585
These fixed-blade return grilles feature 1/2" blade spacing. Deflection will be fixed at 35° or 0°. Available in aluminum or steel construction.

S80P/S580P
These perforated return grilles feature 3/16" holes on 1/4" staggered centers. Available in steel or aluminum construction.

S480
This heavy duty, fixed blade, return grille features 1/2" blade spacing. Deflection will be fixed at 38° or 0°. Available in steel construction only.

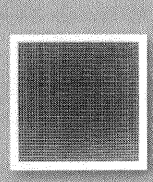


S5480
This heavy duty, fixed blade, return grille features 1/2" blade spacing. Deflection will be fixed at 30° or 0°. Available in aluminum construction only.

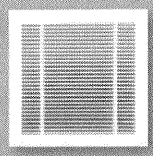


AFS580/AFS585
These return grilles feature fixed blades with 3/4" or 1/2" blade spacing with 45° or 0° deflection. Available in extruded aluminum construction only.

AFCS80/AFCS85
These return grilles feature curved blades, either 3/4" blade spacing with 45° deflection or 1/2" blade spacing with 30° deflection. Available in steel construction only.



EG/EGC Series
This series of egg-crate return grilles feature various sized aluminum cube cores. Available as core only, with channel frame, or lay-in frame.



5810
This fixed-blade return grille features a removable, reversible core. Deflection may be set at 5° or 15° up/down. Available in aluminum construction only.

S80, S580, S85, S585
Introduction J1-3
Dimensional Information J1-4
Reference Charts & Performance Data J1-5
Engineering Specifications J1-25

S80P, S580P
Introduction J1-26
Dimensional Information J1-27
Reference Charts & Performance Data J1-29
Engineering Specifications J1-34

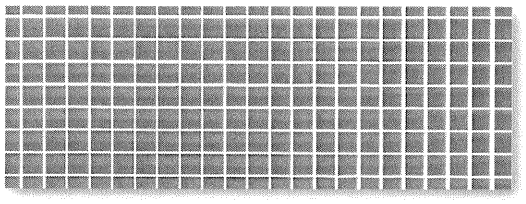
S480, S5480
Introduction J1-35
Dimensional Information J1-36
Reference Charts & Performance Data J1-38
Engineering Specifications J1-58

AFS580, AFS585
Introduction J1-60
Dimensional Information J1-61
Reference Charts & Performance Data J1-64
Engineering Specifications J1-79

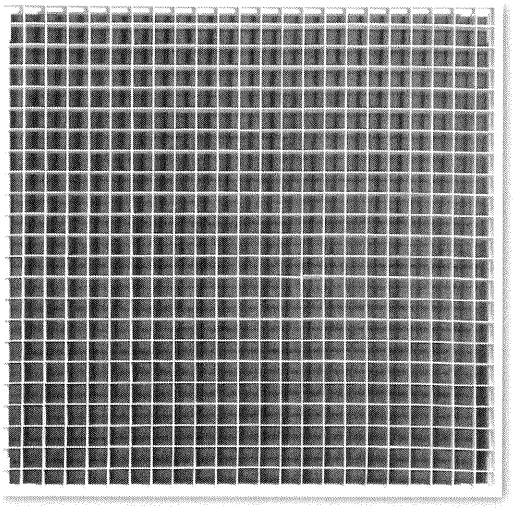
AFCS80, AFCS85
Introduction J1-80
Dimensional Information J1-81
Reference Charts & Performance Data J1-83
Engineering Specifications J1-93

EG5, EG10, EG15, EGC5, EGC10, EGC15
Introduction J1-94
Dimensional Information J1-95
Reference Charts & Performance Data J1-98
Engineering Specifications J1-113

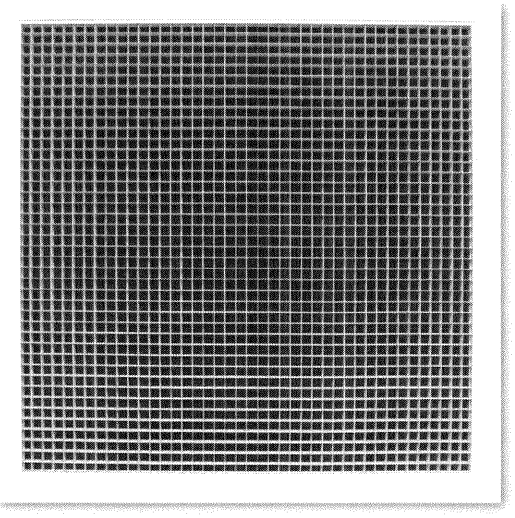
5810
Introduction & Dimensional Information J1-115
Reference Charts & Performance Data J1-116
Engineering Specification J1-122



EG5, Frame 23



EG10, Frame FTB



EGC5, Frame F22

Introduction: EG, EGC Series

The EGC5 egg-crate return grilles are designed to fit common commercial applications were the architect requires a return grille without bars on the face and with limited sight through the grille. The EGC5 offers 1/2"x1/2"x1/2" aluminum cube core and 1 1/4" flange. The EGC5 cube core design maximizes the free area making the EGC5 an excellent choice for applications requiring large amounts of air to be returned through the return grille minimizing the pressure drop and sound.

The EGC10 egg-crate return grilles are designed to fit common commercial applications were the architect requires a return grille without bars on the face. The EGC10 offers 1"x1"x1" aluminum cube core and 1 1/4" flange. The EGC10 cube core design maximizes the free area making the EGC10 an excellent choice for applications requiring large amounts of air to be returned through the return grille minimizing the pressure drop and sound.

The EGC15 egg-crate return grilles are designed to fit common commercial applications were the architect requires a return grille without bars on the face and the maximum available limited sight through the grille. The EGC15 offers 1/2"x1/2"x1" aluminum cube core and 1 1/4" flange. The EGC15 cube core design maximizes the free area making the EGC15 an excellent choice for applications requiring large amounts of air to be returned through the return grille minimizing the pressure drop and sound.

MODELS

EGC5 - 1/2"x1/2"x1/2" Aluminum Cube Core Return Grille with 1 1/4" Flange
EG5 - 1/2"x1/2"x1/2" Aluminum Cube Core Return Grille, Channel Frame or Core Only
EGC10 - 1"x1"x1" Aluminum Cube Core Return Grille with 1 1/4" Flange
EG10 - 1"x1"x1" Aluminum Cube Core Return Grille, Channel Frame or Core Only
EGC15 - 1/2"x1/2"x1" Aluminum Cube Core Return Grille with 1 1/4" Flange
EG15 - 1/2"x1/2"x1" Aluminum Cube Core Return Grille, Channel Frame or Core Only.

ACCESSORIES

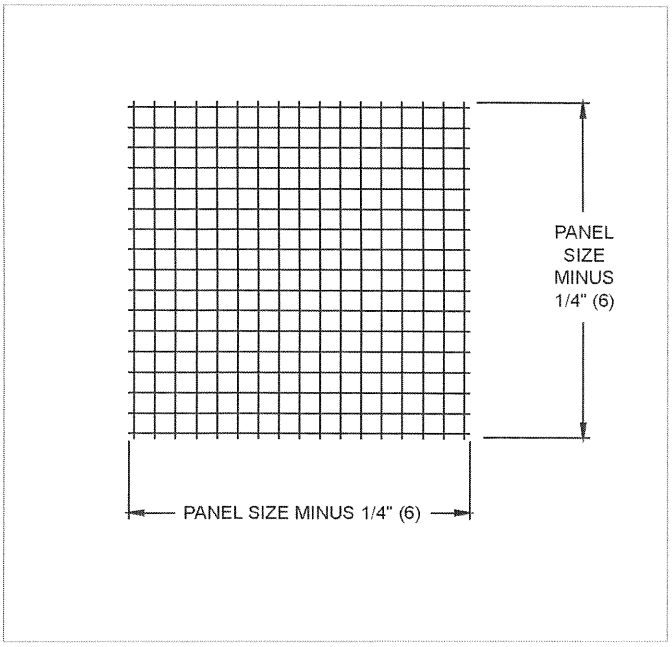
- Steel Opposed Blade Damper (Model OBD)
- Steel Painted Opposed Blade Damper (Model POBD)
- Aluminum Opposed Blade Damper (Model 5OBD)
- Square to Round Adapter (Model SRAC325)
- Steel Plaster Frame (Model 8PF)
- Aluminum Plaster Frame (Model 58PF)
- 1" or 2" Filter Frame - Minimum size is 8"x8" and maximum size is 48"x36". (Model 5FF, available on EGC5 only.)

FINISHES

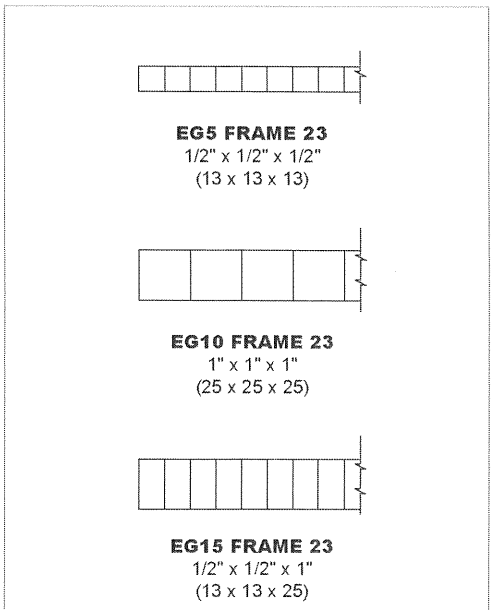
- Standard finish is #44 British White.
- Optional finishes available.

EG5, EG10, EG15 Dimensional Information

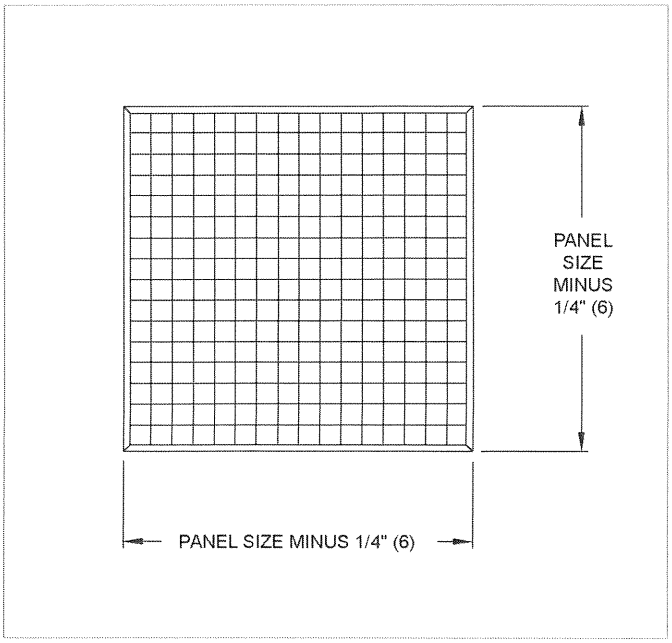
EG SERIES, FACE VIEW



EG SERIES, FRAME 23

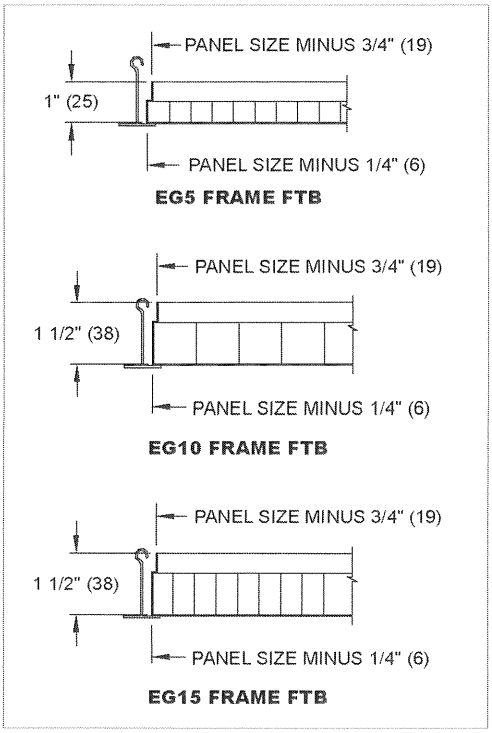


EG SERIES, FACE VIEW WITH FRAME FTB



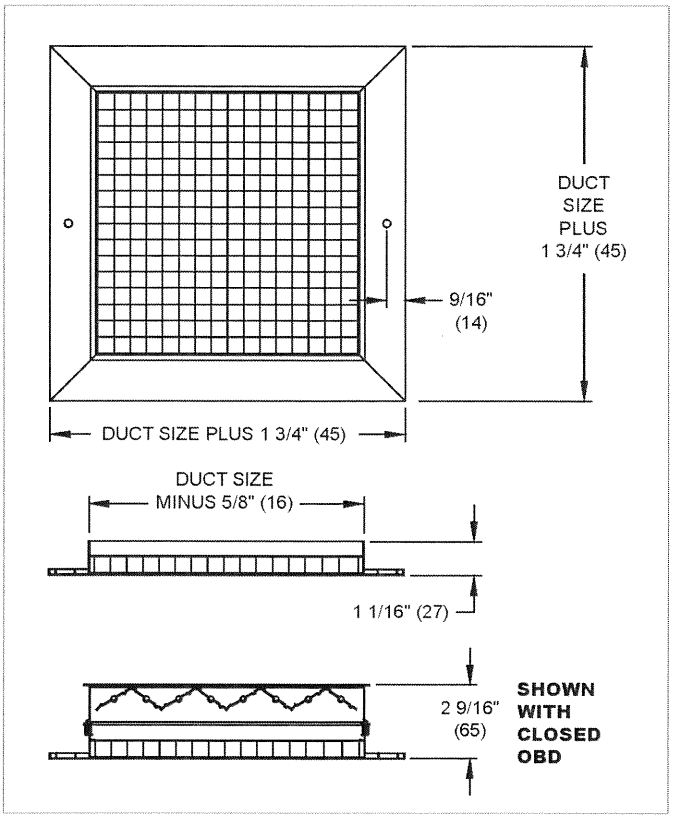
NOTE: Dimensions in parentheses are mm.

EG SERIES, FRAME FTB

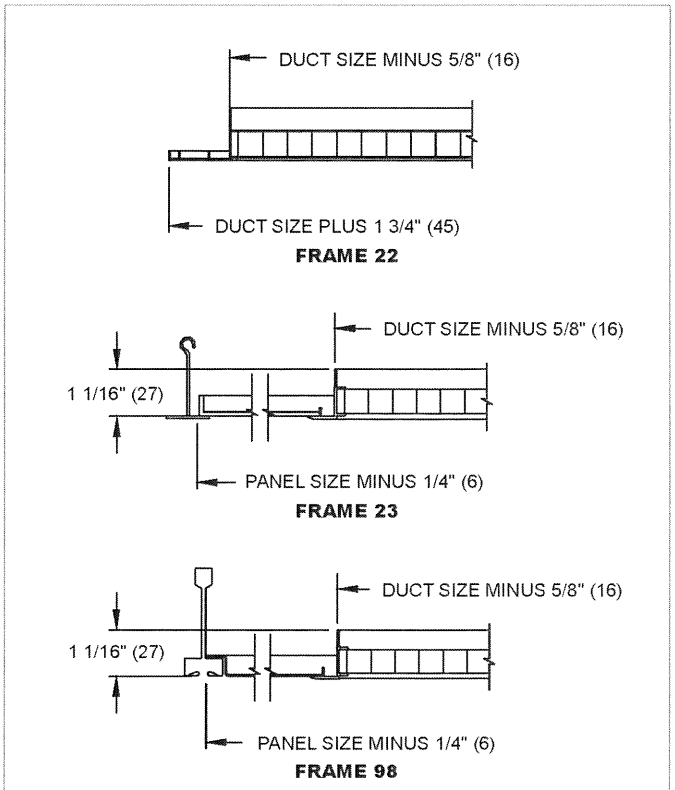


EGC5 Dimensional Information

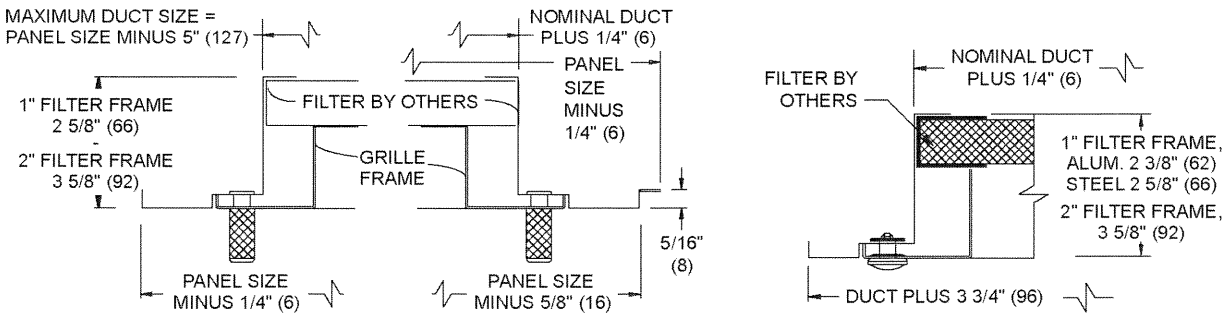
EGC5, FACE VIEW, SIDE VIEW, & CROSS SECTION



EGC5, FRAME STYLES



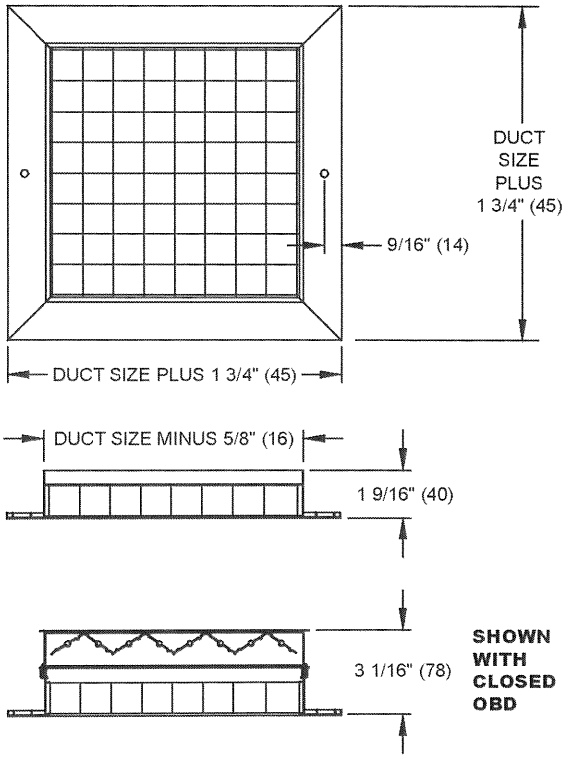
EGC5, FILTER FRAME DETAIL



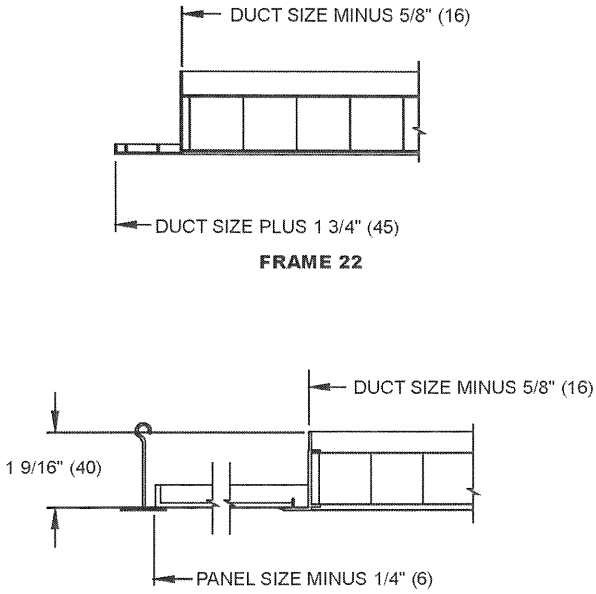
NOTES: Dimensions in parentheses are mm.

EGC10, EGC15 Dimensional Information

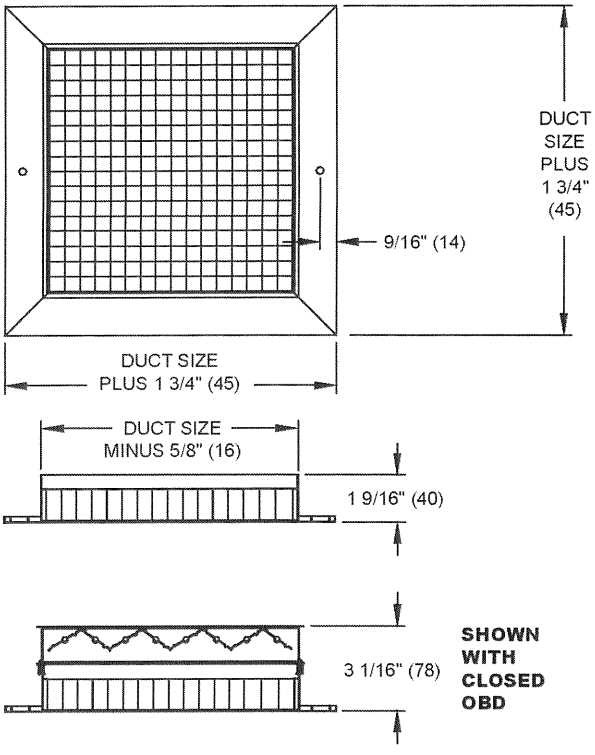
EGC10, FACE VIEW, SIDE VIEW, & CROSS SECTION



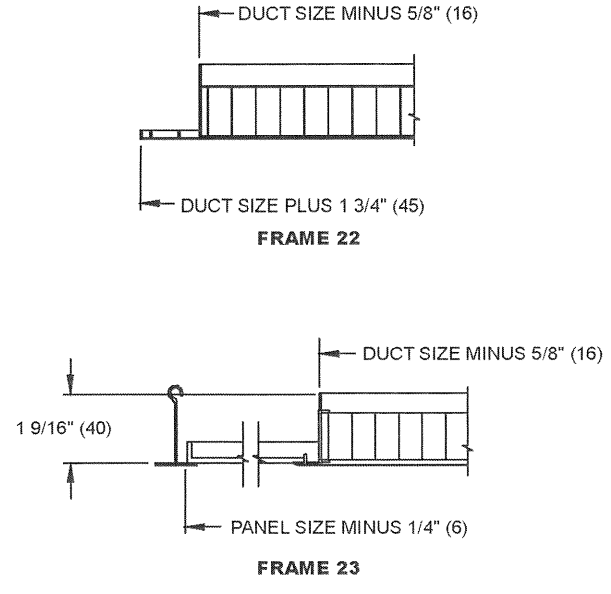
EGC10, FRAME STYLES



EGC15, FACE VIEW, SIDE VIEW, & CROSS SECTION



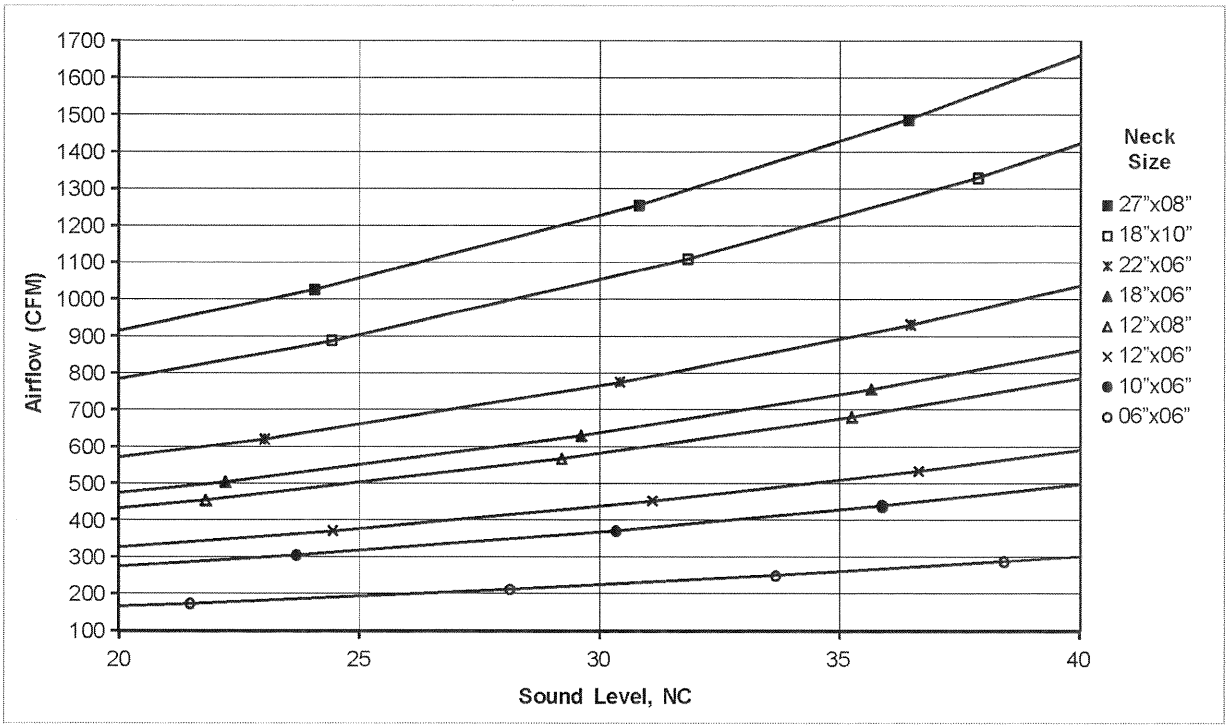
EGC15, FRAME STYLES



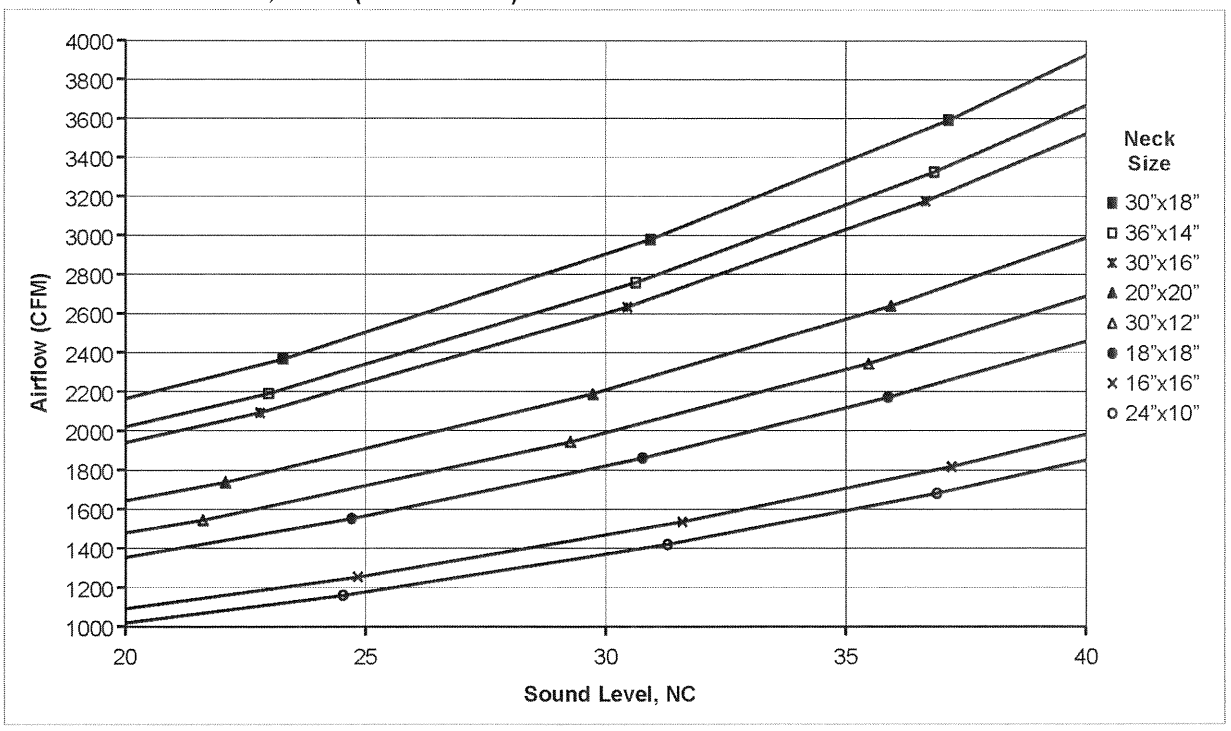
NOTE: Dimensions in parentheses are mm.

EG5, EGC5 Reference Charts

AIRFLOW VS. NC: EG5, EGC5 (NO DAMPER)

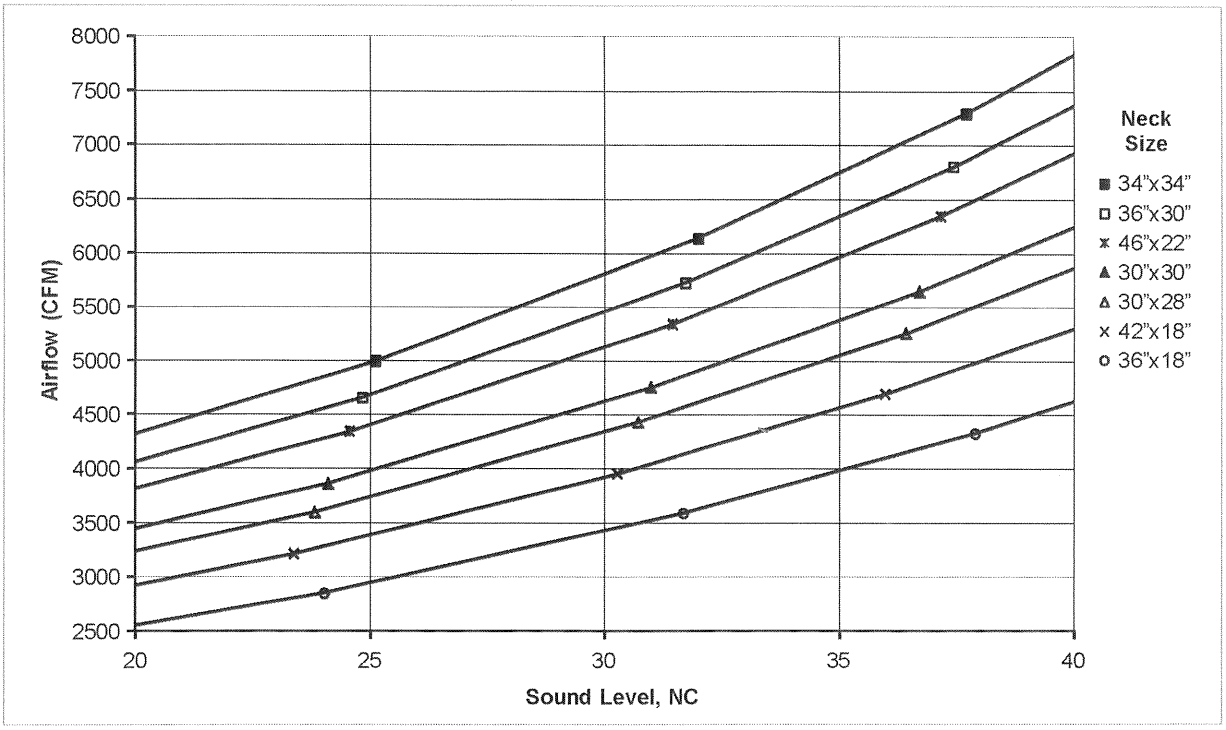


AIRFLOW VS. NC: EG5, EGC5 (NO DAMPER)

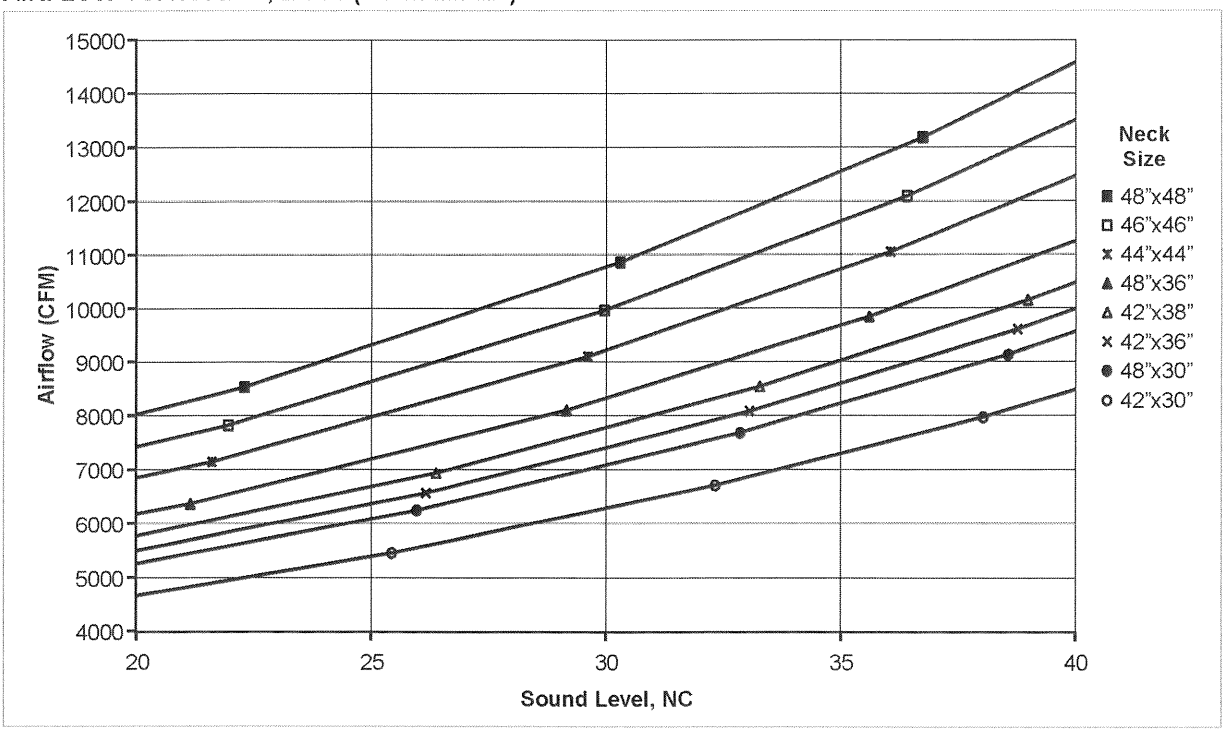


EG5, EGC5 Reference Charts

AIRFLOW VS. NC: EG5, EGC5 (NO DAMPER)



AIRFLOW VS. NC: EG5, EGC5 (NO DAMPER)



EG5, EGC5 Performance Data

IP/METRIC DATA: EG5, EGC5 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
6" x 6"	0.25	700	134	-.073	13	152 x 152	0.02	3.56	63	-18.1	29	22	24	24	24	17
		900	172	-.120	21			4.57	81	-29.9	35	29	30	30	32	29
		1100	211	-.179	28			5.59	99	-44.6	39	35	35	36	39	39
		1300	249	-.250	34			6.60	117	-62.4	42	39	39	40	45	47
		1500	287	-.333	38			7.62	136	-83.0	45	43	43	44	49	54
10" x 6"	0.42	700	236	-.073	15	254 x 152	0.04	3.56	111	-18.1	32	25	26	26	26	20
		900	304	-.120	24			4.57	143	-29.9	37	31	32	33	35	32
		1100	371	-.179	30			5.59	175	-44.6	41	37	37	38	41	41
		1300	438	-.250	36			6.60	207	-62.4	45	42	41	43	47	49
		1500	506	-.333	41			7.62	239	-83.0	48	46	45	46	52	56
12" x 6"	0.50	700	287	-.073	16	305 x 152	0.05	3.56	136	-18.1	32	25	27	27	27	20
		900	369	-.120	24			4.57	174	-29.9	38	32	33	33	35	32
		1100	451	-.179	31			5.59	213	-44.6	42	38	38	39	42	42
		1300	533	-.250	37			6.60	252	-62.4	45	42	42	43	48	50
		1500	615	-.333	41			7.62	290	-83.0	48	46	46	47	52	57
12" x 8"	0.67	600	340	-.053	12	305 x 203	0.06	3.05	160	-13.3	30	22	24	24	23	14
		800	453	-.095	22			4.06	214	-23.6	36	30	31	32	33	28
		1000	566	-.148	29			5.08	267	-36.9	41	36	37	38	40	39
		1200	680	-.213	35			6.10	321	-53.1	45	41	41	42	46	48
		1400	793	-.290	40			7.11	374	-72.3	48	46	45	47	51	55
18" x 6"	0.75	600	377	-.053	13	457 x 152	0.07	3.05	178	-13.3	31	23	25	24	24	15
		800	503	-.095	22			4.06	237	-23.6	37	31	32	32	33	28
		1000	629	-.148	30			5.08	297	-36.9	42	37	37	38	41	39
		1200	755	-.213	36			6.10	356	-53.1	45	42	42	43	47	48
		1400	880	-.290	41			7.11	416	-72.3	49	46	45	47	52	56
22" x 6"	0.92	600	465	-.053	13	559 x 152	0.09	3.05	219	-13.3	32	24	25	25	24	15
		800	620	-.095	23			4.06	293	-23.6	38	31	32	33	34	29
		1000	775	-.148	30			5.08	366	-36.9	42	38	38	39	41	40
		1200	930	-.213	36			6.10	439	-53.1	46	43	42	44	48	49
		1400	1085	-.290	42			7.11	512	-72.3	49	47	46	48	53	56
18" x 10"	1.25	600	665	-.053	15	457 x 254	0.12	3.05	314	-13.3	33	25	27	26	26	17
		800	886	-.095	24			4.06	418	-23.6	39	33	34	34	35	31
		1000	1108	-.148	32			5.08	523	-36.9	44	39	39	40	43	41
		1200	1330	-.213	38			6.10	628	-53.1	48	44	44	45	49	50
		1400	1551	-.290	43			7.11	732	-72.3	51	48	48	49	54	58
27" x 8"	1.50	600	793	-.053	16	686 x 203	0.14	3.05	374	-13.3	34	26	27	27	26	17
		775	1024	-.089	24			3.94	483	-22.2	39	33	34	34	35	30
		950	1256	-.134	31			4.83	593	-33.3	43	38	39	39	42	40
		1125	1487	-.188	36			5.72	702	-46.7	47	43	43	44	47	48
		1300	1718	-.250	41			6.60	811	-62.4	50	47	47	48	52	55
24" x 10"	1.67	600	896	-.053	16	610 x 254	0.15	3.05	423	-13.3	34	26	28	28	27	18
		775	1157	-.089	25			3.94	546	-22.2	40	33	34	35	35	30
		950	1419	-.134	31			4.83	670	-33.3	44	39	39	40	42	40
		1125	1680	-.188	37			5.72	793	-46.7	47	43	43	45	48	48
		1300	1942	-.250	42			6.60	916	-62.4	50	47	47	48	53	55
16" x 16"	1.78	600	969	-.053	16	406 x 406	0.17	3.05	457	-13.3	35	26	28	28	27	18
		775	1252	-.089	25			3.94	591	-22.2	40	33	35	35	36	31
		950	1534	-.134	32			4.83	724	-33.3	44	39	40	40	43	40
		1125	1817	-.188	37			5.72	857	-46.7	48	44	44	45	48	49
		1300	2100	-.250	42			6.60	991	-62.4	51	48	47	49	53	56
18" x 18"	2.25	600	1240	-.053	17	457 x 457	0.21	3.05	585	-13.3	35	27	29	29	28	19
		750	1550	-.083	25			3.81	731	-20.8	40	34	35	35	36	30
		900	1860	-.120	31			4.57	878	-29.9	44	39	39	40	42	39
		1050	2170	-.163	36			5.33	1024	-40.7	47	43	43	44	47	46
		1200	2480	-.213	40			6.10	1170	-53.1	50	46	46	48	51	53

NOTE: See notes on page J1-103.

EG5, EGC5 Performance Data

IP/METRIC DATA: EG5, EGC5 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
30" x 12"	2.50	500	1143	-.037	12	762 x 305	0.23	2.54	539	-9.2	32	23	25	24	23	11
		675	1542	-.068	22			3.43	728	-16.8	38	31	33	32	33	25
		850	1942	-.107	29			4.32	917	-26.7	43	37	38	39	40	36
		1025	2342	-.156	35			5.21	1105	-38.8	47	43	43	44	46	45
		1200	2742	-.213	41			6.10	1294	-53.1	50	47	47	48	52	53
20" x 20"	2.78	500	1287	-.037	12	508 x 508	0.26	2.54	607	-9.2	33	23	26	25	23	11
		675	1737	-.068	22			3.43	820	-16.8	39	31	33	33	33	26
		850	2187	-.107	30			4.32	1032	-26.7	44	38	39	39	41	37
		1025	2638	-.156	36			5.21	1245	-38.8	48	43	43	44	47	46
		1200	3088	-.213	41			6.10	1457	-53.1	51	47	47	48	52	54
30" x 16"	3.33	500	1549	-.037	13	762 x 406	0.31	2.54	731	-9.2	33	24	26	26	24	12
		675	2091	-.068	23			3.43	987	-16.8	40	32	34	34	34	26
		850	2633	-.107	30			4.32	1243	-26.7	44	39	39	40	41	38
		1025	3175	-.156	37			5.21	1498	-38.8	48	44	44	45	48	47
		1200	3717	-.213	42			6.10	1754	-53.1	52	48	48	49	53	54
36" x 14"	3.50	500	1622	-.037	13	914 x 356	0.33	2.54	765	-9.2	33	24	26	26	24	12
		675	2189	-.068	23			3.43	1033	-16.8	40	32	34	34	34	27
		850	2757	-.107	31			4.32	1301	-26.7	45	39	40	40	42	38
		1025	3325	-.156	37			5.21	1569	-38.8	48	44	44	45	48	47
		1200	3892	-.213	42			6.10	1837	-53.1	52	48	48	49	53	54
30" x 18"	3.75	500	1752	-.037	13	762 x 457	0.35	2.54	827	-9.2	34	24	27	26	24	12
		675	2365	-.068	23			3.43	1116	-16.8	40	33	34	34	34	27
		850	2978	-.107	31			4.32	1406	-26.7	45	39	40	40	42	38
		1025	3592	-.156	37			5.21	1695	-38.8	49	44	44	45	48	47
		1200	4205	-.213	42			6.10	1984	-53.1	52	49	48	50	53	55
36" x 18"	4.50	500	2111	-.037	14	914 x 457	0.42	2.54	996	-9.2	34	25	28	27	25	13
		675	2850	-.068	24			3.43	1345	-16.8	41	33	35	35	35	28
		850	3589	-.107	32			4.32	1694	-26.7	46	40	41	41	43	39
		1025	4328	-.156	38			5.21	2043	-38.8	50	45	45	46	49	48
		1200	5067	-.213	43			6.10	2391	-53.1	53	49	49	50	54	55
42" x 18"	5.25	500	2471	-.037	15	1067 x 457	0.49	2.54	1166	-9.2	35	26	28	27	26	14
		650	3212	-.063	23			3.30	1516	-15.6	41	33	35	34	34	26
		800	3953	-.095	30			4.06	1866	-23.6	45	39	40	40	41	36
		950	4694	-.134	36			4.83	2215	-33.3	49	43	44	45	47	45
		1100	5436	-.179	41			5.59	2565	-44.6	52	47	48	49	52	52
30" x 28"	5.83	500	2768	-.037	15	762 x 711	0.54	2.54	1306	-9.2	36	26	29	28	26	14
		650	3598	-.063	24			3.30	1698	-15.6	41	33	35	35	35	27
		800	4428	-.095	31			4.06	2090	-23.6	45	39	40	40	42	37
		950	5258	-.134	36			4.83	2482	-33.3	49	44	44	45	47	45
		1100	6089	-.179	41			5.59	2874	-44.6	52	48	48	49	52	52
30" x 30"	6.25	500	2971	-.037	15	762 x 762	0.58	2.54	1402	-9.2	36	26	29	28	26	14
		650	3862	-.063	24			3.30	1823	-15.6	41	34	35	35	35	27
		800	4753	-.095	31			4.06	2243	-23.6	46	39	40	41	42	37
		950	5644	-.134	37			4.83	2664	-33.3	49	44	45	45	48	46
		1100	6536	-.179	42			5.59	3084	-44.6	52	48	48	49	53	53
46" x 22"	7.03	500	3339	-.037	16	1168 x 559	0.65	2.54	1576	-9.2	36	27	29	29	27	15
		650	4340	-.063	25			3.30	2048	-15.6	42	34	36	36	35	28
		800	5342	-.095	31			4.06	2521	-23.6	46	40	41	41	42	38
		950	6344	-.134	37			4.83	2994	-33.3	50	45	45	46	48	46
		1100	7345	-.179	42			5.59	3467	-44.6	53	49	49	50	53	53
36" x 30"	7.50	500	3580	-.037	16	914 x 762	0.70	2.54	1690	-9.2	37	27	30	29	27	15
		650	4654	-.063	25			3.30	2196	-15.6	42	34	36	36	36	28
		800	5728	-.095	32			4.06	2703	-23.6	46	40	41	41	43	38
		950	6802	-.134	37			4.83	3210	-33.3	50	45	45	46	48	46
		1100	7876	-.179	42			5.59	3717	-44.6	53	49	49	50	53	53

NOTE: See notes on page J1-103.

EG5, EGC5 Performance Data

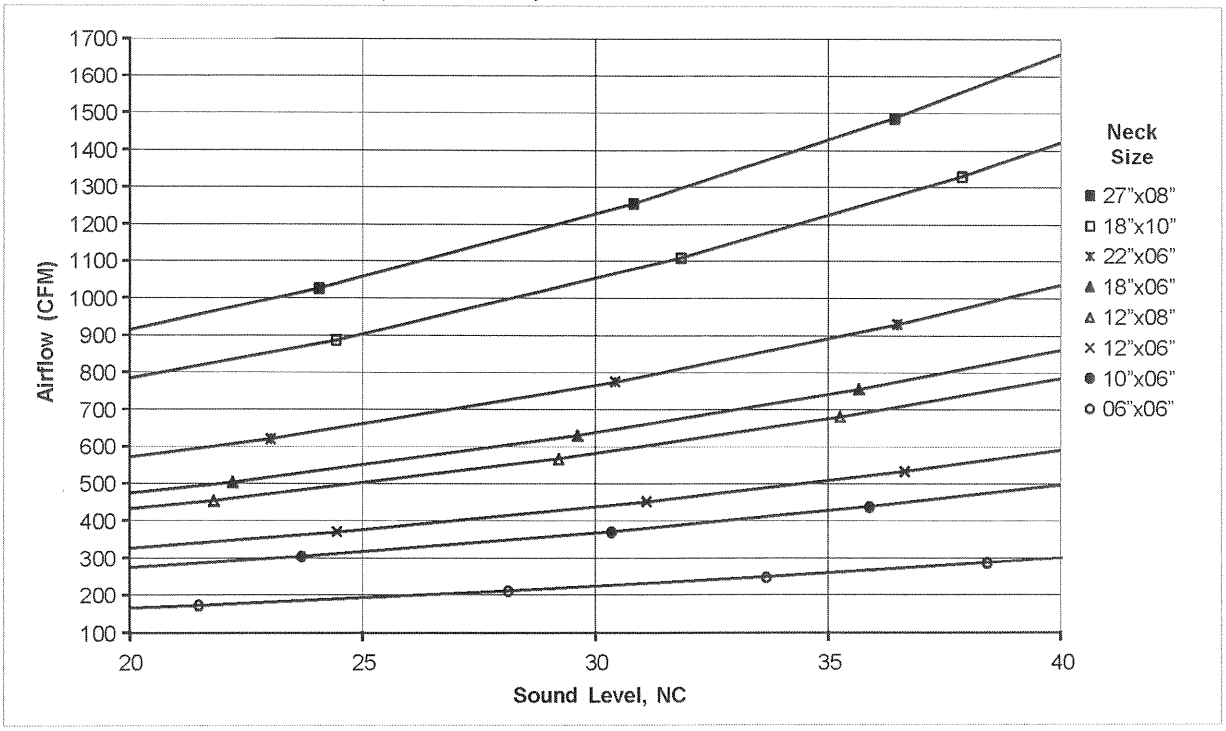
IP/METRIC DATA: EG5, EGC5 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB						
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
34" x 34"	8.03	500	3839	-.037	16	864 x 864	0.75	2.54	1812	-9.2	37	27	30	29	27	15
		650	4990	-.063	25			3.30	2355	-15.6	42	35	36	36	36	28
		800	6142	-.095	32			4.06	2899	-23.6	47	40	41	42	43	38
		950	7294	-.134	38			4.83	3442	-33.3	50	45	46	46	49	47
		1100	8445	-.179	43			5.59	3986	-44.6	53	49	49	50	54	54
42" x 30"	8.75	500	4189	-.037	17	1067 x 762	0.81	2.54	1977	-9.2	37	28	30	29	28	16
		650	5446	-.063	25			3.30	2570	-15.6	43	35	37	37	36	28
		800	6703	-.095	32			4.06	3164	-23.6	47	41	42	42	43	39
		950	7960	-.134	38			4.83	3757	-33.3	51	45	46	47	49	47
		1100	9217	-.179	43			5.59	4350	-44.6	54	50	50	51	54	54
48" x 30"	10.00	500	4799	-.037	17	1219 x 762	0.93	2.54	2265	-9.2	38	28	31	30	28	16
		650	6238	-.063	26			3.30	2944	-15.6	43	36	37	37	37	29
		800	7678	-.095	33			4.06	3624	-23.6	48	41	42	43	44	39
		950	9118	-.134	39			4.83	4303	-33.3	51	46	47	47	50	47
		1100	10557	-.179	43			5.59	4983	-44.6	54	50	50	51	54	54
42" x 36"	10.50	500	5049	-.037	17	1067 x 914	0.98	2.54	2383	-9.2	38	29	31	30	28	17
		650	6563	-.063	26			3.30	3098	-15.6	43	36	37	37	37	29
		800	8078	-.095	33			4.06	3812	-23.6	48	41	43	43	44	39
		950	9593	-.134	39			4.83	4527	-33.3	51	46	47	47	50	48
		1100	11107	-.179	44			5.59	5242	-44.6	54	50	50	51	55	55
42" x 38"	11.08	500	5335	-.037	18	1067 x 965	1.03	2.54	2518	-9.2	38	29	31	30	29	17
		650	6936	-.063	26			3.30	3273	-15.6	44	36	38	37	37	29
		800	8536	-.095	33			4.06	4029	-23.6	48	42	43	43	44	39
		950	10137	-.134	39			4.83	4784	-33.3	52	46	47	48	50	48
		1100	11738	-.179	44			5.59	5540	-44.6	55	50	51	52	55	55
48" x 36"	12.00	400	4627	-.024	11	1219 x 914	1.11	2.03	2183	-5.9	34	23	26	25	21	-
		550	6362	-.045	21			2.79	3002	-11.2	40	32	34	33	32	22
		700	8096	-.073	29			3.56	3821	-18.1	45	38	40	40	40	33
		850	9831	-.107	36			4.32	4640	-26.7	50	44	45	45	47	43
		1000	11566	-.148	41			5.08	5459	-36.9	53	48	49	49	52	51
44" x 44"	13.44	400	5196	-.024	11	1118 x 1118	1.25	2.03	2452	-5.9	34	23	26	25	22	-
		550	7145	-.045	22			2.79	3372	-11.2	41	32	34	34	33	22
		700	9093	-.073	30			3.56	4291	-18.1	46	39	40	40	41	34
		850	11042	-.107	36			4.32	5211	-26.7	50	44	45	45	47	43
		1000	12990	-.148	41			5.08	6131	-36.9	53	49	49	50	52	51
46" x 46"	14.69	400	5688	-.024	11	1168 x 1168	1.37	2.03	2684	-5.9	35	24	27	26	22	-
		550	7821	-.045	22			2.79	3691	-11.2	41	32	35	34	33	22
		700	9953	-.073	30			3.56	4697	-18.1	46	39	41	41	41	34
		850	12086	-.107	36			4.32	5704	-26.7	50	44	45	46	47	44
		1000	14219	-.148	42			5.08	6711	-36.9	54	49	49	50	53	51
48" x 48"	16.00	400	6202	-.024	12	1219 x 1219	1.49	2.03	2927	-5.9	35	24	27	26	23	-
		550	8527	-.045	22			2.79	4024	-11.2	42	33	35	34	33	23
		700	10853	-.073	30			3.56	5122	-18.1	47	39	41	41	41	34
		850	13178	-.107	37			4.32	6219	-26.7	51	45	46	46	48	44
		1000	15504	-.148	42			5.08	7317	-36.9	54	49	50	50	53	52

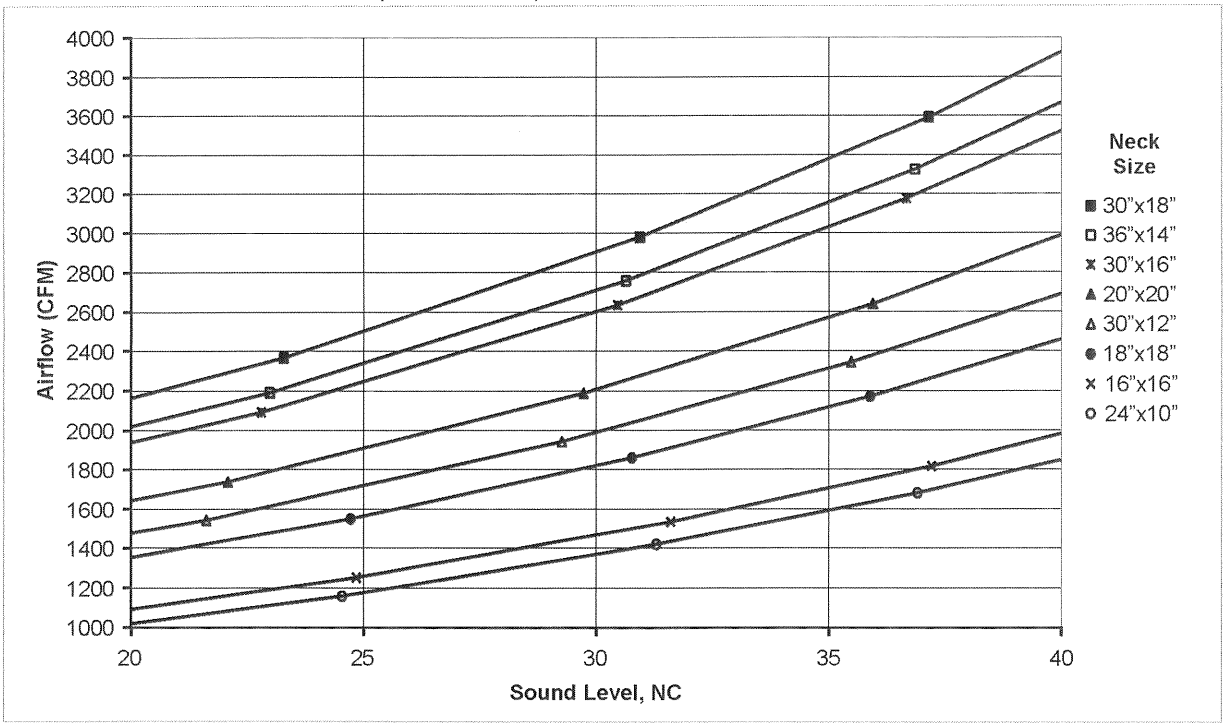
NOTES: NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re 10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. See Krueger's selection program for performance data not shown, including octave band data.

EG10, EGC10 Reference Charts

AIRFLOW VS. NC: EG10, EGC10 (NO DAMPER)

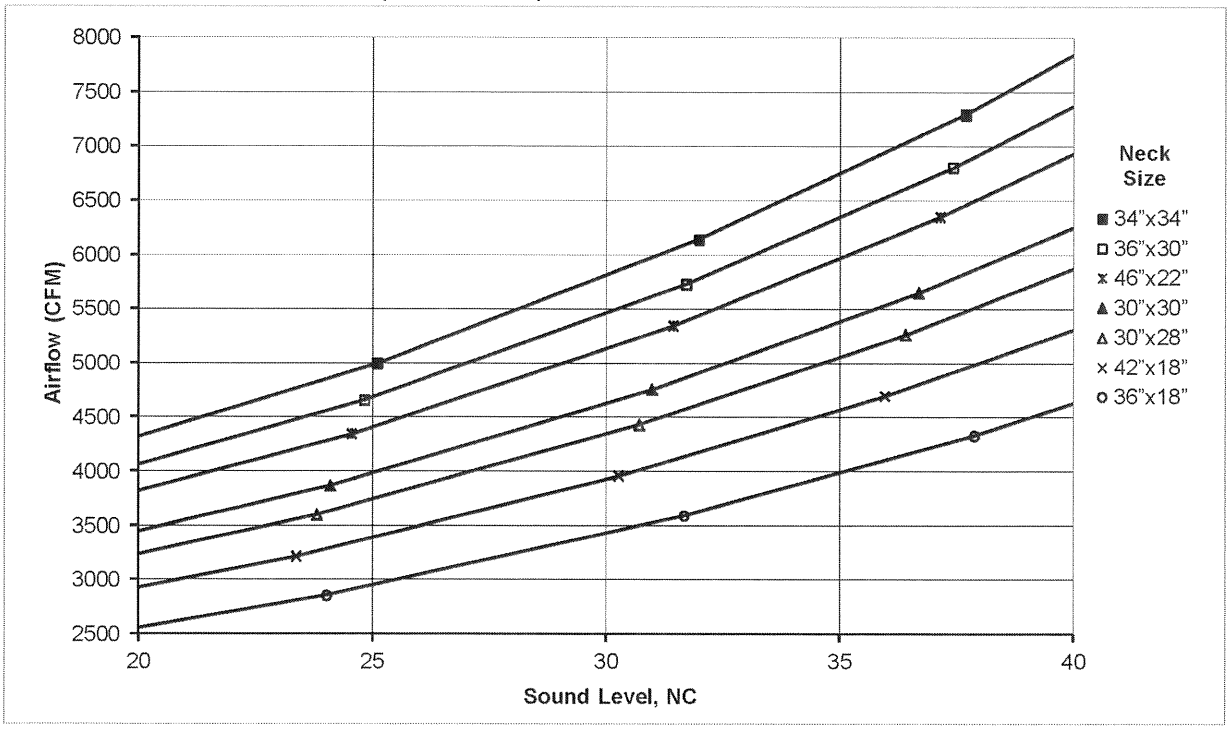


AIRFLOW VS. NC: EG10, EGC10 (NO DAMPER)

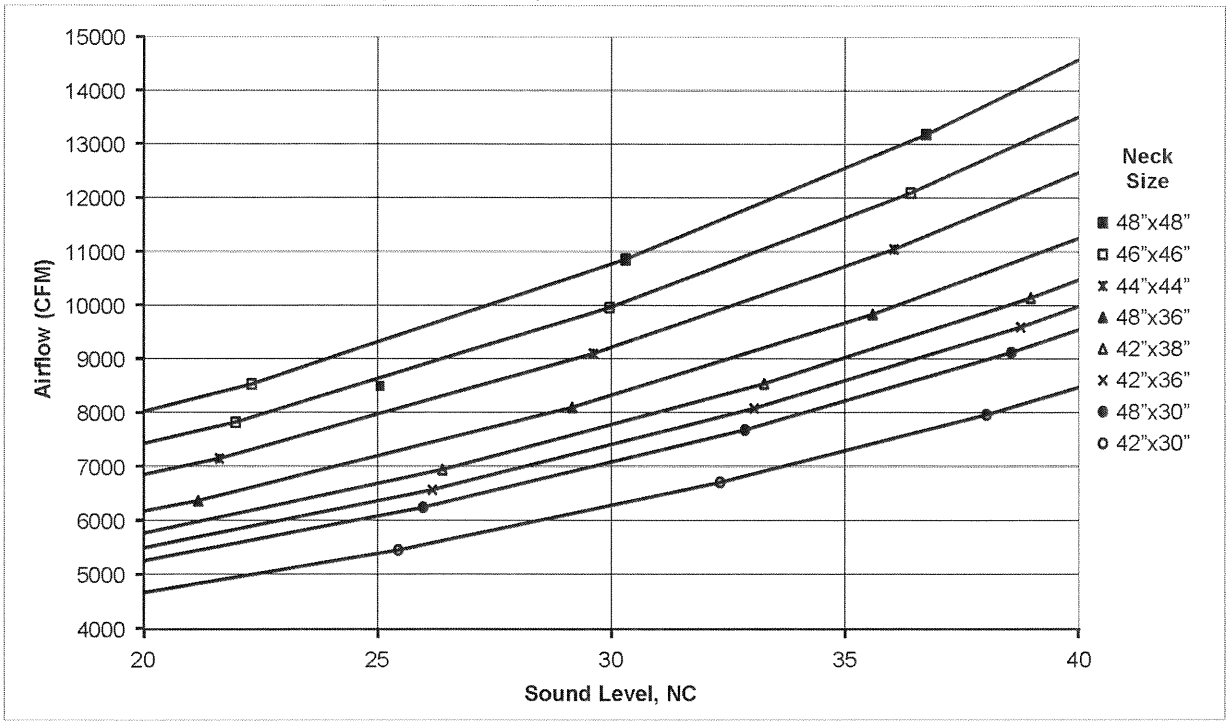


EG10, EGC10 Reference Charts

AIRFLOW VS. NC: EG10, EGC10 (NO DAMPER)



AIRFLOW VS. NC: EG10, EGC10 (NO DAMPER)



EG10, EGC10 Performance Data

IP/METRIC DATA: EG10, EGC10 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
6" x 6"	0.25	700	134	-.074	13	152 x 152	0.02	3.56	63	-18.3	29	22	24	24	24	17
		900	172	-.122	21			4.57	81	-30.3	35	29	30	30	32	29
		1100	211	-.182	28			5.59	99	-45.3	39	35	35	36	39	39
		1300	249	-.254	34			6.60	117	-63.2	42	39	39	40	45	47
		1500	287	-.338	38			7.62	136	-84.2	45	43	43	44	49	54
10" x 6"	0.42	700	236	-.074	15	254 x 152	0.04	3.56	111	-18.3	32	25	26	26	26	20
		900	304	-.122	24			4.57	143	-30.3	37	31	32	33	35	32
		1100	371	-.182	30			5.59	175	-45.3	41	37	37	38	41	41
		1300	438	-.254	36			6.60	207	-63.2	45	42	41	43	47	49
		1500	506	-.338	41			7.62	239	-84.2	48	46	45	46	52	56
12" x 6"	0.50	700	287	-.074	16	305 x 152	0.05	3.56	136	-18.3	32	25	27	27	27	20
		900	369	-.122	24			4.57	174	-30.3	38	32	33	33	35	32
		1100	451	-.182	31			5.59	213	-45.3	42	38	38	39	42	42
		1300	533	-.254	37			6.60	252	-63.2	45	42	42	43	48	50
		1500	615	-.338	41			7.62	290	-84.2	48	46	46	47	52	57
12" x 8"	0.67	600	340	-.054	12	305 x 203	0.06	3.05	160	-13.5	30	22	24	24	23	14
		800	453	-.096	22			4.06	214	-23.9	36	30	31	32	33	28
		1000	566	-.150	29			5.08	267	-37.4	41	36	37	38	40	39
		1200	680	-.216	35			6.10	321	-53.9	45	41	41	42	46	48
		1400	793	-.294	40			7.11	374	-73.3	48	46	45	47	51	55
18" x 6"	0.75	600	377	-.054	13	457 x 152	0.07	3.05	178	-13.5	31	23	25	24	24	15
		800	503	-.096	22			4.06	237	-23.9	37	31	32	32	33	28
		1000	629	-.150	30			5.08	297	-37.4	42	37	37	38	41	39
		1200	755	-.216	36			6.10	356	-53.9	45	42	42	43	47	48
		1400	880	-.294	41			7.11	416	-73.3	49	46	45	47	52	56
22" x 6"	0.92	600	465	-.054	13	559 x 152	0.09	3.05	219	-13.5	32	24	25	25	24	15
		800	620	-.096	23			4.06	293	-23.9	38	31	32	33	34	29
		1000	775	-.150	30			5.08	366	-37.4	42	38	38	39	41	40
		1200	930	-.216	36			6.10	439	-53.9	46	43	42	44	48	49
		1400	1085	-.294	42			7.11	512	-73.3	49	47	46	48	53	56
18" x 10"	1.25	600	665	-.054	15	457 x 254	0.12	3.05	314	-13.5	33	25	27	26	26	17
		800	886	-.096	24			4.06	418	-23.9	39	33	34	34	35	31
		1000	1108	-.150	32			5.08	523	-37.4	44	39	39	40	43	41
		1200	1330	-.216	38			6.10	628	-53.9	48	44	44	45	49	50
		1400	1551	-.294	43			7.11	732	-73.3	51	48	48	49	54	58
27" x 8"	1.50	600	793	-.054	16	686 x 203	0.14	3.05	374	-13.5	34	26	27	27	26	17
		775	1024	-.090	24			3.94	483	-22.5	39	33	34	34	35	30
		950	1256	-.136	31			4.83	593	-33.8	43	38	39	39	42	40
		1125	1487	-.190	36			5.72	702	-47.3	47	43	43	44	47	48
		1300	1718	-.254	41			6.60	811	-63.2	50	47	47	48	52	55
24" x 10"	1.67	600	896	-.054	16	610 x 254	0.15	3.05	423	-13.5	34	26	28	28	27	18
		775	1157	-.090	25			3.94	546	-22.5	40	33	34	35	35	30
		950	1419	-.136	31			4.83	670	-33.8	44	39	39	40	42	40
		1125	1680	-.190	37			5.72	793	-47.3	47	43	43	45	48	48
		1300	1942	-.254	42			6.60	916	-63.2	50	47	47	48	53	55
16" x 16"	1.78	600	969	-.054	16	406 x 406	0.17	3.05	457	-13.5	35	26	28	28	27	18
		775	1252	-.090	25			3.94	591	-22.5	40	33	35	35	36	31
		950	1534	-.136	32			4.83	724	-33.8	44	39	40	40	43	40
		1125	1817	-.190	37			5.72	857	-47.3	48	44	44	45	48	49
		1300	2100	-.254	42			6.60	991	-63.2	51	48	47	49	53	56
18" x 18"	2.25	600	1240	-.054	17	457 x 457	0.21	3.05	585	-13.5	35	27	29	29	28	19
		750	1550	-.085	25			3.81	731	-21.0	40	34	35	35	36	30
		900	1860	-.122	31			4.57	878	-30.3	44	39	39	40	42	39
		1050	2170	-.166	36			5.33	1024	-41.2	47	43	43	44	47	46
		1200	2480	-.216	40			6.10	1170	-53.9	50	46	46	48	51	53

NOTE: See notes on page J1-108.

EG10, EGC10 Performance Data

IP/METRIC DATA: EG10, EGC10 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
30" x 12"	2.50	500	1143	-.038	12	762 x 305	0.23	2.54	539	-9.4	32	23	25	24	23	11
		675	1542	-.068	22			3.43	728	-17.0	38	31	33	32	33	25
		850	1942	-.109	29			4.32	917	-27.0	43	37	38	39	40	36
		1025	2342	-.158	35			5.21	1105	-39.3	47	43	43	44	46	45
		1200	2742	-.216	41			6.10	1294	-53.9	50	47	47	48	52	53
20" x 20"	2.78	500	1287	-.038	12	508 x 508	0.26	2.54	607	-9.4	33	23	26	25	23	11
		675	1737	-.068	22			3.43	820	-17.0	39	31	33	33	33	26
		850	2187	-.109	30			4.32	1032	-27.0	44	38	39	39	41	37
		1025	2638	-.158	36			5.21	1245	-39.3	48	43	43	44	47	46
		1200	3088	-.216	41			6.10	1457	-53.9	51	47	47	48	52	54
30" x 16"	3.33	500	1549	-.038	13	762 x 406	0.31	2.54	731	-9.4	33	24	26	26	24	12
		675	2091	-.068	23			3.43	987	-17.0	40	32	34	34	34	26
		850	2633	-.109	30			4.32	1243	-27.0	44	39	39	40	41	38
		1025	3175	-.158	37			5.21	1498	-39.3	48	44	44	45	48	47
		1200	3717	-.216	42			6.10	1754	-53.9	52	48	48	49	53	54
36" x 14"	3.50	500	1622	-.038	13	914 x 356	0.33	2.54	765	-9.4	33	24	26	26	24	12
		675	2189	-.068	23			3.43	1033	-17.0	40	32	34	34	34	27
		850	2757	-.109	31			4.32	1301	-27.0	45	39	40	40	42	38
		1025	3325	-.158	37			5.21	1569	-39.3	48	44	44	45	48	47
		1200	3892	-.216	42			6.10	1837	-53.9	52	48	48	49	53	54
30" x 18"	3.75	500	1752	-.038	13	762 x 457	0.35	2.54	827	-9.4	34	24	27	26	24	12
		675	2365	-.068	23			3.43	1116	-17.0	40	33	34	34	34	27
		850	2978	-.109	31			4.32	1406	-27.0	45	39	40	40	42	38
		1025	3592	-.158	37			5.21	1695	-39.3	49	44	44	45	48	47
		1200	4205	-.216	42			6.10	1984	-53.9	52	49	48	50	53	55
36" x 18"	4.50	500	2111	-.038	14	914 x 457	0.42	2.54	996	-9.4	34	25	28	27	25	13
		675	2850	-.068	24			3.43	1345	-17.0	41	33	35	35	35	28
		850	3589	-.109	32			4.32	1694	-27.0	46	40	41	41	43	39
		1025	4328	-.158	38			5.21	2043	-39.3	50	45	45	46	49	48
		1200	5067	-.216	43			6.10	2391	-53.9	53	49	49	50	54	55
42" x 18"	5.25	500	2471	-.038	15	1067 x 457	0.49	2.54	1166	-9.4	35	26	28	27	26	14
		650	3212	-.063	23			3.30	1516	-15.8	41	33	35	34	34	26
		800	3953	-.096	30			4.06	1866	-23.9	45	39	40	40	41	36
		950	4694	-.136	36			4.83	2215	-33.8	49	43	44	45	47	45
		1100	5436	-.182	41			5.59	2565	-45.3	52	47	48	49	52	52
30" x 28"	5.83	500	2768	-.038	15	762 x 711	0.54	2.54	1306	-9.4	36	26	29	28	26	14
		650	3598	-.063	24			3.30	1698	-15.8	41	33	35	35	35	27
		800	4428	-.096	31			4.06	2090	-23.9	45	39	40	40	42	37
		950	5258	-.136	36			4.83	2482	-33.8	49	44	44	45	47	45
		1100	6089	-.182	41			5.59	2874	-45.3	52	48	48	49	52	52
30" x 30"	6.25	500	2971	-.038	15	762 x 762	0.58	2.54	1402	-9.4	36	26	29	28	26	14
		650	3862	-.063	24			3.30	1823	-15.8	41	34	35	35	35	27
		800	4753	-.096	31			4.06	2243	-23.9	46	39	40	41	42	37
		950	5644	-.136	37			4.83	2664	-33.8	49	44	45	45	48	46
		1100	6536	-.182	42			5.59	3084	-45.3	52	48	48	49	53	53
46" x 22"	7.03	500	3339	-.038	16	1168 x 559	0.65	2.54	1576	-9.4	36	27	29	29	27	15
		650	4340	-.063	25			3.30	2048	-15.8	42	34	36	36	35	28
		800	5342	-.096	31			4.06	2521	-23.9	46	40	41	41	42	38
		950	6344	-.136	37			4.83	2994	-33.8	50	45	45	46	48	46
		1100	7345	-.182	42			5.59	3467	-45.3	53	49	49	50	53	53
36" x 30"	7.50	500	3580	-.038	16	914 x 762	0.70	2.54	1690	-9.4	37	27	30	29	27	15
		650	4654	-.063	25			3.30	2196	-15.8	42	34	36	36	36	28
		800	5728	-.096	32			4.06	2703	-23.9	46	40	41	41	43	38
		950	6802	-.136	37			4.83	3210	-33.8	50	45	45	46	48	46
		1100	7876	-.182	42			5.59	3717	-45.3	53	49	49	50	53	53

NOTE: See notes on page J1-108.

EG10, EGC10 Performance Data

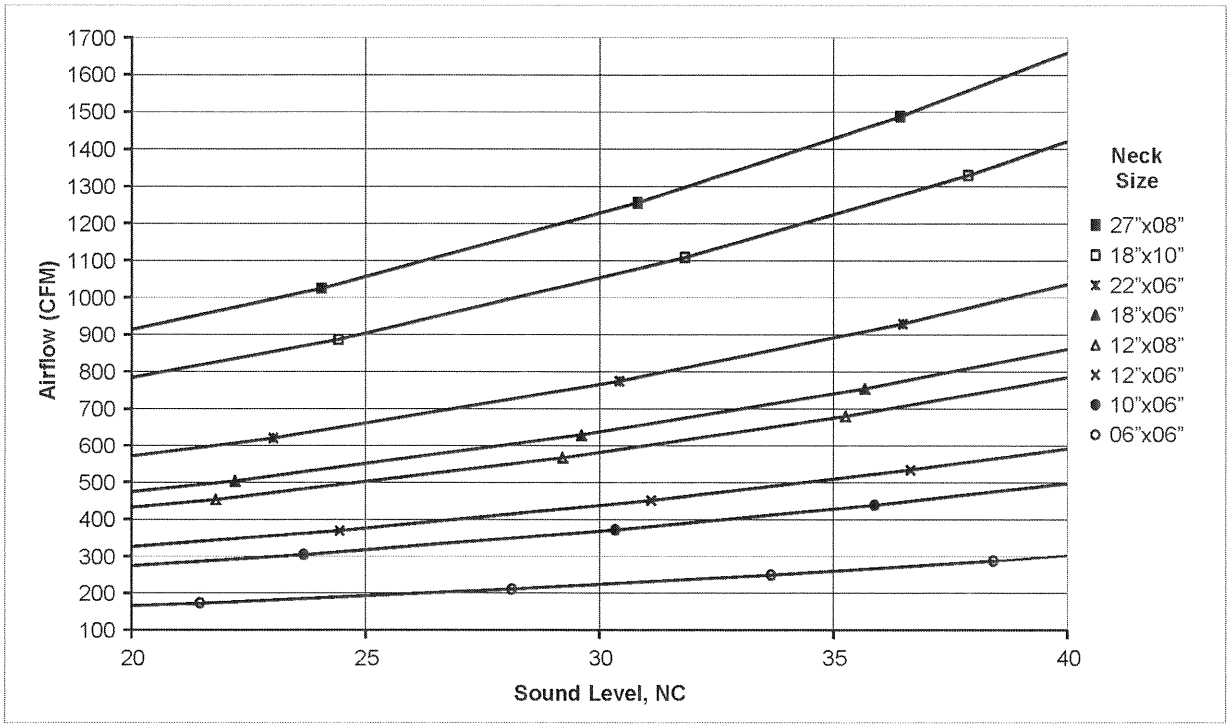
IP/METRIC DATA: EG10, EGC10 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
34" x 34"	8.03	500	3839	-.038	16	864 x 864	0.75	2.54	1812	-9.4	37	27	30	29	27	15
		650	4990	-.063	25			3.30	2355	-15.8	42	35	36	36	36	28
		800	6142	-.096	32			4.06	2899	-23.9	47	40	41	42	43	38
		950	7294	-.136	38			4.83	3442	-33.8	50	45	46	46	49	47
		1100	8445	-.182	43			5.59	3986	-45.3	53	49	49	50	54	54
42" x 30"	8.75	500	4189	-.038	17	1067 x 762	0.81	2.54	1977	-9.4	37	28	30	29	28	16
		650	5446	-.063	25			3.30	2570	-15.8	43	35	37	37	36	28
		800	6703	-.096	32			4.06	3164	-23.9	47	41	42	42	43	39
		950	7960	-.136	38			4.83	3757	-33.8	51	45	46	47	49	47
		1100	9217	-.182	43			5.59	4350	-45.3	54	50	50	51	54	54
48" x 30"	10.00	500	4799	-.038	17	1219 x 762	0.93	2.54	2265	-9.4	38	28	31	30	28	16
		650	6238	-.063	26			3.30	2944	-15.8	43	36	37	37	37	29
		800	7678	-.096	33			4.06	3624	-23.9	48	41	42	43	44	39
		950	9118	-.136	39			4.83	4303	-33.8	51	46	47	47	50	47
		1100	10557	-.182	43			5.59	4983	-45.3	54	50	50	51	54	54
42" x 36"	10.50	500	5049	-.038	17	1067 x 914	0.98	2.54	2383	-9.4	38	29	31	30	28	17
		650	6563	-.063	26			3.30	3098	-15.8	43	36	37	37	37	29
		800	8078	-.096	33			4.06	3812	-23.9	48	41	43	43	44	39
		950	9593	-.136	39			4.83	4527	-33.8	51	46	47	47	50	48
		1100	11107	-.182	44			5.59	5242	-45.3	54	50	50	51	55	55
42" x 38"	11.08	500	5335	-.038	18	1067 x 965	1.03	2.54	2518	-9.4	38	29	31	30	29	17
		650	6936	-.063	26			3.30	3273	-15.8	44	36	38	37	37	29
		800	8536	-.096	33			4.06	4029	-23.9	48	42	43	43	44	39
		950	10137	-.136	39			4.83	4784	-33.8	52	46	47	48	50	48
		1100	11738	-.182	44			5.59	5540	-45.3	55	50	51	52	55	55
48" x 36"	12.00	400	4627	-.024	11	1219 x 914	1.11	2.03	2183	-6.0	34	23	26	25	21	-
		550	6362	-.045	21			2.79	3002	-11.3	40	32	34	33	32	22
		700	8096	-.074	29			3.56	3821	-18.3	45	38	40	40	40	33
		850	9831	-.109	36			4.32	4640	-27.0	50	44	45	45	47	43
		1000	11566	-.150	41			5.08	5459	-37.4	53	48	49	49	52	51
44" x 44"	13.44	400	5196	-.024	11	1118 x 1118	1.25	2.03	2452	-6.0	34	23	26	25	22	-
		550	7145	-.045	22			2.79	3372	-11.3	41	32	34	34	33	22
		700	9093	-.074	30			3.56	4291	-18.3	46	39	40	40	41	34
		850	11042	-.109	36			4.32	5211	-27.0	50	44	45	45	47	43
		1000	12990	-.150	41			5.08	6131	-37.4	53	49	49	50	52	51
46" x 46"	14.69	400	5688	-.024	11	1168 x 1168	1.37	2.03	2684	-6.0	35	24	27	26	22	-
		550	7821	-.045	22			2.79	3691	-11.3	41	32	35	34	33	22
		700	9953	-.074	30			3.56	4697	-18.3	46	39	41	41	41	34
		850	12086	-.109	36			4.32	5704	-27.0	50	44	45	46	47	44
		1000	14219	-.150	42			5.08	6711	-37.4	54	49	49	50	53	51
48" x 48"	16.00	400	6202	-.024	12	1219 x 1219	1.49	2.03	2927	-6.0	35	24	27	26	23	-
		550	8527	-.045	22			2.79	4024	-11.3	42	33	35	34	33	23
		700	10853	-.074	30			3.56	5122	-18.3	47	39	41	41	41	34
		850	13178	-.109	37			4.32	6219	-27.0	51	45	46	46	48	44
		1000	15504	-.150	42			5.08	7317	-37.4	54	49	50	50	53	52

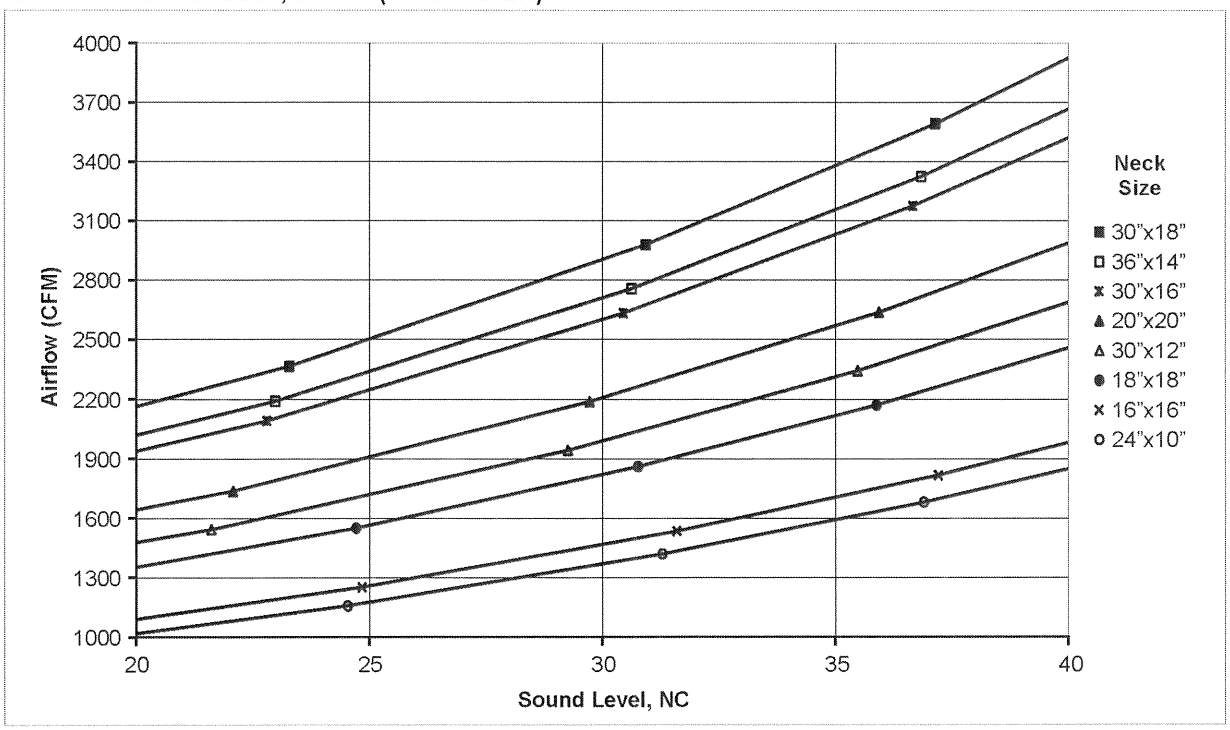
NOTES: NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re 10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. See Krueger's selection program for performance data not shown, including octave band data.

EG15, EGC15 Reference Charts

AIRFLOW VS. NC: EG15, EGC15 (NO DAMPER)

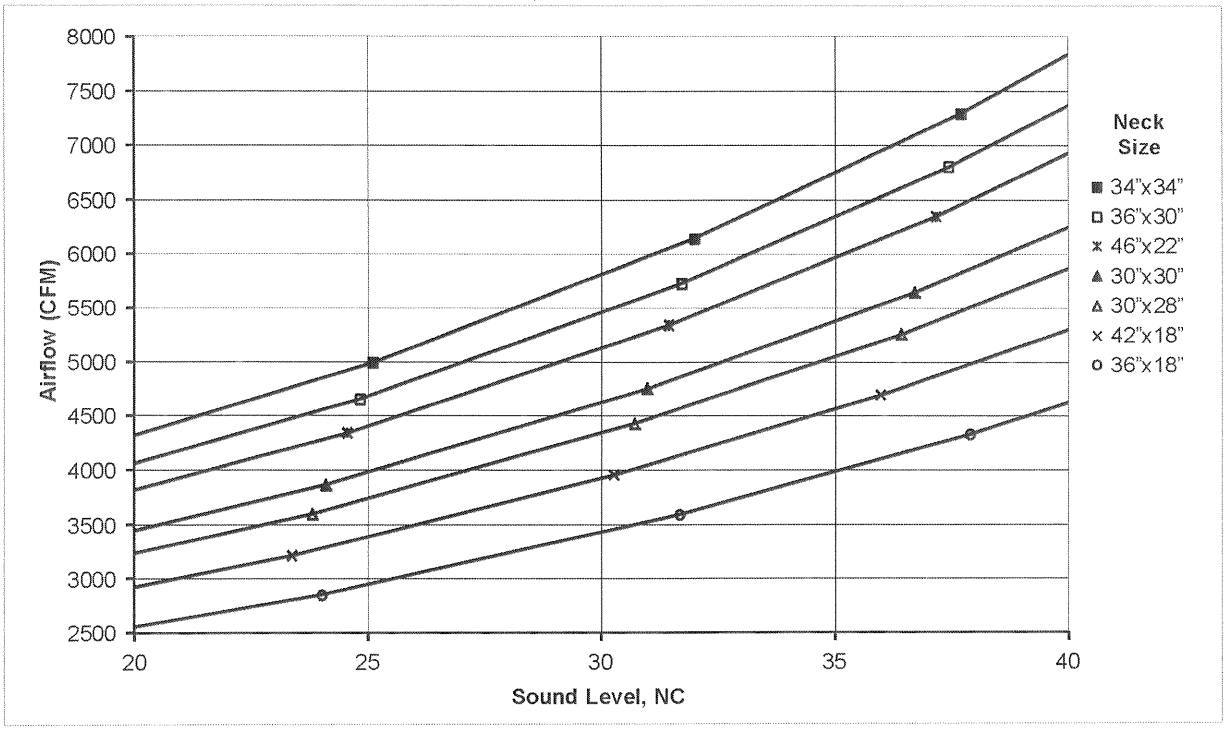


AIRFLOW VS. NC: EG15, EGC15 (NO DAMPER)

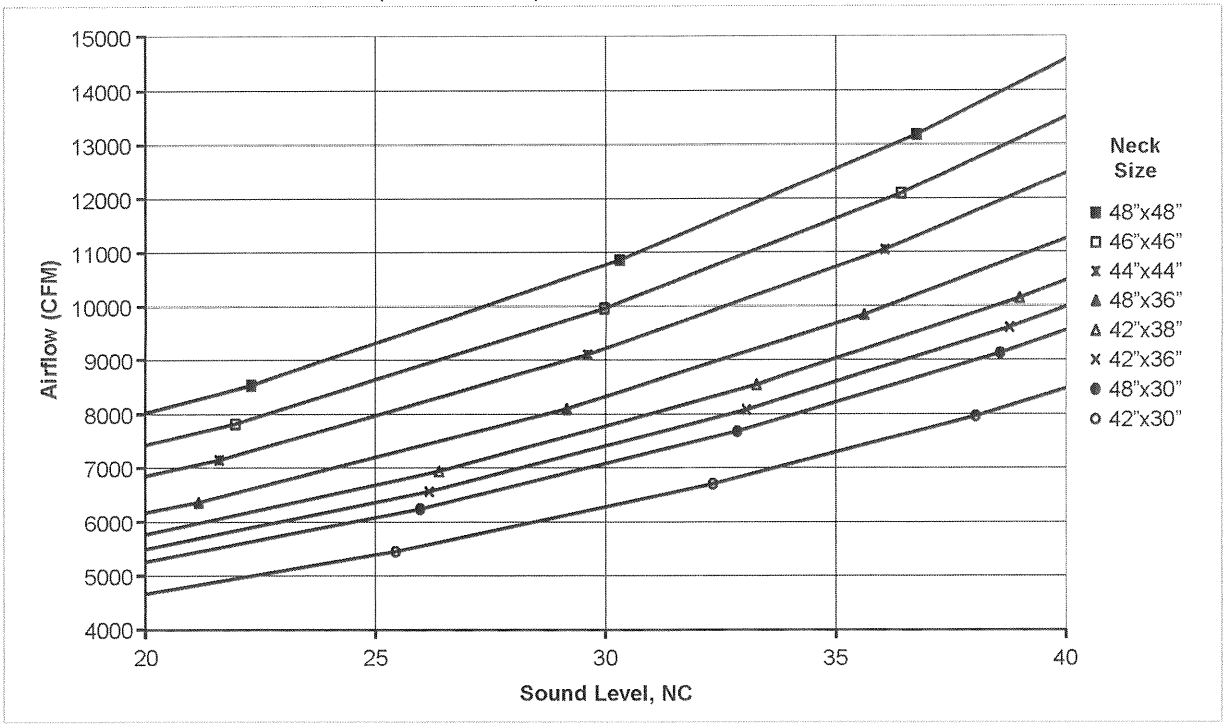


EG15, EGC15 Reference Charts

AIRFLOW VS. NC: EG15, EGC15 (NO DAMPER)



AIRFLOW VS. NC: EG15, EGC15 (NO DAMPER)



EG15, EGC15 Performance Data

IP/METRIC DATA: EG15, EGC15 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB						
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7	
6" x 6"	0.25	700	134	-.074	13	152 x 152	0.02	3.56	63	-18.3	29	22	24	24	24	17	
		900	172	-.122	21			4.57	81	-30.3	35	29	30	30	32	29	
		1100	211	-.182	28			5.59	99	-45.3	39	35	35	36	39	39	
		1300	249	-.254	34			6.60	117	-63.2	42	39	39	40	45	47	
		1500	287	-.338	38			7.62	136	-84.2	45	43	43	44	49	54	
10" x 6"	0.42	700	236	-.074	15	254 x 152	0.04	3.56	111	-18.3	32	25	26	26	26	20	
		900	304	-.122	24			4.57	143	-30.3	37	31	32	33	35	32	
		1100	371	-.182	30			5.59	175	-45.3	41	37	37	38	41	41	
		1300	438	-.254	36			6.60	207	-63.2	45	42	41	43	47	49	
		1500	506	-.338	41			7.62	239	-84.2	48	46	45	46	52	56	
12" x 6"	0.50	700	287	-.074	16	305 x 152	0.05	3.56	136	-18.3	32	25	27	27	27	20	
		900	369	-.122	24			4.57	174	-30.3	38	32	33	33	35	32	
		1100	451	-.182	31			5.59	213	-45.3	42	38	38	39	42	42	
		1300	533	-.254	37			6.60	252	-63.2	45	42	42	43	48	50	
		1500	615	-.338	41			7.62	290	-84.2	48	46	46	47	52	57	
12" x 8"	0.67	600	340	-.054	12	305 x 203	0.06	3.05	160	-13.5	30	22	24	24	23	14	
		800	453	-.096	22			4.06	214	-23.9	36	30	31	32	33	28	
		1000	566	-.150	29			5.08	267	-37.4	41	36	37	38	40	39	
		1200	680	-.216	35			6.10	321	-53.9	45	41	41	42	46	48	
		1400	793	-.294	40			7.11	374	-73.3	48	46	45	47	51	55	
18" x 6"	0.75	600	377	-.054	13	457 x 152	0.07	3.05	178	-13.5	31	23	25	24	24	15	
		800	503	-.096	22			4.06	237	-23.9	37	31	32	32	33	28	
		1000	629	-.150	30			5.08	297	-37.4	42	37	37	38	41	39	
		1200	755	-.216	36			6.10	356	-53.9	45	42	42	43	47	48	
		1400	880	-.294	41			7.11	416	-73.3	49	46	45	47	52	56	
22" x 6"	0.92	600	465	-.054	13	559 x 152	0.09	3.05	219	-13.5	32	24	25	25	24	15	
		800	620	-.096	23			4.06	293	-23.9	38	31	32	33	34	29	
		1000	775	-.150	30			5.08	366	-37.4	42	38	38	39	41	40	
		1200	930	-.216	36			6.10	439	-53.9	46	43	42	44	48	49	
		1400	1085	-.294	42			7.11	512	-73.3	49	47	46	48	53	56	
18" x 10"	1.25	600	665	-.054	15	457 x 254	0.12	3.05	314	-13.5	33	25	27	26	26	17	
		800	886	-.096	24			4.06	418	-23.9	39	33	34	34	35	31	
		1000	1108	-.150	32			5.08	523	-37.4	44	39	39	40	43	41	
		1200	1330	-.216	38			6.10	628	-53.9	48	44	44	45	49	50	
		1400	1551	-.294	43			7.11	732	-73.3	51	48	48	49	54	58	
27" x 8"	1.50	600	793	-.054	16	686 x 203	0.14	3.05	374	-13.5	34	26	27	27	26	17	
		775	1024	-.090	24			3.94	483	-22.5	39	33	34	34	35	30	
		950	1256	-.136	31			4.83	593	-33.8	43	38	39	39	42	40	
		1125	1487	-.190	36			5.72	702	-47.3	47	43	43	44	47	48	
		1300	1718	-.254	41			6.60	811	-63.2	50	47	47	48	52	55	
24" x 10"	1.67	600	896	-.054	16	610 x 254	0.15	3.05	423	-13.5	34	26	28	28	27	18	
		775	1157	-.090	25			3.94	546	-22.5	40	33	34	35	35	30	
		950	1419	-.136	31			4.83	670	-33.8	44	39	39	40	42	40	
		1125	1680	-.190	37			5.72	793	-47.3	47	43	43	45	48	48	
		1300	1942	-.254	42			6.60	916	-63.2	50	47	47	48	53	55	
16" x 16"	1.78	600	969	-.054	16	406 x 406	0.17	3.05	457	-13.5	35	26	28	28	27	18	
		775	1252	-.090	25			3.94	591	-22.5	40	33	35	35	36	31	
		950	1534	-.136	32			4.83	724	-33.8	44	39	40	40	43	40	
		1125	1817	-.190	37			5.72	857	-47.3	48	44	44	45	48	49	
		1300	2100	-.254	42			6.60	991	-63.2	51	48	47	49	53	56	
18" x 18"	2.25	600	1240	-.054	17	457 x 457	0.21	3.05	585	-13.5	35	27	29	29	28	19	
		750	1550	-.085	25			3.81	731	-21.0	40	34	35	35	36	30	
		900	1860	-.122	31			4.57	878	-30.3	44	39	39	40	42	39	
		1050	2170	-.166	36			5.33	1024	-41.2	47	43	43	44	47	46	
		1200	2480	-.216	40			6.10	1170	-53.9	50	46	46	48	51	53	

NOTE: See notes on page J1-113.

EG15, EGC15 Performance Data

IP/METRIC DATA: EG15, EGC15 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
30" x 12"	2.50	500	1143	-.038	12	762 x 305	0.23	2.54	539	-9.4	32	23	25	24	23	11
		675	1542	-.068	22			3.43	728	-17.0	38	31	33	32	33	25
		850	1942	-.109	29			4.32	917	-27.0	43	37	38	39	40	36
		1025	2342	-.158	35			5.21	1105	-39.3	47	43	43	44	46	45
		1200	2742	-.216	41			6.10	1294	-53.9	50	47	47	48	52	53
20" x 20"	2.78	500	1287	-.038	12	508 x 508	0.26	2.54	607	-9.4	33	23	26	25	23	11
		675	1737	-.068	22			3.43	820	-17.0	39	31	33	33	33	26
		850	2187	-.109	30			4.32	1032	-27.0	44	38	39	39	41	37
		1025	2638	-.158	36			5.21	1245	-39.3	48	43	43	44	47	46
		1200	3088	-.216	41			6.10	1457	-53.9	51	47	47	48	52	54
30" x 16"	3.33	500	1549	-.038	13	762 x 406	0.31	2.54	731	-9.4	33	24	26	26	24	12
		675	2091	-.068	23			3.43	987	-17.0	40	32	34	34	34	26
		850	2633	-.109	30			4.32	1243	-27.0	44	39	39	40	41	38
		1025	3175	-.158	37			5.21	1498	-39.3	48	44	44	45	48	47
		1200	3717	-.216	42			6.10	1754	-53.9	52	48	48	49	53	54
36" x 14"	3.50	500	1622	-.038	13	914 x 356	0.33	2.54	765	-9.4	33	24	26	26	24	12
		675	2189	-.068	23			3.43	1033	-17.0	40	32	34	34	34	27
		850	2757	-.109	31			4.32	1301	-27.0	45	39	40	40	42	38
		1025	3325	-.158	37			5.21	1569	-39.3	48	44	44	45	48	47
		1200	3892	-.216	42			6.10	1837	-53.9	52	48	48	49	53	54
30" x 18"	3.75	500	1752	-.038	13	762 x 457	0.35	2.54	827	-9.4	34	24	27	26	24	12
		675	2365	-.068	23			3.43	1116	-17.0	40	33	34	34	34	27
		850	2978	-.109	31			4.32	1406	-27.0	45	39	40	40	42	38
		1025	3592	-.158	37			5.21	1695	-39.3	49	44	44	45	48	47
		1200	4205	-.216	42			6.10	1984	-53.9	52	49	48	50	53	55
36" x 18"	4.50	500	2111	-.038	14	914 x 457	0.42	2.54	996	-9.4	34	25	28	27	25	13
		675	2850	-.068	24			3.43	1345	-17.0	41	33	35	35	35	28
		850	3589	-.109	32			4.32	1694	-27.0	46	40	41	41	43	39
		1025	4328	-.158	38			5.21	2043	-39.3	50	45	45	46	49	48
		1200	5067	-.216	43			6.10	2391	-53.9	53	49	49	50	54	55
42" x 18"	5.25	500	2471	-.038	15	1067 x 457	0.49	2.54	1166	-9.4	35	26	28	27	26	14
		650	3212	-.063	23			3.30	1516	-15.8	41	33	35	34	34	26
		800	3953	-.096	30			4.06	1866	-23.9	45	39	40	40	41	36
		950	4694	-.136	36			4.83	2215	-33.8	49	43	44	45	47	45
		1100	5436	-.182	41			5.59	2565	-45.3	52	47	48	49	52	52
30" x 28"	5.83	500	2768	-.038	15	762 x 711	0.54	2.54	1306	-9.4	36	26	29	28	26	14
		650	3598	-.063	24			3.30	1698	-15.8	41	33	35	35	35	27
		800	4428	-.096	31			4.06	2090	-23.9	45	39	40	40	42	37
		950	5258	-.136	36			4.83	2482	-33.8	49	44	44	45	47	45
		1100	6089	-.182	41			5.59	2874	-45.3	52	48	48	49	52	52
30" x 30"	6.25	500	2971	-.038	15	762 x 762	0.58	2.54	1402	-9.4	36	26	29	28	26	14
		650	3862	-.063	24			3.30	1823	-15.8	41	34	35	35	35	27
		800	4753	-.096	31			4.06	2243	-23.9	46	39	40	41	42	37
		950	5644	-.136	37			4.83	2664	-33.8	49	44	45	45	48	46
		1100	6536	-.182	42			5.59	3084	-45.3	52	48	48	49	53	53
46" x 22"	7.03	500	3339	-.038	16	1168 x 559	0.65	2.54	1576	-9.4	36	27	29	29	27	15
		650	4340	-.063	25			3.30	2048	-15.8	42	34	36	36	35	28
		800	5342	-.096	31			4.06	2521	-23.9	46	40	41	41	42	38
		950	6344	-.136	37			4.83	2994	-33.8	50	45	45	46	48	46
		1100	7345	-.182	42			5.59	3467	-45.3	53	49	49	50	53	53
36" x 30"	7.50	500	3580	-.038	16	914 x 762	0.70	2.54	1690	-9.4	37	27	30	29	27	15
		650	4654	-.063	25			3.30	2196	-15.8	42	34	36	36	36	28
		800	5728	-.096	32			4.06	2703	-23.9	46	40	41	41	43	38
		950	6802	-.136	37			4.83	3210	-33.8	50	45	45	46	48	46
		1100	7876	-.182	42			5.59	3717	-45.3	53	49	49	50	53	53

NOTE: See notes on page J1-113.

EG15, EGC15 Performance Data

IP/METRIC DATA: EG15, EGC15 (NO DAMPER)

IP Data						Metric Data											
Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	NC	Nom Duct	Duct Area	Neck Vel	Air Flow	Ps	Octave Band, dB					
in	ft²	FPM	CFM	"WG		mm	m²	m/s	L/s	Pa	2	3	4	5	6	7
34" x 34"	8.03	500	3839	-.038	16	864 x 864	0.75	2.54	1812	-9.4	37	27	30	29	27	15
		650	4990	-.063	25			3.30	2355	-15.8	42	35	36	36	36	28
		800	6142	-.096	32			4.06	2899	-23.9	47	40	41	42	43	38
		950	7294	-.136	38			4.83	3442	-33.8	50	45	46	46	49	47
		1100	8445	-.182	43			5.59	3986	-45.3	53	49	49	50	54	54
42" x 30"	8.75	500	4189	-.038	17	1067 x 762	0.81	2.54	1977	-9.4	37	28	30	29	28	16
		650	5446	-.063	25			3.30	2570	-15.8	43	35	37	37	36	28
		800	6703	-.096	32			4.06	3164	-23.9	47	41	42	42	43	39
		950	7960	-.136	38			4.83	3757	-33.8	51	45	46	47	49	47
		1100	9217	-.182	43			5.59	4350	-45.3	54	50	50	51	54	54
48" x 30"	10.00	500	4799	-.038	17	1219 x 762	0.93	2.54	2265	-9.4	38	28	31	30	28	16
		650	6238	-.063	26			3.30	2944	-15.8	43	36	37	37	37	29
		800	7678	-.096	33			4.06	3624	-23.9	48	41	42	43	44	39
		950	9118	-.136	39			4.83	4303	-33.8	51	46	47	47	50	47
		1100	10557	-.182	43			5.59	4983	-45.3	54	50	50	51	54	54
42" x 36"	10.50	500	5049	-.038	17	1067 x 914	0.98	2.54	2383	-9.4	38	29	31	30	28	17
		650	6563	-.063	26			3.30	3098	-15.8	43	36	37	37	37	29
		800	8078	-.096	33			4.06	3812	-23.9	48	41	43	43	44	39
		950	9593	-.136	39			4.83	4527	-33.8	51	46	47	47	50	48
		1100	11107	-.182	44			5.59	5242	-45.3	54	50	50	51	55	55
42" x 38"	11.08	500	5335	-.038	18	1067 x 965	1.03	2.54	2518	-9.4	38	29	31	30	29	17
		650	6936	-.063	26			3.30	3273	-15.8	44	36	38	37	37	29
		800	8536	-.096	33			4.06	4029	-23.9	48	42	43	43	44	39
		950	10137	-.136	39			4.83	4784	-33.8	52	46	47	48	50	48
		1100	11738	-.182	44			5.59	5540	-45.3	55	50	51	52	55	55
48" x 36"	12.00	400	4627	-.024	11	1219 x 914	1.11	2.03	2183	-6.0	34	23	26	25	21	-
		550	6362	-.045	21			2.79	3002	-11.3	40	32	34	33	32	22
		700	8096	-.074	29			3.56	3821	-18.3	45	38	40	40	40	33
		850	9831	-.109	36			4.32	4640	-27.0	50	44	45	45	47	43
		1000	11566	-.150	41			5.08	5459	-37.4	53	48	49	49	52	51
44" x 44"	13.44	400	5196	-.024	11	1118 x 1118	1.25	2.03	2452	-6.0	34	23	26	25	22	-
		550	7145	-.045	22			2.79	3372	-11.3	41	32	34	34	33	22
		700	9093	-.074	30			3.56	4291	-18.3	46	39	40	40	41	34
		850	11042	-.109	36			4.32	5211	-27.0	50	44	45	45	47	43
		1000	12990	-.150	41			5.08	6131	-37.4	53	49	49	50	52	51
46" x 46"	14.69	400	5688	-.024	11	1168 x 1168	1.37	2.03	2684	-6.0	35	24	27	26	22	-
		550	7821	-.045	22			2.79	3691	-11.3	41	32	35	34	33	22
		700	9953	-.074	30			3.56	4697	-18.3	46	39	41	41	41	34
		850	12086	-.109	36			4.32	5704	-27.0	50	44	45	46	47	44
		1000	14219	-.150	42			5.08	6711	-37.4	54	49	49	50	53	51
48" x 48"	16.00	400	6202	-.024	12	1219 x 1219	1.49	2.03	2927	-6.0	35	24	27	26	23	-
		550	8527	-.045	22			2.79	4024	-11.3	42	33	35	34	33	23
		700	10853	-.074	30			3.56	5122	-18.3	47	39	41	41	41	34
		850	13178	-.109	37			4.32	6219	-27.0	51	45	46	46	48	44
		1000	15504	-.150	42			5.08	7317	-37.4	54	49	50	50	53	52

NOTES: NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re 10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. See Krueger's selection program for performance data not shown, including octave band data.

EG5, EG10, EG15 Suggested Specification & Configuration

1. **SERIES: (XXXX)**
   EG5 - 1/2"x1/2"x1/2" Core
   EG10 - 1"x1"x1" Core
   EG15 - 1/2"x1/2"x1" Core

2. **WIDTH: (XX) ***
   4" - 48" in 2" Increments

3. **HEIGHT: (XX) ***
   4" - 48" in 2" Increments

4. **FRAME STYLE: (XXX)**
   F23 - Lay-in T-Bar (Core Only)
   FTB - Channel Frame for Lay-in

5. **PANEL: (XX)x(XX) ****
   12"x12"
   12"x24"
   12"x48"
   24"x24"
   24"x48"

6. **FINISH: (XX)**
   01 - Mill
   10 - Alumican
   35 - Black
   44 - British White

* *Choose only if Frame Style is FTB.*
** *Choose only if Frame Style is F23.*

EG5, EG10, EG15
The return grille shall be a Krueger model EG. This grille must have a free area of at least 90% for the following core styles: 1/2"x1/2"x1/2" (EG5), 1"x1"x1" (EG10), and 1/2"x1/2"x1" (EG15). The channel frame of the grille must be constructed of extruded aluminum with a thickness of 0.04" – 0.05" and provide a means for duct and or damper attachment (or no frame for core only). This frame must produce a border of 3/8" around all sides of the grille.

PERFORMANCE
The manufacturer shall provide published (printed or electronic) performance data for the diffuser. Performance data shall include 2 - 7 octave band sound power levels. The diffuser shall be tested in accordance to the data standards at the time of product introduction or ANSI/ASHRAE Standard 70.

FINISH
The paint finish shall be #44 British White and be an anodic acrylic paint, baked at 315°F for 30 minutes. The paint thickness shall be 0.8 – 1.0 mils, gloss at 60° per ASTM D523-89 of 50 – 85%, pencil hardness per ASTM D3363-92A of HB – H, crosshatch adhesion per ASTM D3359-83 of 4B – 5B, impact per ASTM D2794-93 of direct impact >100 in/lb and reverse impact >80 in/lb, salt spray per ASTM B117-9048 of 96 hours, humidity per ASTM D2247-92 of >500 hours and water soak per ASTM D870-92 of 250 hours.

SAMPLE CONFIGURATIONS: EG5 - F23 - 24x24 - 44 **&** EG10 - 10x10 - FTB - 44

EGC5, EGC10, EGC15 Suggested Specification & Configuration

EGC5, EGC10, EGC15
The return grille shall be a Krueger model EGC. This grille must have at least a 90% free area for the following core style: 1/2"x1/2"x1/2" (EGC5), 1"x1"x1" (EGC10), and 1/2"x1/2"x1" (EGC15). The frame of the grille must be constructed of extruded aluminum with a thickness of 0.04" – 0.05" and countersunk screw holes. This frame must also produce a border of 1 1/4" around all sides of the grille with mitered corners that are mechanically staked for rigidity.

OPTION (STEEL FRAME)
Steel frame shall be constructed of 22 gage roll formed steel to produce a 1 1/4" border around all sides of the grille with mitered corners that are assembled with full penetration resistance welds with a reinforcing patch for rigidity.

OPTION (FILTER FRAME)
The return grille shall be a Krueger model EGC5. This grille must have a free area of at least 90% for the 1/2"x1/2"x1/2" core. The frame of the grille must be constructed of extruded aluminum with a thickness of 0.04" – 0.05" and countersunk screw holes. This frame must also produce a border of 1 1/4" around all sides of the grille with mitered corners that are mechanically staked for rigidity. The grille shall have a filter frame to fit standard 1" filters.

PERFORMANCE
The manufacturer shall provide published (printed or electronic) performance data for the diffuser. Performance data shall include 2 - 7 octave band sound power levels. The diffuser shall be tested in accordance to the data standards at the time of product introduction or ANSI/ASHRAE Standard 70.

FINISH
The paint finish shall be #44 British White applied by an anodic electrocoating process. This process shall include washing, rinsing, applying iron phosphate, sealing and rinsing again. While hanging from an anodic hook, the product will then be dipped into a high performance electrocoating dip. Then the product shall be forced air dried and baked to a peak temperature of 350°F until cured. The overall process shall result to the following film properties: a film thickness of 0.8 – 1.0 mils, gloss at 60° per ASTM D523-89 of 50 – 85%, pencil hardness per ASTM D3363-92A of HB – H, crosshatch adhesion per ASTM D3359-83 of 4B – 5B, impact per ASTM D2794-93 of direct impact >100 in/lb and reverse impact >80 in/lb, salt spray per ASTM B117-9048 of 96 hours, humidity per ASTM D2247-92 of >500 hours and water soak per ASTM D870-92 of 250 hours.

1. SERIES: (XXXXX)
EGC5 - 1/2"x1/2"x1/2" Aluminum Core, Egg-Crate Return Grille
EGC10 - 1"x1"x1" Aluminum Core, Egg-Crate Return Grille
EGC15 - 1/2"x1/2"x1" Aluminum Core, Egg-Crate Return Grille

2. WIDTH: (XX) *
4" - 96" in 1" Increments

3. HEIGHT: (XX) *
4" - 96" in 1" Increments

4. FRAME STYLE: (XXX)
F22 - Surface Mount, Aluminum
F23 - Lay-in T-Bar, Aluminum ***
F98 - Narrow-T, 24"x24" Only, Aluminum **
S22 - Surface Mount, Steel Frame
S23 - Lay-in T-Bar, Steel Frame ***

5. PANEL: (XX)x(XX) ‡
NONE
12"x12"
12"x24"
24"x24"
24"x48"
48"x48"

6. FASTENING METHOD: (XX)
00 - No Screw Holes
01 - Standard Screw Holes
03 - Knurled Knob **
08 - 1/4 Turn Fasteners **

7. DAMPER: (XX)
00 - No Damper
01 - Steel Opposed Blade Damper (Model OBD)
15 - Aluminum Opposed Blade Damper (Model 5OBD)

8. ACCESSORIES: (XX) (XX)
00 - No Damper
01 - Plaster Frame
04 - 1" Filter Frame **
05 - 2" Filter Frame **

9. FINISH: (XX)
01 - Mill
10 - Alumican
35 - Black
44 - British White

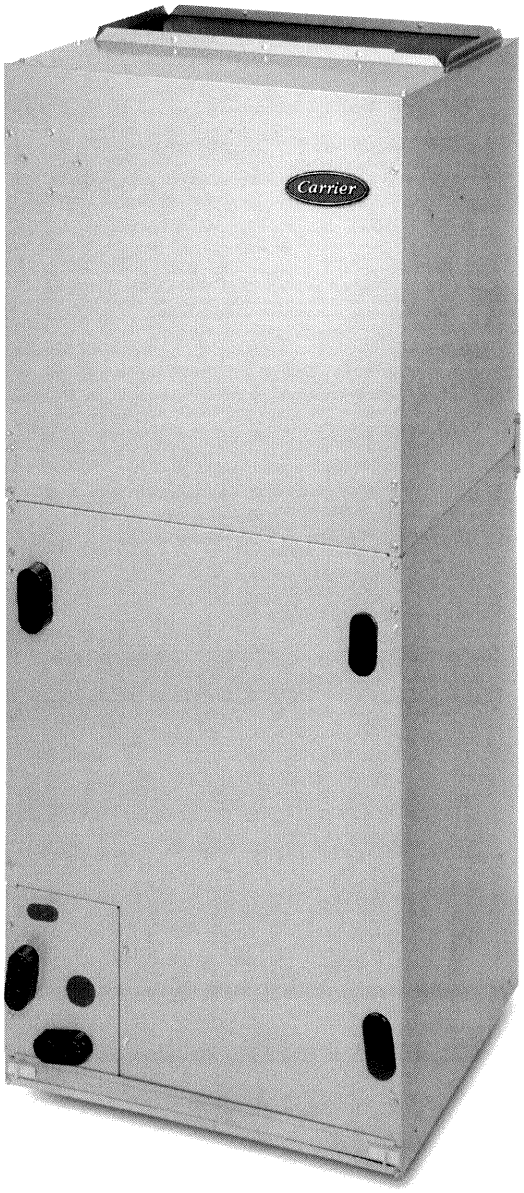
* *Minimum width for EGC5 is 6".*
Minimum width and height for EGC15 is 6".
** *Minimum size is 8"x8" and maximum size is 48"x36". (Only available on EGC5.)*
*** *Minimum of 4" difference is required between neck size and panel size.*
‡ *Frame S23 only available with panel sizes 24"x24" and 24"x48".*

SAMPLE CONFIGURATION: EGC5 - 12x14 - S22 - NONE - 01 - 01 - 00 - 00 - 44

FV4B
Performance™ Series Fan Coil
Sizes 002 Thru 006

Carrier®
Turn to the Experts.

Product Data



PREMIUM ENVIRONMENTALLY SOUND FAN COIL

The FV4B is the premium air handler combining the proven technology of Carrier fan coils with environmentally sound Puron© refrigerant. The FV4B achieves an operational advantage when the ECM (Electronically Commutated Motor) is combined with a Carrier Performance™ heat pump with Puron© refrigerant.

With attention to quiet, efficient, and comfortable operation, Carrier has developed a new benchmark for superior indoor comfort and control. ArmorCoat™ provides a tin plating of the indoor coil's copper hairpins. This creates a barrier between the corrosion-causing elements and the coil.

Carrier's heat pump and air conditioning systems now feature Puron© refrigerant (R-410A), the chlorine-free refrigerant that is the future for the residential heating and cooling industry. The FV4B using Puron© refrigerant maximizes performance for environmentally sound systems. In addition to environmental safety, these systems are 30 to 40% more efficient than standard heating and cooling systems, thereby combining excellence in efficiency and environmental safety.

The FV4B provides these benefits due to Carrier's command of ECM technology. These motors are extremely efficient at all speeds, and enable the FV4B to operate at the correct speed to deliver airflow precisely, ensuring proper performance across a wide range of duct static pressures. This adaptive efficiency also makes installation quality easier to achieve for today's demanding homeowner.

Carrier's command of ECM technology may be most evident in the comfort advantages that ECM can deliver. Operation set up steps on the Easy Select™ Board provide the installing technician with alternatives to maximize comfort and efficiency. For true indoor comfort, the homeowner can achieve command of both temperature and humidity in cooling and heating modes.

Another feature which sets the FV4B apart is the factory-installed TXV, which enhances efficiency and provides compressor protecting operation at all recommended conditions. Grooved copper tubing, louvered aluminum fins, and the large face areas of the FV4B refrigerant coils also provide superior efficiency, for high SEER and HSPF performance. Carrier leads the way in condensate control, a hallmark of these multipoise fan coils. All of these featured components are protected within a rugged, prepainted metal cabinet lined with super thick, high density insulation. For neat, high quality installations the unit exterior features sweat refrigerant connections for simple leak free performance, and multiple electrical entry for both high and low voltage service.

For superior technology and unmatched comfort, the environmentally sound and efficient FV4B can't be beat.

FEATURES

Environmentally Sound Refrigerant Technology

- Puron®, chlorine-free non-ozone depleting refrigerant
- Thermostatic Expansion Valve (TXV) designed to maximize performance with Puron® refrigerant

Energy Efficient Operation

- Electronically Commutating Motor (ECM) operates efficiently at all speeds
- Maximizes efficiency of heating and cooling systems
- Ultra low power consumption during fan only operation

Indoor Weather Control

- Warm, comfortable heating air temperatures
- Unmatched humidity control, especially with Carrier's Thermidistat™ Control

Airflow and Sound Technology

- Diffuser air discharge section for high airflow efficiency and quiet, smooth operation
- High duct static capability
- Unique cabinet design that meets new stringent regulations for air leakage. Meets requirements of a 2% cabinet leakage rate when tested at 1.0 inches of static pressure

Condensate Control and Disposal Technology

- Minimal standing water - less microbial growth for improved IAQ and reduced condensate line clogging and related condensate leakage
- Condensate fittings relocated away from turbulent airflow patterns at the blower entrance for improved condensate control performance
- Overflow feature for slope coil units allows condensate to exit the unit without damage to product under clogged primary and secondary line conditions
- Tested for condensate disposal at conditions much more severe than those required by ARI
- Primary and secondary drain connections to comply with HUD
- All pans constructed of an injection molded glass-filled polycarbonate engineered resin material, with brass drain connections.
- High density, super thick cabinetry insulation with vapor barrier
- Pre-painted galvanized sheet metal cabinet

Heat Transfer Technology

- Grooved copper tubing
- Lanced sine wave aluminum fins
- Discreet refined counterflow refrigerant circuitry
- Bi-flow hard shut-off TXV metering device
- ArmorCoat™ coil protection available

Quality Assisting, Ease of Installation and Service Features

- All units multipoise
- Provision made for suspending from roof or ceiling joints
- Modular cabinet on 003 thru 006 units
- Sweat connections for leak free service
- Multiple electrical entry for application flexibility (high and low voltage)
- Low voltage terminal strip, to safely hold connections within the cabinet
- Inspection plate on A-coil models for quick coil cleanliness inspection
- Cabinet construction features innovations designed to prevent cabinet sweating

Controls and Electrical Features

- Easy Select™ Board to maximize comfort, efficiency, and safe heater airflow operation
- Easy plug connection provided for quick installation of accessory heater packages
- 40VA 208/230v transformer
- Replaceable 5-amp blade-type auto fuse protects against transformer secondary short

Filter Features

- Factory supplied filter
- Cleanable polyester filter media
- Filter "springs" out for easy access - no tools required
- Newly improved filter rack area - filter door insulation added for an improved air seal

MODEL NUMBER NOMENCLATURE

1	2	3	4	5	6	7–9	10–12
F	**V**	**4**	**B**	**N**	**B**	**003**	**000**
Product	Type	Position	Series	Electrical	Cabinet/ Insulation	Capacity	Heating Size
F = Fan Coil	V = Performance™ Puron® refrigerant	4 = Multipoise	B	N = 208/230v, 1ph–60Hz	B = Modular F = Single piece	002 = 18–36,000 003 = 24–42,000 005 = 30–48,000 006 = 30–60,000	T00 = Armor-Coat™ 000 = No Heat 005 = 5 kW 075 = 7.5 kW 008 = 8 kW 010 = 10 kW 011 = 11 kW 015 = 15 kW

FV4B

Puron™ the environmentally sound refrigerant

ARI PERFORMANCE CERTIFIED ARI Standard 210/240 Unitary Air Conditioners

ARI PERFORMANCE CERTIFIED ARI Standard 210/240 Unitary Heat Pumps

c UL us

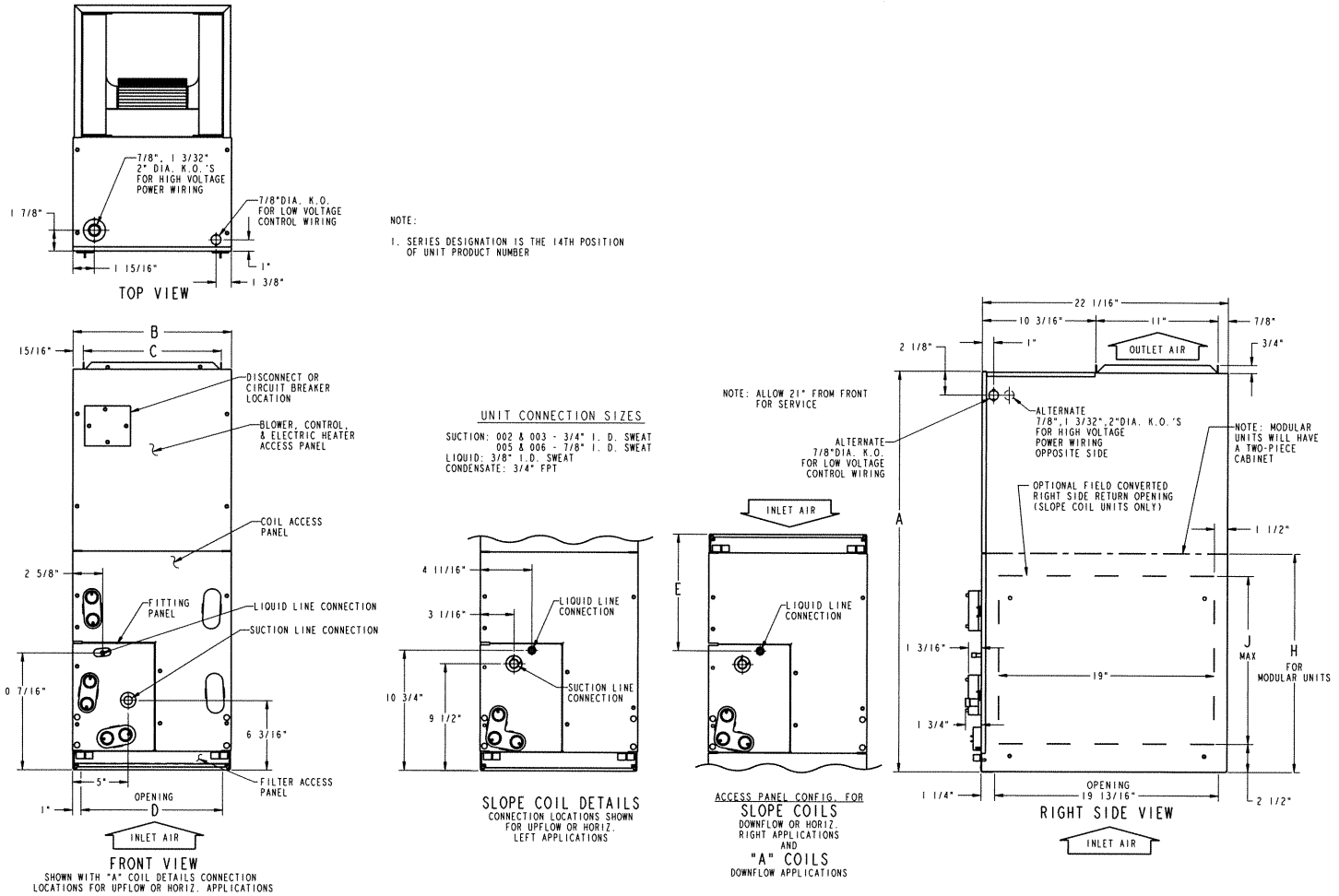
ISO 9001:2000 QMI REGISTERED

CERTIFICATION APPLIES ONLY WHEN THE COMPLETE SYSTEM IS LISTED WITH ARI

ArmorCoat™

SPECIFICATIONS

MODEL FV4B	002	003	005	006
COIL				
Refrigerant Metering Device	Puron® Refrigerant (R–410A)			
TXV Size	2 Ton	3 Ton	4 Ton	
Rows/Fins Per In.	3 / 14.5			
Face Area (Sq Ft)	3.46		5.93	7.42
Configuration	A	Slope	A	
BLOWER & MOTOR				
Air Discharge	Upflow, Downflow, Horizontal			
CFM (Nominal Clg/Htg)	525 / 470 700 / 630 875 / 785 1050 / 945	700 / 630 875 / 785 1050 / 945 1225 / 1100	875 / 785 1050 / 945 1225 / 1100 1400 / 1260	1050 / 945 1225 / 1100 1400 / 1260 1750 / 1575
Motor HP (ECM)	1/2			3/4
FILTER CLEANABLE				
21–1/2" / 546 mm X	16–3/8" / 417 mm	19–7/8" / 505 mm		23–5/16" / 585 mm
CABINET CONFIGURATION OPTIONS				
	1 Piece	1 Piece or Modular		Modular

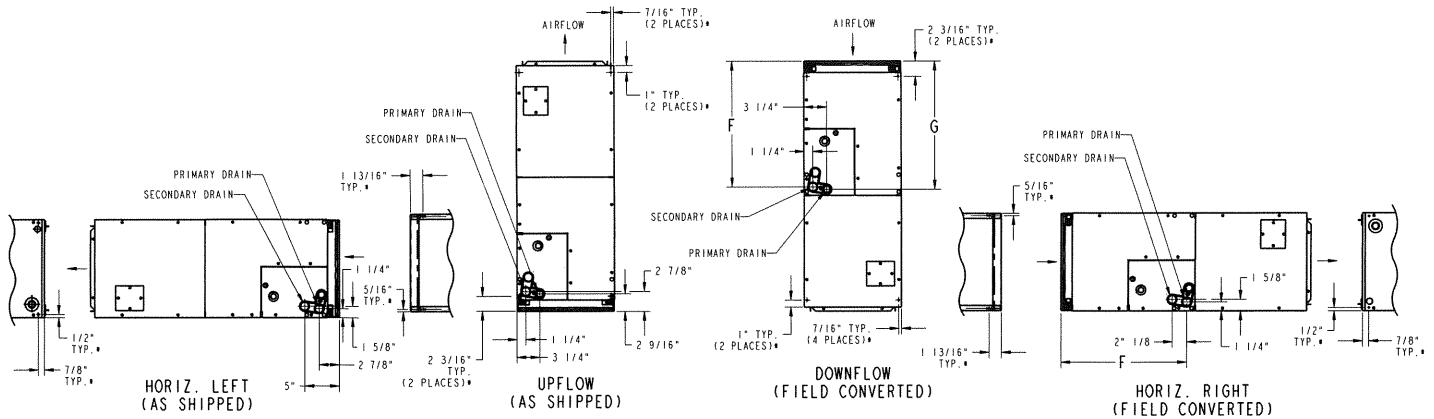


DIMENSIONS

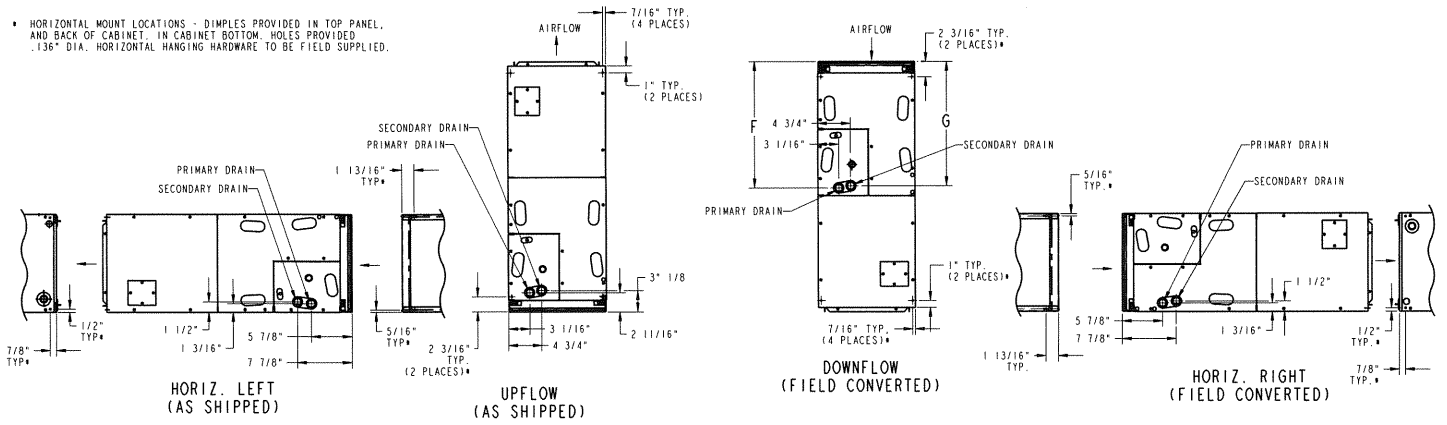
UNIT SIZE	A		B		C		D		E		H		J	
	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
FV4BNB003	53–7/16	1357	21–1/8	537	19–1/4	489	19–1/8	486	19–3/16	487	28–5/16	735	19	483
FV4BNB005	53–7/16	1357	21–1/8	537	19–1/4	489	19–1/8	486	19–3/16	487	28–5/16	735	—	—
FV4BNB006	59–3/16	1503	24–11/16	627	22–3/4	578	22–11/16	576	25–1/4	642	34–1/16	865	—	—
FV4BNF002	42–11/16	1084	17–5/8	448	15–3/4	400	15–5/8	397	10–3/4	273	—	—	—	—
FV4BNF003	53–7/16	1357	21–1/8	537	19–1/4	489	19–1/8	486	19–3/16	487	—	—	19	483
FV4BNF005	53–7/16	1357	21–1/8	537	19–1/4	489	19–1/8	486	19–1/2	495	—	—	—	—

NOTES:
1. CONDENSATE PAN DRAIN CAPS NOT SHOWN FOR CLARITY.

SLOPE COIL



* HORIZONTAL MOUNT LOCATIONS - DIMPLES PROVIDED IN TOP PANEL, AND BACK OF CABINET. IN CABINET BOTTOM, HOLES PROVIDED .136" DIA. HORIZONTAL HANGING HARDWARE TO BE FIELD SUPPLIED.



A-COIL

DIMENSIONS

UNIT SIZE	F		G		COIL TYPE	SHIPPING WEIGHT	
	in	mm	in	mm		lb	kg
FV4BNB003	26-15/16	684	27-1/2	699	SLOPE	150	68
FV4BNB005	26-15/16	684	27-1/2	699	A	172	78
FV4BNB006	32-15/16	837	32-5/8	829	A	207	94
FV4BNF002	18-9/16	471	18-1/4	464	A	135	61
FV4BNF003	26-15/16	684	27-1/2	699	SLOPE	150	68
FV4BNF005	27-1/4	692	26-15/16	684	A	172	78

PERFORMANCE DATA

FV4V ADVANCED FAN COIL AIRFLOW DELIVERY CHART (CFM)

UNIT SIZE	OUTDOOR UNIT CAPACITY*	OPERATING MODE—COOLING						FAN ONLY Lo/Med/Hi
		Single-Speed Application		Two-Speed Application				
				High Speed		Low Speed		
		Nominal A/C Cooling	A/C Cooling De-humidify	Nominal A/C Cooling	A/C Cooling De-humidify	Nominal A/C Cooling	A/C Cooling De-humidify	
002	018	525	420	—	—	—	—	350/350/525
	024	700	560	735	590	440	350	350/440/700
	030	875	700	—	—	—	—	440/550/875
	036	1050	840	1100	880	660	530	525/660/1050
003	024	700	560	735	590	440	415	415/440/700
	030	875	700	—	—	—	—	440/550/875
	036	1050	840	1100	880	660	530	525/660/1050
	042	1225	980	—	—	—	—	610/770/1225
005	030	875	700	—	—	—	—	440/550/875
	036	1050	840	1100	880	660	530	525/660/1050
	042	1225	980	—	—	—	—	610/770/1225
	048	1400	1120	1470	1175	880	705	700/880/1400
006	036	1050	840	1100	880	660	530	525/660/1050
	042	1225	980	—	—	—	—	610/770/1225
	048	1400	1120	1470	1175	880	705	700/880/1400
	060	1750	1400	1835	1470	1100	880	875/1100/1750

*Consult ARI ratings before matching outdoor unit with FV4B fan coil.

NOTES:

1. The above airflows result with the AC/HP CFM ADJUST select jumper set on NOM.
2. Airflow can be adjusted +15% or −10% by selecting HI or LO respectively for all modes except fan only.
3. Dry coil at 230 volts and with 10−kW heater and filter installed.
4. Airflows shown are at standard air conditions. (0.075 lb/ft^3 at 29.92 in−Hg).

FV4B ADVANCED FAN COIL AIRFLOW DELVERY CHART (CFM)

UNIT SIZE	OUTDOOR UNIT CAPACITY*	OPERATING MODE—HEAT PUMP ONLY HEATING						FAN ONLY Lo/Med/Hi
		Single-Speed Application		Two-Speed Application				
				High Speed		Low Speed		
		Heat Pump Comfort	Heat Pump Efficiency	Heat Pump Comfort	Heat Pump Efficiency	Heat Pump Comfort	Heat Pump Efficiency	
002	018	470	525	—	—	—	—	350/350/470
	024	630	700	660	735	395	440	350/395/630
	030	785	875	—	—	—	—	440/495/785
	036	945	1050	990	1100	595	660	525/595/945
003	024	630	700	660	735	415	440	415/415/630
	030	785	875	—	—	—	—	440/495/785
	036	945	1050	990	1100	595	660	525/595/945
	042	1100	1225	—	—	—	—	610/695/1100
005	030	785	875	—	—	—	—	440/495/785
	036	945	1050	990	1100	595	660	525/595/945
	042	1100	1225	—	—	—	—	610/695/1100
	048	1260	1400	1320	1470	795	880	700/795/1260
006	036	945	1050	990	1100	595	660	540/595/945
	042	1100	1225	—	—	—	—	610/695/1100
	048	1260	1400	1325	1470	795	880	700/795/1260
	060	1575	1750	1655	1835	990	1100	875/990/1575

* Consult ARI ratings before matching outdoor unit with FV4B fan coil.

NOTES:

1. The above airflows result with the AC/HP CFM ADJUST select jumper set on NOM.
2. Airflow can be adjusted +15% or −10% by selecting HI or LO respectively for all modes except fan only.
3. Dry coil at 230 volts and with 10−kW heater and filter installed.
4. Airflows shown are at standard air conditions. (0.075 lb/ft^3 at 29.92 in−Hg).

PERFORMANCE DATA (cont)

AIRFLOW DELIVERY CHART (CFM) — ELECTRIC HEATING MODES

UNIT SIZE OUTDOOR UNIT CAPACITY BTUH		ELECTRIC HEATER kW RANGE											
		0–5			0–10			0–15			0–20		
		Lo	Nom	Hi	Lo	Nom	Hi	Lo	Nom	Hi	Lo	Nom	Hi
002	18,000	625	625	625	675	675	675	—	—	—	—	—	—
	24,000	650	725	835	—	725	835	875	875	875	—	—	—
	30,000	815	905	1040	—	905	1040	900	900	1040	1100	1100	1100
	36,000	980	1085	1250	980	1085	1250	980	1085	1250	1100	1100	1250
003	24,000	675	725	835	875	875	875	—	—	—	—	—	—
	30,000	815	905	1040	875	905	1040	1100	1100	1100	—	—	—
	36,000	980	1085	1250	980	1085	1250	1100	1100	1250	1225	1225	1250
	42,000	1140	1270	1460	1140	1270	1460	1140	1270	1460	1225	1270	1460
005	30,000	975	975	1040	1100	1100	1100	—	—	—	—	—	—
	36,000	980	1085	1250	1100	1100	1250	1250	1250	1250	—	—	—
	42,000	1140	1270	1460	1140	1270	1460	1250	1270	1460	—	—	—
	48,000	1305	1450	1665	1305	1450	1665	1305	1450	1665	1500	1500	1665
006	36,000	1100	1100	1250	1350	1350	1350	—	—	—	—	—	—
	42,000	1140	1270	1460	1350	1350	1460	1525	1525	1525	—	—	—
	48,000	1305	1450	1665	1350	1450	1665	1525	1525	1665	1750	1750	1750
	60,000	1630	1810	2085	1630	1810	2085	1630	1810	2085	1750	1810	2085

Where dash (—) appears indicates airflow not recommended for heater/system size.
NOTE: LO, NOM and HI refer to the AC/HP CFM ADJUST selection.

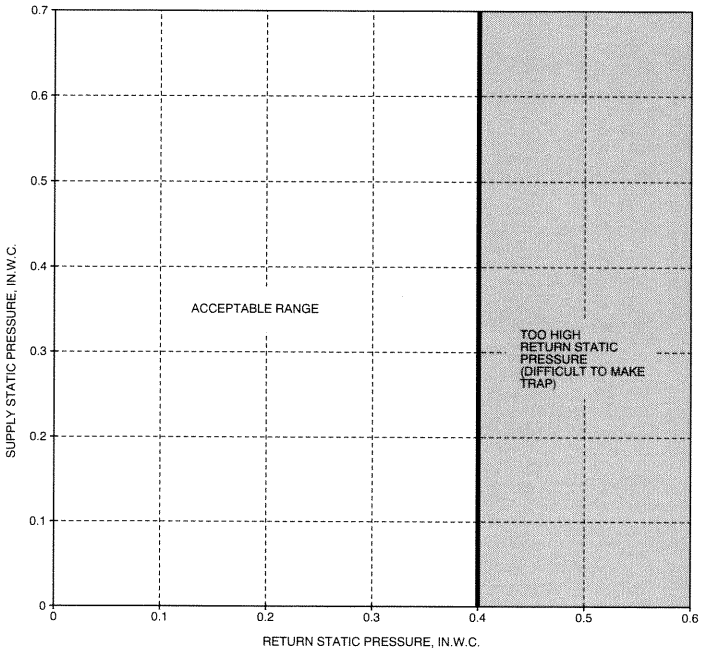
MINIMUM CFM FOR ELECTRIC HEATER APPLICATION

UNIT SIZE	HEAT PUMP UNIT SIZE	CFM				
		Heater Size kW				
		5	8, 9, 10	15	18, 20	24, 30
002	Heater Only	625	625	725	875	—
	018	625	625	—	—	—
	024	650	725	875	—	—
	030	800	875	875	1040	—
	036	970	970	970	1040	—
003	Heater Only	675	700	1050	1050	—
	024	675	875	—	—	—
	030	800	875	1100	—	—
	036	975	975	1100	1225	—
	042	1125	1125	1125	1225	—
005	Heater Only	675	700	1050	1050	1400
	030	800	875	1100	—	—
	036	975	975	1100	1225	—
	042	1125	1125	1125	1225	—
	048	1305	1305	1305	1305	1400
006	Heater Only	1050	1050	1050	1050	1750
	036	1100	1100	1350	1350	—
	042	1125	1125	1350	1350	—
	048	1300	1300	1350	1465	1750
	060	1625	1625	1625	1750	1750

NOTES:
1. Heater Only — Air Conditioner with electric heater application.
2. These airflows are minimum acceptable airflows as UL listed.
3. Actual airflow delivered will be per the airflow delivery chart for Electric Heating Modes.

FV4B

PERFORMANCE DATA (cont)



A02296

ACCEPTABLE DUCT CONDITIONS

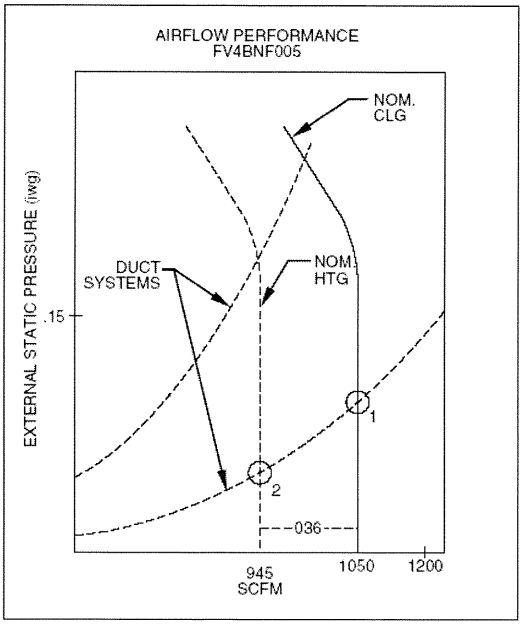
For satisfactory operation (specifically making dry secondary trap), subject fan coils must be installed with duct systems which fall within the "Acceptable Range" illustrated above.

The airflow performance charts for the FV4B fan coil depict nominal airflow delivery for heating and cooling mode operation versus duct system static pressure drop. Cooling mode operation is shown as solid vertical lines for all 4 system size selections. Heating mode operation for the 4 system size selections are shown as dashed vertical lines.

The dotted curved lines are static pressure drop characteristics for several fixed-duct systems. These lines can be used to predict the system static pressure drop at any airflow given the actual drop at 1 known point.

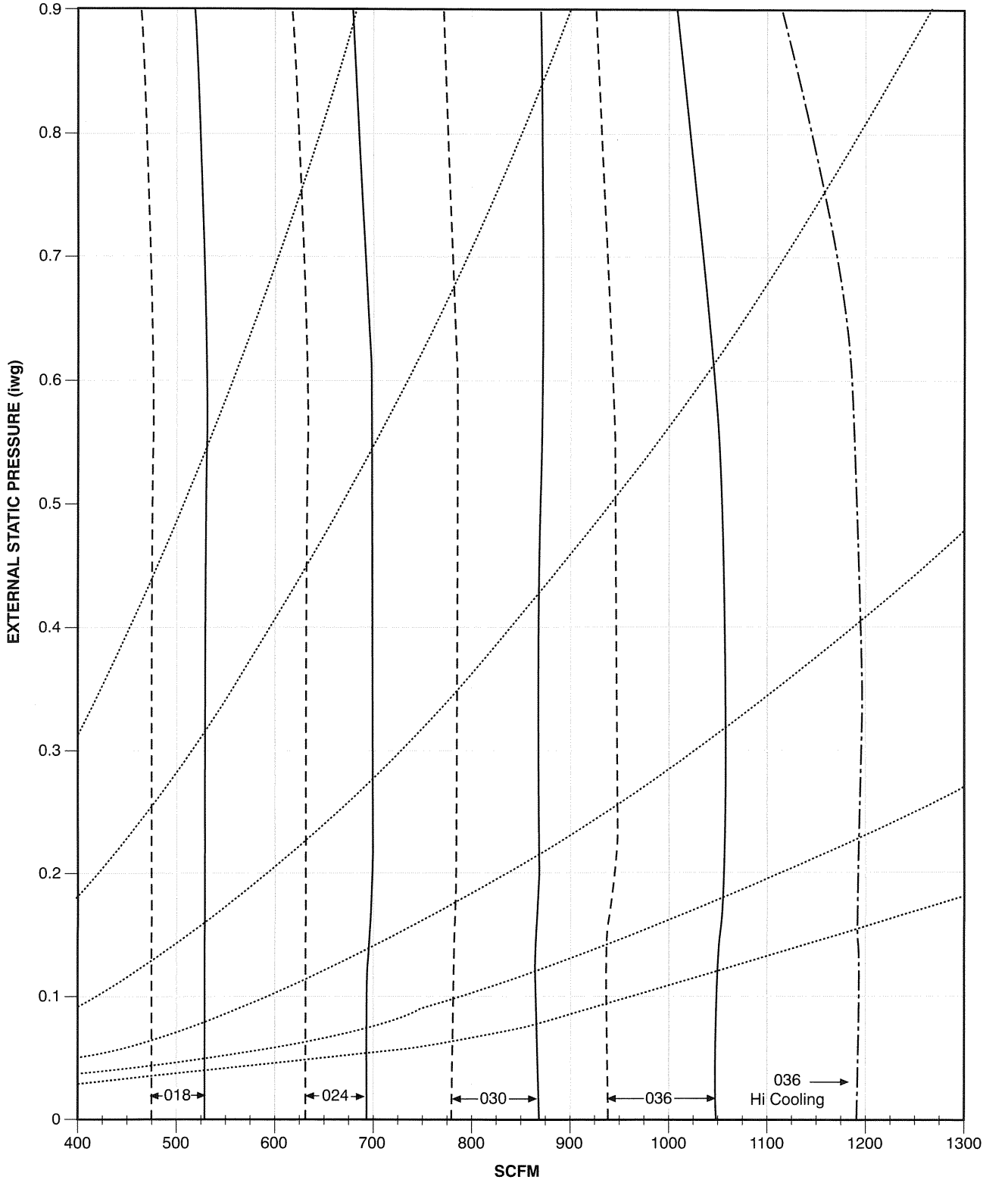
For example, a duct system is designed for 0.15 in. water gauge (iwg) drop at 1200 CFM. The FV4BNF005 operating at nominal cooling airflow would deliver 1050 CFM with a duct system drop of 0.11 iwg. (See point 1.) On the same duct system, the FV4BNF005 operating at nominal heating airflow would deliver 945 CFM with a duct system drop of 0.09 iwg. (See point 2.)

This example is but one of many possible duct system designs. The FV4BNF005 will deliver the above airflows against much higher static pressures.



A02341

AIRFLOW PERFORMANCE



A01339

FV4BNF002

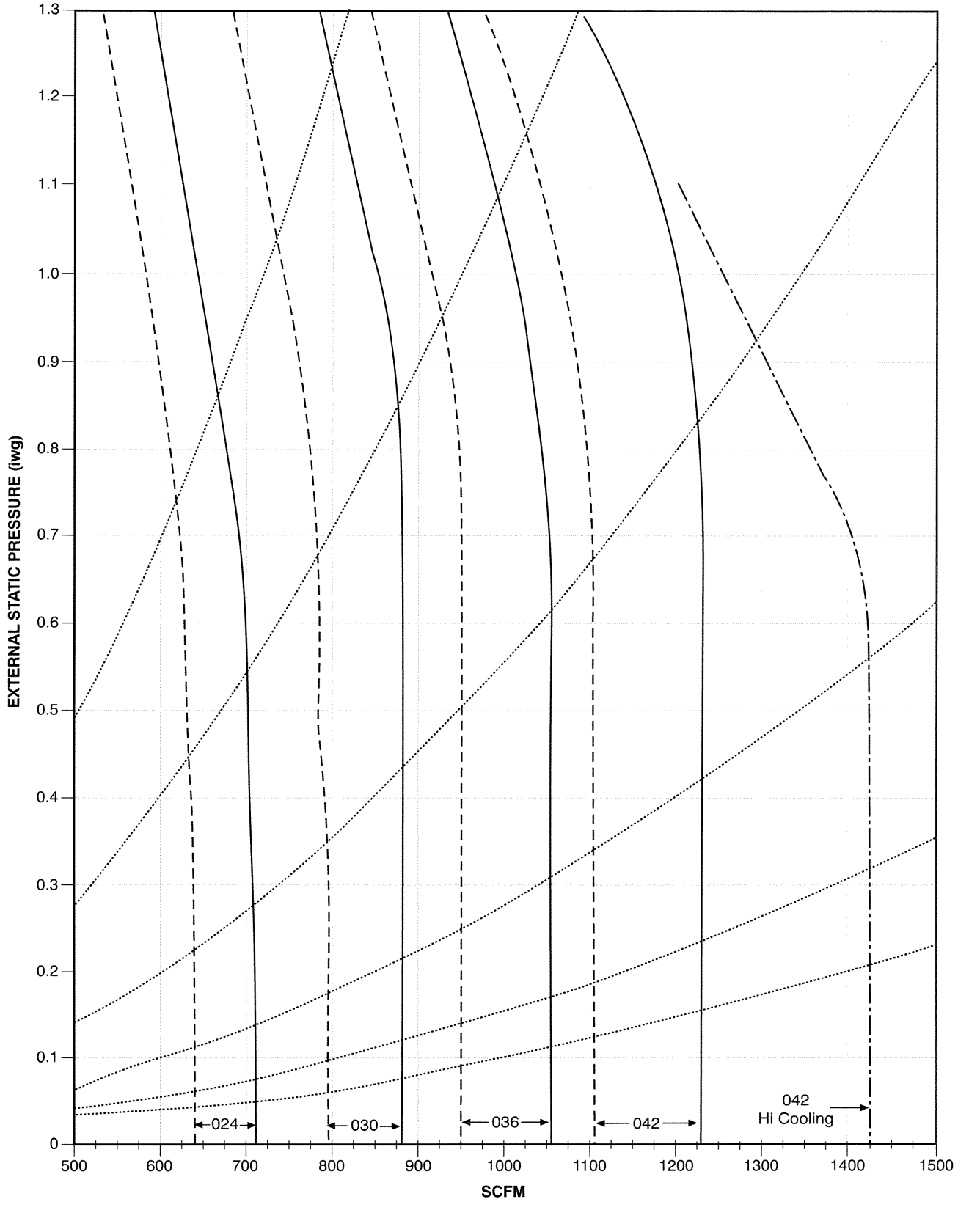
——— Nominal Cooling and Heat Pump Efficiency airflow for each size selection. Airflow can be adjusted +15% to −10%.

– – – – Nominal Heat Pump Comfort airflow for each size selection. Airflow can be adjusted +15% to −10%.

· – · – Maximum cooling airflow for largest size selection. Adjusted +15% from nominal.

· · · · · · Fixed Duct Systems (See description under Acceptable Duct Conditions.)

AIRFLOW PERFORMANCE



A01336

FV4BN(B,F)003

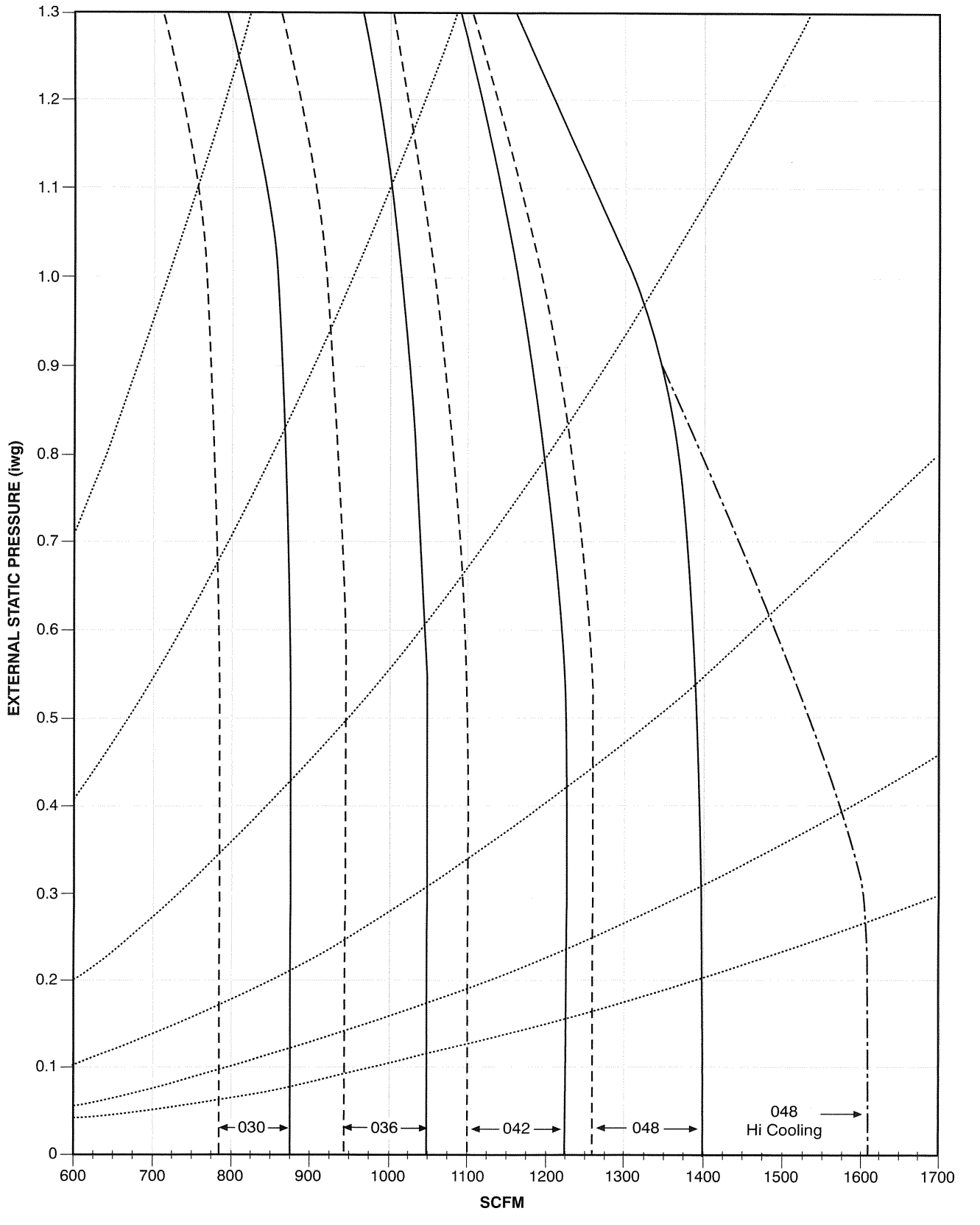
——— Nominal Cooling and Heat Pump Efficiency airflow for each size selection. Airflow can be adjusted +15% to −10%.

– – – – Nominal Heat Pump Comfort airflow for each size selection. Airflow can be adjusted +15% to −10%.

· – · – Maximum cooling airflow for largest size selection. Adjusted +15% from nominal.

· · · · · · Fixed Duct Systems (See description under Acceptable Duct Conditions.)

AIRFLOW PERFORMANCE



A01337

FV4BN(B,F)005

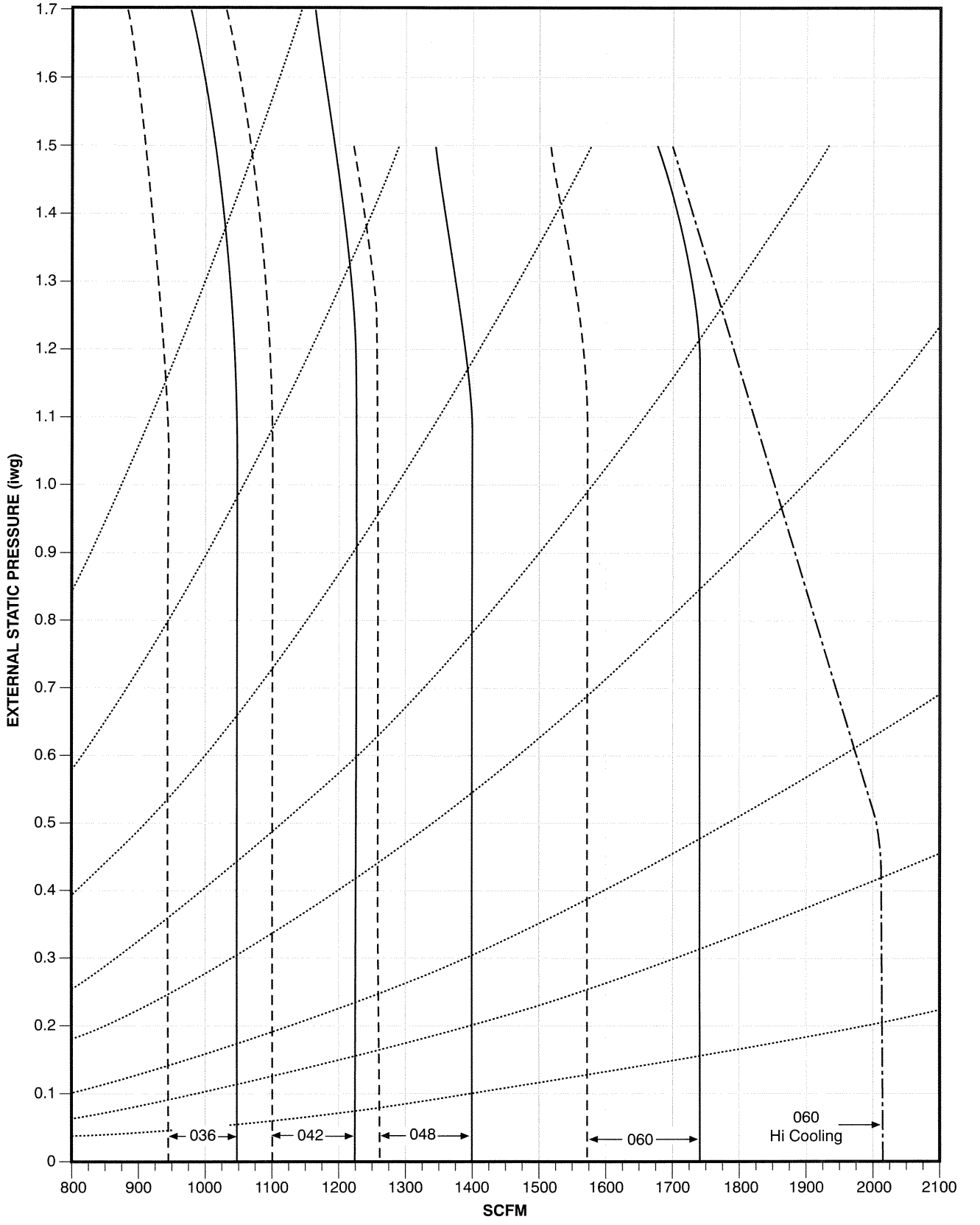
——— Nominal Cooling and Heat Pump Efficiency airflow for each size selection. Airflow can be adjusted +15% to −10%.

– – – – Nominal Heat Pump Comfort airflow for each size selection. Airflow can be adjusted +15% to −10%.

· – · – Maximum cooling airflow for largest size selection. Adjusted +15% from nominal.

· · · · · · Fixed Duct Systems (See description under Acceptable Duct Conditions.)

AIRFLOW PERFORMANCE



A01338

——— Nominal Cooling and Heat Pump Efficiency airflow for each size selection. Airflow can be adjusted +15% to −10%.

– – – – Nominal Heat Pump Comfort airflow for each size selection. Airflow can be adjusted +15% to −10%.

· – · – Maximum cooling airflow for largest size selection. Adjusted +15% from nominal.

· · · · · · Fixed Duct Systems (See description under Acceptable Duct Conditions.)

FV4BNB006
PERFORMANCE DATA (cont)

COOLING CAPACITIES (MBtuh)

UNIT SIZE	EVAP COIL AIR Cfm BF	SATURATED TEMPERATURE LEAVING EVAPORATOR (°F / °C)														
		35 / 2			40 / 4			45 / 7			50 / 10			55 /13		
		Evaporator Air — Entering Wet-Bulb Temperature														
		72°F 22°C	67°F 19°C	62°F 17°C	72°F 22°C	67°F 19°C	62°F 17°C	72°F 22°C	67°F 19°C	62°F 17°C	72°F 22°C	67°F 19°C	62°F 17°C	72°F 22°C	67°F 19°C	62°F 17°C
002	500	40	32	26	36	28	22	32	24	18	27	19	14	21	13	11
	0.04	18	18	19	16	16	17	14	14	15	12	12	13	10	10	11
	650	50	40	32	45	36	27	39	30	22	33	24	18	26	17	14
	0.07	21	22	23	19	20	21	16	17	18	14	15	16	12	13	14
	875	58	49	38	53	42	32	46	35	27	39	28	22	31	20	18
	0.10	24	26	28	22	24	25	19	21	22	17	19	19	15	16	18
	1000	62	51	41	56	45	35	50	38	29	42	30	24	33	22	20
	0.11	26	28	31	23	26	28	21	23	25	18	20	21	16	18	20
	1250	67	55	45	61	49	39	54	42	33	46	34	28	37	25	24
	0.13	29	33	36	27	30	33	24	27	30	22	24	26	19	21	24
003	800	59	48	38	53	42	32	46	35	24	39	27	20	30	18	16
	0.20	28	29	31	25	27	28	22	23	24	19	20	20	16	16	16
	1000	68	56	45	61	49	37	54	41	29	45	32	25	35	22	20
	0.22	32	34	37	29	31	33	26	28	28	23	24	25	19	20	20
	1200	75	62	49	68	54	42	60	45	34	50	36	29	40	25	23
	0.25	35	39	42	32	36	38	29	32	33	26	28	29	22	23	23
	1400	80	67	54	73	59	46	64	49	38	54	39	32	43	28	27
	0.27	38	43	47	35	39	43	32	36	37	28	32	32	24	26	27
005	750	61	49	39	55	43	33	48	37	27	41	29	20	33	21	17
	0.04	27	27	28	24	25	25	21	22	22	18	18	18	15	15	15
	950	74	60	48	67	53	40	59	45	33	50	35	25	39	24	21
	0.06	32	34	35	29	30	31	25	26	27	22	23	23	18	18	19
	1150	89	72	57	79	63	48	69	52	38	58	41	31	44	29	25
	0.07	37	39	41	33	35	36	29	31	32	25	26	27	20	22	22
	1500	103	84	66	92	73	56	81	61	46	67	48	39	52	34	31
	0.10	43	46	49	38	41	44	34	37	39	29	32	33	25	27	27
	1700	110	89	71	99	78	60	86	65	49	72	51	42	56	37	35
	0.11	45	50	53	41	45	48	36	39	42	31	34	36	27	29	30
006	1050	77	62	50	69	55	43	61	47	35	52	38	27	41	27	22
	0.01	34	36	37	31	32	33	27	28	29	23	25	24	20	20	20
	1300	100	82	65	90	71	55	79	60	45	66	47	37	49	32	27
	0.02	42	45	47	37	40	42	33	35	37	29	31	32	23	25	24
	1750	117	96	77	106	84	65	93	71	53	78	56	46	60	40	34
	0.04	48	53	57	44	48	52	39	43	46	34	38	39	29	31	31
	2050	126	103	83	114	91	71	99	76	59	84	60	50	65	44	39
	0.05	52	58	63	48	53	57	43	47	51	37	42	43	33	35	35
	2300	132	108	87	119	95	75	105	80	63	88	63	54	70	47	42
	0.06	55	62	68	50	57	61	45	51	54	40	45	46	35	39	38

BF – Bypass Factor

▒ – Sensible Heat Capacity (1000 Btuh)

□ – Gross Cooling Capacity (1000 Btuh)

NOTES:

1. Contact manufacturer for cooling capacities at conditions other than shown in table.
2. Formulas:
   Leaving db = entering db $-\frac{\text{sensible heat cap.}}{1.09 \times \text{CFM}}$
   Leaving wb = wb corresponding to enthalpy of air leaving coil (h_{lwb})
   $h_{lwb} = h_{ewb} - \frac{\text{total capacity (Btuh)}}{4.5 \times \text{CFM}}$
   where h_{ewb} = enthalpy of air entering coil. Direct interpolation is permissible. Do not extrapolate.
3. SHC is based on 80°F db temperature of air entering coil. Below 80°F db, subtract (Correction Factor x CFM) from SHC. Above 80°F db, add (Correction Factor x CFM) to SHC.
4. Bypass Factor = 0 indicates no psychometric solution. Use bypass factor of next lower EWB for approximation.

Interpolation is permissible.
Correction Factor = 1.09 x (1 – BF) x (db – 80)

SHC CORRECTION FACTOR

BYPASS FACTOR	ENTERING AIR DRY-BULB TEMPERATURE (°F)					
	79	78	77	76	75	Under 75
	81	82	83	84	85	Over 85
	Correction Factor					
0.10	.098	1.96	2.94	3.92	4.91	Use formula shown below
0.20	0.87	1.74	2.62	3.49	4.36	
0.30	0.76	1.53	2.29	3.05	3.82	

PERFORMANCE DATA (cont)

ESTIMATED SOUND POWER LEVEL (dBA)*

UNIT SIZE	CONDITIONS		OCTAVE BAND CENTER FREQUENCY						
	CFM	ESP	63	125	250	500	1000	2000	4000
FV–002	400	0.25	63.0	59.0	55.0	52.0	50.0	48.0	44.0
	600	0.25	64.7	60.7	56.7	53.7	51.7	49.7	45.7
	800	0.25	66.0	62.0	58.0	55.0	53.0	51.0	47.0
	1000	0.25	67.0	63.0	59.0	56.0	54.0	52.0	48.0
	1200	0.25	67.8	63.8	59.8	56.8	54.8	52.8	48.8
	1400	0.25	68.4	64.4	60.4	57.4	55.4	53.4	49.4
FV–003	400	0.25	63.0	59.0	55.0	52.0	50.0	48.0	44.0
	600	0.25	64.7	60.7	56.7	53.7	51.7	49.7	45.7
	800	0.25	66.0	62.0	58.0	55.0	53.0	51.0	47.0
	1000	0.25	67.0	63.0	59.0	56.0	54.0	52.0	48.0
	1200	0.25	67.8	63.8	59.8	56.8	54.8	52.8	48.8
	1400	0.25	68.4	64.4	60.4	57.4	55.4	53.4	49.4
	636	0.25	65.0	61.0	57.0	54.0	52.0	50.0	46.0
FV–005	400	0.25	63.0	59.0	55.0	52.0	50.0	48.0	44.0
	600	0.25	64.7	60.7	56.7	53.7	51.7	49.7	45.7
	800	0.25	66.0	62.0	58.0	55.0	53.0	51.0	47.0
	1000	0.25	67.0	63.0	59.0	56.0	54.0	52.0	48.0
	1200	0.25	67.8	63.8	59.8	56.8	54.8	52.8	48.8
	1400	0.25	68.4	64.4	60.4	57.4	55.4	53.4	49.4
	1600	0.25	69.0	65.0	61.0	58.0	56.0	54.0	50.0
FV–006	600	0.25	64.7	60.7	56.7	53.7	51.7	49.7	45.7
	800	0.25	66.0	62.0	58.0	55.0	53.0	51.0	47.0
	1000	0.25	67.0	63.0	59.0	56.0	54.0	52.0	48.0
	1200	0.25	67.8	63.8	59.8	56.8	54.8	52.8	48.8
	1400	0.25	68.4	64.4	60.4	57.4	55.4	53.4	49.4
	1600	0.25	69.0	65.0	61.0	58.0	56.0	54.0	50.0
	1800	0.25	69.5	65.5	61.5	58.5	56.5	54.5	50.5
	2000	0.25	70.0	66.0	62.0	59.0	57.0	55.0	51.0
	2150	0.25	70.3	66.3	62.3	59.3	57.3	55.3	51.3

* Estimated sound power levels have been derived using the method described in the 1987 ASHRAE Systems & Applications Handbook, chapter 52, p. 52.7.
CFM – Cubic Ft Per Minute
ESP – External Static Pressure
RPM – Revolutions Per Minute

AIRFLOW PERFORMANCE CORRECTION FACTORS

HEATER kW	ELEMENTS	STATIC PRESSURE CORRECTION (in. wc)	
		Sizes 002–005	Size 006
0	0	+.02	+.03
5	1	+.01	+.02
8, 10	2	0	0
9, 15	3	–.02	–.03
20	4	–.04	–.06
18, 24, 30	6	–.06	–.10

The FV4B airflow performance table was developed using fan coils with 10–kW electric heaters (2 elements) in the units. For fan coils with heaters made up of a different number of elements, the external available static at a given CFM from the table may be corrected by adding or subtracting pressure. Use table for this correction.

FACTORY-INSTALLED FILTER STATIC PRESSURE DROP (in. wc)

UNIT SIZE	CFM								
	400	600	800	1000	1200	1400	1600	1800	2000
002	0.020	0.044	0.048	0.072	0.100	—	—	—	—
003	—	0.020	0.035	0.051	0.070	0.092	—	—	—
005	—	—	0.035	0.051	0.070	0.092	0.120	—	—
006	—	—	—	0.038	0.053	0.070	0.086	0.105	0.133

PERFORMANCE DATA (cont)

AIR DELIVERY PERFORMANCE CORRECTION COMPONENT PRESSURE DROP (IN. WC) AT INDICATED AIRFLOW (DRY TO WET COIL)

UNIT SIZE	CFM										
	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
002	0.012	0.016	0.022	0.028	0.034	0.040	0.049	—	—	—	—
003	—	0.026	0.034	0.042	0.052	0.063	0.075	0.083	0.091	0.098	0.110
005	—	0.006	0.008	0.010	0.012	0.015	0.017	0.020	0.023	0.027	0.030
	CFM										
	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100
006	0.013	0.016	0.018	0.020	0.023	0.027	0.030	0.034	0.039	0.044	0.048

UNITS WITHOUT ELECTRICAL HEAT

UNIT SIZE	VOLTS–PHASE	FLA	MIN CKT AMPS	BRANCH CIRCUIT	
				Min Wire Size Awg*	Fuse/Ckt Bkr Amps
002	208/230–1	4.3	5.4	14	15
003	208/230–1	4.3	5.4	14	15
005	208/230–1	4.3	5.4	14	15
006	208/230–1	6.8	8.5	14	15

* Use copper wire only to connect unit. If other than uncoated (nonplated) 75°F ambient, copper wire (solid wire for 10 AWG and smaller, stranded wire for larger than 10 AWG) is used consult applicable tables of the National Electric Code (ANSI/NFPA 70).

NOTE: If branch circuit wire length exceeds 100 ft, consult NEC 210–19a to determine maximum wire length. Use 2% voltage drop.

FLA — Full Load Amps

ELECTRIC HEATERS

HEATER PART NO.	kW @ 240V	VOLTS/ PHASE	STAGES (kW OPERATING)	INTERNAL CIRCUIT PROTECTION	FAN COIL SIZE USED WITH	HEATING CAP. @ 230V‡	INTELLIGENT HEAT CAPABLE†† (kW OPERATING)
KFCEH0501N05	5	230/1	5	None	All	15,700	—
KFCEH0801N08	8	230/1	8	None	All	25,100	—
KFCEH0901N10	10	230/1	10	None	All	31,400	—
KFCEH3001F15	15	230/1	5, 15	Fuses**	All	47,100	5, 10, 15
KFCEH3201F20	20	230/1	5, 20	Fuses**	All	62,800	5, 10, 15, 20
KFCEH2901N09	9	230/1*	3, 9	None	All	28,300	3, 6, 9
KFCEH1601315	15	230/3	5, 15	None	All	47,100	—
KFCEH2001318	18	230/3	6, 12, 18	None	003, 005, 006	56,500	—
KFCEH3401F24	24	230/3†	8, 16, 24	Fuses	005, 006	78,500	8, 16, 24
KFCEH3501F30	30	230/3†	10, 20, 30	Fuses	005, 006	94,200	10, 20, 30
KFCEH2401C05	5	230/1	5	Ckt Bkr	All	15,700	—
KFCEH2501C08	8	230/1	8	Ckt Bkr	All	25,100	—
KFCEH2601C10	10	230/1	10	Ckt Bkr	All	31,400	—
KFCEH3101C15	15	230/1	5, 15	Ckt Bkr	All	47,100	5, 10, 15
KFCEH3301C20	20	230/1	5, 20	Ckt Bkr	All	62,800	5, 10, 15, 20

* Field convertible to 3 phase.

† These heaters field convertible to single phase.

‡ Blower motor heat not included.

** Single point wiring kit required for these heaters in Canada.

†† Heaters designated with kW Operating Values are Intelligent Heat capable when used with corporate 2–speed programmable thermostat (TSTATCCP2S01–B), Thermidistat™ Control (TSTATCCPRH01–B), or Comfort Zone II.

ELECTRIC HEATER INTERNAL PROTECTION

HEATER kW	PHASE	FUSES QTY/SIZE	CKT BKR QTY/SIZE*
5	1	—	1/60
8	1	—	1/60
9	1/3	—	—
10	1	—	1/60
15	1	2/30, 2/60	2/60
15	3	—	—
18	3	—	—
20	1	4/60	2/60
24	3/1	6/60	—
30	3/1	6/60	—

* All circuit breakers are 2 pole.

ACCESSORY ELECTRIC HEATER ELECTRICAL DATA

HEATER PART NO.	kW		PHASE	INTERNAL CIRCUIT PROTECTION	HEATER AMPS 208/230V			BRANCH CIRCUIT													
								Min Ampacity 208/230V**			Min Wire Size (AWG) 208/230V††			Min Gnd Wire Size 208/230V			Max Fuse/Ckt Bkr Amps 208/230V			Max Wire Length 208/230V (ft)‡‡		
					Single Circuit	Dual Circuit		Single Circuit	Dual Circuit		Single Circuit	Dual Circuit		Single Circuit	Dual Circuit		Single Circuit	Dual Circuit		Single Circuit	Dual Circuit	
	240v	208v				L1,L2	L3,L4		L1,L2	L3,L4		L1,L2	L3,L4		L1,L2	L3,L4		L1,L2	L3,L4		L1,L2	L3,L4
KFCEH0401N03	3	2.3	1	None	10.9/12.0	—	—	15.9/17.3	—	—	12/12	—	—	12/12	—	—	20/20	—	—	67/68	—	—
KFCEH0501N05[1]	5	3.8	1	None	18.1/20.0	—	—	26.0/28.4	—	—	10/10	—	—	10/10	—	—	30/30	—	—	66/66	—	—
KFCEH0501N05[2]	5	3.8	1	None	18.1/20.0	—	—	31.2/33.5	—	—	8/8	—	—	10/10	—	—	35/35	—	—	85/88	—	—
KFCEH2401C05[1]	5	3.8	1	Ckt Bkr	18.1/20.0	—	—	26.0/28.4	—	—	10/10	—	—	10/10	—	—	30/30	—	—	66/66	—	—
KFCEH2401C05[2]	5	3.8	1	Ckt Bkr	18.1/20.0	—	—	31.2/33.5	—	—	8/8	—	—	10/10	—	—	35/35	—	—	85/88	—	—
KFCEH0801N08	8	6.0	1	None	28.9/32.0	—	—	44.7/48.5	—	—	8/8	—	—	10/10	—	—	45/50	—	—	59/60	—	—
KFCEH2501C08	8	6.0	1	Ckt Bkr	28.9/32.0	—	—	44.7/48.5	—	—	8/8	—	—	10/10	—	—	45/50	—	—	59/60	—	—
KFCEH2901N09*	9	6.8	1	None	32.8/36.0	—	—	49.5/53.5	—	—	8/6	—	—	10/10	—	—	50/60	—	—	54/87	—	—
KFCEH2901N09*‡	9	6.8	3	None	18.8/20.8	—	—	32.0/34.5	—	—	8/8	—	—	10/10	—	—	35/35	—	—	83/85	—	—
KFCEH0901N10	10	7.5	1	None	36.2/40.0	—	—	53.8/58.5	—	—	6/6	—	—	10/10	—	—	60/60	—	—	78/80	—	—
KFCEH2601C10	10	7.5	1	Ckt Bkr	36.2/40.0	—	—	53.8/58.5	—	—	6/6	—	—	10/10	—	—	60/60	—	—	78/80	—	—
KFCEH3001F15*	15	11.3	1	Fuse	54.2/59.9	36.2/40.0	18.1/20.0	76.3/83.4	53.8/58.5	22.7/25.0	4/4	6/6	10/10	8/8	10/10	10/10	80/90	60/60	25/25	88/89	78/80	75/76
KFCEH3101C15*	15	11.3	1	Ckt Bkr	—	36.2/40.0	18.1/20.0	—	53.8/58.5	22.7/25.0	—	6/6	10/10	—	10/10	10/10	—	60/60	25/25	—	78/80	75/76
KFCEH1601315	15	11.3	3	None	31.3/34.6	—	—	47.7/51.8	—	—	8/6	—	—	10/10	—	—	50/60	—	—	56/90	—	—
KFCEH2001318	18	13.5	3	None	37.6/41.5	—	—	55.5/60.4	—	—	6/6	—	—	10/8	—	—	60/70	—	—	76/77	—	—
KFCEH3201F20*	20	15.0	1	Fuse	72.3/79.9	36.2/40.0	36.2/40.0	98.9/108.4	53.8/58.5	45.3/50.0	3/2	6/6	8/8	8/6	10/10	10/10	100/110	60/60	50/50	85/109	78/80	59/59
KFCEH3301C20*	20	15.0	1	Ckt Bkr	—	36.2/40.0	36.2/40.0	—	53.8/58.5	45.3/50.0	—	6/6	8/8	—	10/10	10/10	—	60/60	50/50	—	78/80	59/59
KFCEH3401F24*†	24	18.0	3	Fuse	50.1/55.4	—	—	71.2/77.8	—	—	4/4	—	—	8/8	—	—	80/80	—	—	94/95	—	—
	24	18.0	1	Fuse	86.7/95.5	—	—	116.9/127.9	—	—	1/1	—	—	6/6	—	—	125/150	—	—	115/116	—	—
KFCEH3501F30*†	30	22.5	3	Fuse	62.6/69.2	—	—	86.8/95.0	—	—	3/3	—	—	8/8	—	—	90/100	—	—	97/98	—	—
	30	22.5	1	Fuse	109.0/120.0	—	—	144.8/158.5	—	—	0/00	—	—	6/6	—	—	150/175	—	—	117/150	—	—

FIELD MULTIPOINT WIRING OF 24-AND 30-kW SINGLE PHASE

HEATER PART NO.	kW		PHASE	HEATER AMPS 208/230V			MIN AMPACITY 208/230V**			MIN WIRE SIZE (AWG) 208/230V††			MIN GND WIRE SIZE 208/230V	MAX FUSE/CKT BKR AMPS 208/230V			MAX WIRE LENGTH 208/230V (FT)‡‡		
	240V	208V		L1,L2	L3,L4	L5,L6	L1,L2	L3,L4	L5,L6	L1,L2	L3,L4	L5,L6		L1,L2	L3,L4	L5,L6	L1,L2	L3,L4	L5,L6
KFCEH3401F24*†	24	18.0	1	28.9/32.0	28.9/32.0	28.9/32.0	44.7/48.5	36.2/40.0	36.2/40.0	8/8	8/8	8/8	10/10	45/50	40/40	40/40	59/60	73/73	73/73
KFCEH3501F30*†	30	22.5	1	36.2/40.0	36.2/40.0	36.2/40.0	53.8/58.5	45.3/50.0	45.3/50.0	6/6	8/8	8/8	10/10	60/60	50/50	50/50	78/80	59/59	59/59

* Heaters are Intelligent Heat capable when used with the FV fan coil and Comfort Zone II™ or Infinity Control™.

† Field convertible to 1 phase, single or multiple supply circuit.

‡ Field convertible to 3 phase.

** Includes blower motor amps of largest fan coil used with heater.

†† Copper wire must be used. If other than uncoated (non–plated), 75°C ambient, copper wire (solid wire for 10 AWG and smaller, stranded wire for larger than 10 AWG) is used, consult applicable tables of the National Electric Code (ANSI/NFPA 70).

‡‡ Length shown is as measured 1 way along wire path between unit and service panel for a voltage drop not to exceed 2%.

NOTES:

1. For fan coil sizes 001–003.
2. For fan coil sizes 004–006.
3. Single circuit application of F15 and F20 heaters requires single–point wiring kit accessory.

ACCESSORIES

ITEM		ACCESSORY PART NO.*	FAN COIL SIZE USED WITH
1.	Disconnect Kit	KFADK0201DSC	Cooling controls and heaters 3– through 10–kW
2.	Downflow Base Kit	KFACB0201CFB	002
		KFACB0301CFB	003, 005
		KFACB0401CFB	006
3.	Downflow Conversion Kit	KFADC0201SLP	003
		KFADC0401ACL	002, 005, 006
4.	Single–Point Wiring Kit	KFASP0101SPK	Only with 15– and 20–kW Fused Heaters
5.	Filter Kit (12 Pack)	KFAFK0212MED	002
		KFAFK0312LRG	003, 005
		KFAFK0412XXL	006
6.	Fan Coil Filter Cabinet (Fan Coil Filter Media)	FNCCABCC0017 (FILCCFNC0017)	002
		FNCCABCC0021 (FILCCFNC0021)	003, 005
		FNCCABCC0024 (FILCCFNC0024)	006
7.	Infinity™ Air Purifier (Infinity™ Purifier Replacement Cartridge)	GAPABXCC1620 (GAPCCCAR1620)	002
		GAPABXCC2020 (GAPCCCAR2020)	003, 005
		GAPABXCC2420 (GAPCCCAR2420)	006
8.	PVC Condensate Trap Kit (50 pack)	KFAET0150ETK	All
9.	Air Cleaner 240–volt Conversion Kit	KEAVC0201240	All
10.	Downflow/Horizontal Conversion Gasket Kit	KFAHD0101SLP	All
11.	Airflow Sensor Kit (Air Cleaner)	KEAAC0101AAA	All
12.	ECM Motor Test	KFASD0301VSP	All
13.	Horizontal Water Management Kit (25 pack)	KFAHC0125AAA	All

* Factory authorized and listed, field installed.

Accessory Kits Description Suggested and Required Use

1. **Disconnect Kit**
   The kit is used to disconnect electrical power to the fan coil so service or maintenance may be performed safely.
   SUGGESTED USE: Units for 3- through 10-kW electric resistance heaters and cooling controls.
2. **Downflow Base Kit**
   This kit is designed to provide a 1-in. minimum clearance between unit discharge plenum, ductwork, and combustible materials. It also provides a gap-free seal with the floor.
   REQUIRED USE: This kit must be used whenever fan coils are used in downflow applications.
3. **Downflow Conversion Kit**
   Fan coils are shipped from the factory for upflow or horizontal-left applications. Downflow conversion kits provide proper condensate water drainage and support for the coil when used in downflow applications. Separate kits are available for slope coils and A-coils.
   REQUIRED USE: This kit must be used whenever fan coils are used in downflow applications.
4. **Single Point Wiring Kit**
   The single point wiring kit acts as a jumper between L1 and L3 lugs, and between the L2 and L4 lugs. This allows the installer to run 2 heavy-gauge, high-voltage wires into the fan coil rather than 4 light-gauge, high-voltage wires.
   SUGGESTED USE: Fan coils with 15- and 20-kW fused heaters only.
5. **Filter Kit (12 pack)**
   The kit consists of 12 fan coil framed filters. These filters collect large dust particles from the return air entering the fan coil and prevents them from collecting on the coil. This process helps to keep the coil clean, which increases heat transfer and, in turn, the efficiency of the system.
   SUGGESTED USE: To replace filters in fan coils.
   REQUIRED USE: All units unless a filter grille is used.
6. **Fan Coil Filter Cabinet**
   This cabinet is mounted to the fan coil on the return air end and designed to slip over the outer fan coil casing. The cabinets are insulated using the same insulation as production fan coils. They are designed for the removal of particulates from indoor air using FILCCFNC00(14, 17, 21, 24) media filter cartridges. These fan coil media filter cartridge kits are designed for the removal of particles from indoor air. The cartridge is installed in the return air duct next to the air handler or further upstream.
   SUGGESTED USE: All fan coils.
7. **Infinity™ Air Purifier**
   The Infinity Air Purifier wires directly to fan coil and requires no duct transitions with Carrier units. These purifiers both capture and kill airborne viruses, bacteria, mold spores, and allergens. It comes with an airflow sensor. Maintenance is limited to replacement of the purification cartridge, GAPCCAR (1620/2020/or 2420), and inspection/brush cleaning of the ionization array.
   SUGGESTED USE: All fan coils.
8. **Condensate Drain Trap Kit**
   This kit consists of 50 PVC condensate traps. Each trap is pre-formed and ready for field installation. This deep trap helps the system make and hold proper condensate flow even during blower initiation.
   SUGGESTED USE: All fan coils.

9. **Air Cleaner 240-volt Conversion Kit**
   The AIRA electronic air cleaner comes ready for 115-v operation.
   REQUIRED USE: This kit is required when running 240-volt circuit to air cleaner.
10. **Downflow/Horizontal Conversion Gasket Kit**
    This kit provides the proper gasketing of units when applied in either a downflow (FE4A or FE5A) or horizontal (FE4A only) application.
    REQUIRED USE: Fan coils in either downflow or horizontal applications.
11. **Airflow Sensor Kit (Air Cleaner)**
    The AIRA electronic air cleaner comes ready for 115-v operation
    REQUIRED USE: This kit is required whenever an electronic air cleaner is used.
12. **ECM Motor Test Kit**
    Operates variable speed blower at several speeds independent of circuit board and wiring harness.
13. **Horizontal Water Management Kit**
    This kit provides proper installation of fan coils under conditions of high static pressure and high relative humidty.
    SUGGESTED USE: All fan coils.

 Printed in U.S.A. Edition Date: 09/07 **Catalog No: FV4B–06PD**

 Replaces: FV4B–05PD

117 East Colorado Blvd, Suite 200 Pasadena, CA 91105 626.578.1121 kpff.com

Hoover HVAC Bldg 11000

651 Glenwood Rd, Glendale, CA 91202

CALCULATIONS
For DSA Review

KPFF Job #1600283
March 20, 2017

Hoover HVAC Bldg 11000
Glendale, California
KPFF Job # 1600283

TABLE OF CONTENTS

A. DESIGN CRITERIA A.1

B. MEP UNIT ANCHORAGE

FC-1 UNIT ANCHORAGE ..... B.1 – B.2

FC-2 TO FC-19 UNIT ANCHORAGE ..... B.3 – B.6

HP-1 UNIT ANCHORAGE ..... B.7 – B.10

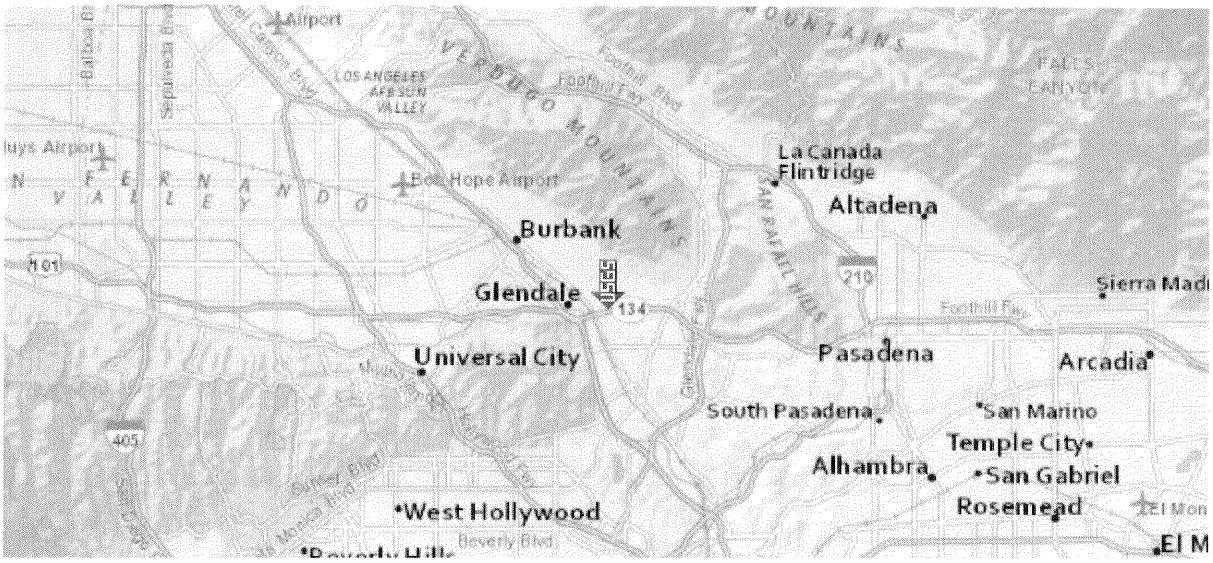
HP-2 TO HP-19 UNIT ANCHORAGE ..... B.11 – B.14

A. DESIGN CRITERIA

USGS Design Maps Summary Report

User-Specified Input

Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.16589°N, 118.26964°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

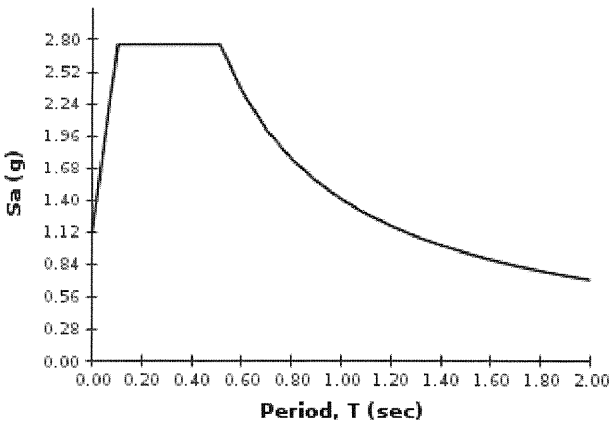


USGS-Provided Output

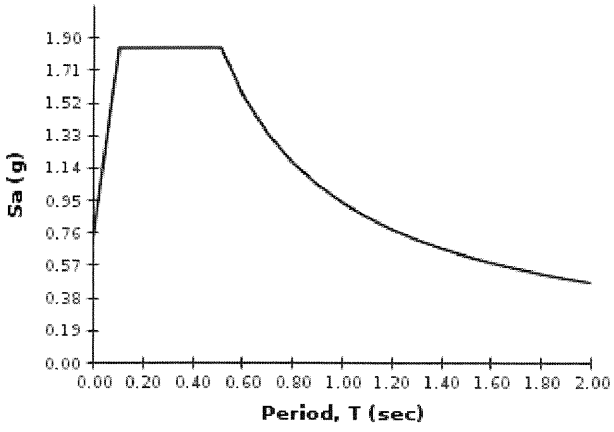
S_S =	2.755 g	S_{MS} =	2.755 g	S_{DS} =	1.837 g
S_1 =	0.938 g	S_{M1} =	1.407 g	S_{D1} =	0.938 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

MCE_R Response Spectrum



Design Response Spectrum



For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

B. MEP UNIT ANCHORAGE

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.1
301 North Lake Avenue, Suite 550	Location:	LOS ANGELES, CA				
Pasadena, CA 91101	Client:	NAC	Job No.:	114931		
(626) 578-1121 Fax (626) 578-9121	Equip ID:	FC-1				

HANGING EQUIPMENT ANCHORAGE

Mounted to Deck Underside with Unsymmetrical or Rectangular Multiple Bolt Group Pattern (2013-CBC).

Equipment Description	=	FAN COIL, FC-1			
Base	=	(E) 3 1/2" LWC OVR 3" METAL DECK			
W = weight of equipment	=	135	lb		
l = overall length	=	22	in	z = 30	ft
w = overall width	=	17.63	in	h_r = 45.5	ft
h = height of C.G. above base	=	28.46	in		

Center of Mass Location

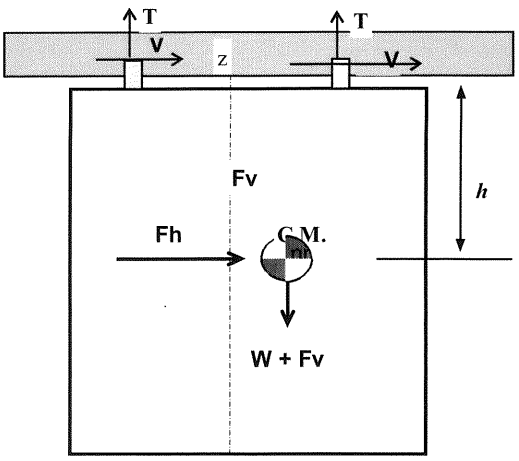
CG_x = dist. in x-dir from Origin	=	8.815	in
CG_y = dist. in y-dir from Origin	=	11	in
n = # of anchors	=	4	
m = # of bolts @ each anchor	=	2	

Seismic Accelerations

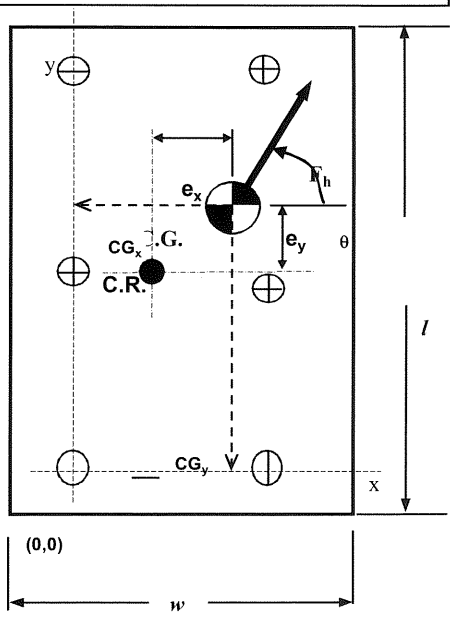
a_p = amplification factor	=	2.5	Ip = Imp. Factor =	1
R_p = response factor	=	2	Ω_0 = Factor =	2.5
S_{DS} = spectral acceleration	=	1.837		
$\Omega_0 F_h$ = from (13.3-1, 13.2-2, 13.3-3)	=	719 lb	= 5.33 Wp	
F_v = vertical force = $0.2 S_{DS} W_p$	=	50 lb	= 0.37 Wp	

Bolt Group Properties

x_{bar} = x-dist. of C.R.from Origin	=	8.81 in
y_{bar} = y-dist. of C.R.from Origin	=	11 in
e_x = x-eccen. of C.G.from C.R.	=	0.00 in
e_y = y-eccen. of C.G.from C.R.	=	0.00 in
I_x = Sum (dx_i^2)	=	512 in^2
I_y = Sum (dy_i^2)	=	489 in^2
$I_{polar} = I_x + I_y$	=	1001 in^2



FRONT ELEVATION



PLAN AT BASE

BOLT LOCATIONS (up to 20 anchors)

#	X	Y	dx^2	dy^2	d^2
1	1.00	19.00	122.1	128.00	250.1
2	16.63	19.00	122.1	128.00	250.1
3	1.00	3.00	122.1	128.00	250.1
4	16.63	3.00	122.1	128.00	250.1
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

kpff Consulting Engineers
3131 Camino Del Rio North, Suite 1080
San Diego, CA 92108
(619) 521-8500 Fax (619) 521-8591

Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.2
Location:	LOS ANGELES, CA	Date:	1/20/2017		
Client:	NAC	Job No.:	114931.00		
Equipment:	FAN COIL, FC-1				

Bolt Forces

Tension(i) = $[M_x \cdot dy/I_x + M_y \cdot dx/I_y + (1.2W+Fv)/(n*m)]$

$M_x = \Omega_0 F_h * \sin\theta * h + (1.2W+F_v) * e_y$

$M_y = \Omega_0 F_h * \cos\theta * h + (1.2W+F_v) * e_x$

Search θ _max from 0° to 359° to get maximum Tension(i) at each A.B.

Note: Negative sign means force is in compression.

#	θ _max	M_x*dy/I_x	M_y*dx/I_y	(0.9W-Fv)/n*m	$\Omega_0 T$
1	315.5	-224.0	-233.4	-26.4	483.9
2	224.5	-224.0	-233.4	-26.4	483.9
3	44.5	-224.0	-233.4	-26.4	483.9
4	135.5	-224.0	-233.4	-26.4	483.9

Notes for Tension Calculations Below:

(1) Use Tmax for Connection of Angle to Equipment at Vertical Angle Leg (i.e. Screws)

*(2) Use Tmax*EF for Connection of Angle to Base at Horizontal Angle Leg (i.e. Hilti KB TZ)*

(3) Eccentricity factor (EF) arises from indirect connection (EF = 1 through equipment, 2.5 single angle, ~3 channel-plate

This connection is: through equipment

Tension

(1) $\Omega_0 T_{max}$ = MAX (Tension(i))	=	**484** lb/support
Base Connx Eccentricity Factor (EF)	=	**1.0**
(2) $\Omega_0 T_{max}$*EF	=	**484** lb/support

Shear

$M_p = \Omega_0 F_h (\sin\theta * e_x + \cos\theta * e_y)$

$\Omega_0 V(i) = |Mp*d/I_{polar} + \Omega_0 Fh/(n*m)|$

$\Omega_0 V_{max}$ = Maximum($\Omega_0 V(i)$) = **90** lb/support

Search θ _max from 0° to 359° to get max $\Omega_0 V(i)$ at each A.B.

#	θ _max	M_p*d/I_{polar}	$\Omega_0 Fh/(n*m)$	$\Omega_0 V$
1	0.0	0.0	89.8	89.8
2	0.0	0.0	89.8	89.8
3	0.0	0.0	89.8	89.8
4	0.0	0.0	89.8	89.8

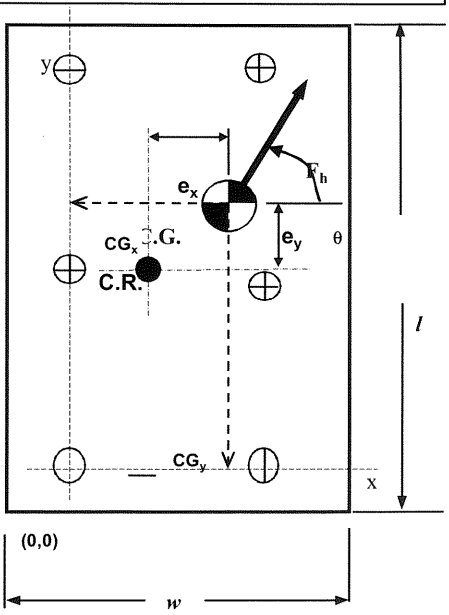
REFERENCE ANCHORAGE CALCS
AFTER FC-2 THROUGH FC-19

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.3
301 North Lake Avenue, Suite 550	Location:	LOS ANGELES, CA				
Pasadena, CA 91101	Client:	NAC	Job No.:	114931		
(626) 578-1121 Fax (626) 578-9121	Equip ID:	FC-2_TO_FC-19				

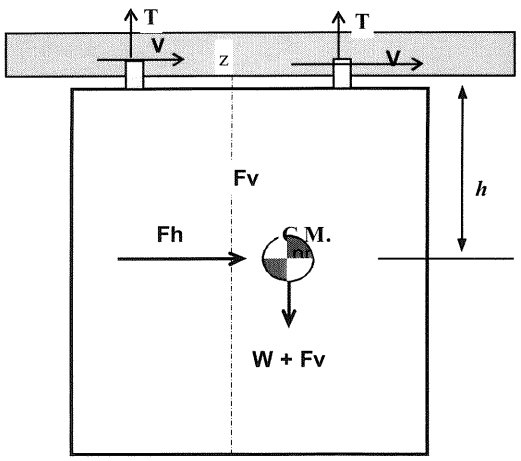
HANGING EQUIPMENT ANCHORAGE

Mounted to Deck Underside with Unsymmetrical or Rectangular Multiple Bolt Group Pattern (2013-CBC).

Equipment Description	=	FAN COIL, FC-2_TO_FC-19			
Base	=	(E) 3 1/2" LWC OVR 3" METAL DECK			
W = weight of equipment	=	175	lb		
l = overall length	=	22	in	z = 30	ft
w = overall width	=	21.13	in	h_r = 45.5	ft
h = height of C.G. above base	=	35.63	in		
Center of Mass Location					
CG_x = dist. in x-dir from Origin	=	10.565	in		
CG_y = dist. in y-dir from Origin	=	11	in		
n = # of anchors	=	4			
m = # of bolts @ each anchor	=	2			
Seismic Accelerations					
a_p = amplification factor	=	2.5		Ip = Imp. Factor = 1	
R_p = response factor	=	2		Ω_0 = Factor = 2.5	
S_{DS} = spectral acceleration	=	1.837			
$\Omega_0 F_h$ = from (13.3-1, 13.2-2, 13.3-3)	=	932	lb	= 5.33 Wp	
F_v = vertical force = $0.2 S_{DS} W_p$	=	64	lb	= 0.37 Wp	
Bolt Group Properties					
x_{bar} = x-dist. of C.R.from Origin	=	10.56	in		
y_{bar} = y-dist. of C.R.from Origin	=	11	in		
e_x = x-eccen. of C.G.from C.R.	=	0.00	in		
e_y = y-eccen. of C.G.from C.R.	=	0.00	in		
I_x = Sum (dx_i^2)	=	512	in^2		
I_y = Sum (dy_i^2)	=	732	in^2		
$I_{polar} = I_x + I_y$	=	1244	in^2		



PLAN AT BASE



FRONT ELEVATION

BOLT LOCATIONS (up to 20 anchors)

#	X	Y	dx^2	dy^2	d^2
1	1.00	19.00	183.0	128.00	311.0
2	20.13	19.00	183.0	128.00	311.0
3	1.00	3.00	183.0	128.00	311.0
4	20.13	3.00	183.0	128.00	311.0
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.4
3131 Camino Del Rio North, Suite 1080	Location:	LOS ANGELES, CA	Date:	1/20/2017		
San Diego, CA 92108	Client:	NAC	Job No.:	114931.00		
(619) 521-8500 Fax (619) 521-8591	Equipment:	FAN COIL, FC-2_TO_FC-19				

Bolt Forces

Tension(i) = $[M_x \cdot dy/I_x + M_y \cdot dx/I_y + (1.2W+Fv)/(n*m)]$

$M_x = \Omega_0 F_h * \sin\theta * h + (1.2W+F_v) * e_y$

$M_y = \Omega_0 F_h * \cos\theta * h + (1.2W+F_v) * e_x$

Search θ _max from 0° to 359° to get maximum Tension(i) at each A.B.

Note: Negative sign means force is in compression.

#	θ _max	M_x*dy/I_x	M_y*dx/I_y	(0.9W-Fv)/n*m	$\Omega_0 T$
1	310.0	-397.3	-278.8	-34.3	710.5
2	230.0	-397.3	-278.8	-34.3	710.5
3	50.0	-397.3	-278.8	-34.3	710.5
4	130.0	-397.3	-278.8	-34.3	710.5

Notes for Tension Calculations Below:

(1) Use Tmax for Connection of Angle to Equipment at Vertical Angle Leg (i.e. Screws)

*(2) Use Tmax*EF for Connection of Angle to Base at Horizontal Angle Leg (i.e. Hilti KB TZ)*

(3) Eccentricity factor (EF) arises from indirect connection (EF = 1 through equipment, 2.5 single angle, ~3 channel-plate

This connection is: through equipment

Tension

(1) $\Omega_0 T_{max}$ = MAX (Tension(i))	=	**710** lb/support
Base Connx Eccentricity Factor (EF)	=	**1.0**
(2) $\Omega_0 T_{max}$*EF	=	**710** lb/support

Shear

$M_p = \Omega_0 F_h (\sin\theta * e_x + \cos\theta * e_y)$

$\Omega_0 V(i) = |Mp*d/I_{polar} + \Omega_0 Fh/(n*m)|$

$\Omega_0 V_{max}$ = Maximum(Ω_0V(i)) = **116** lb/support

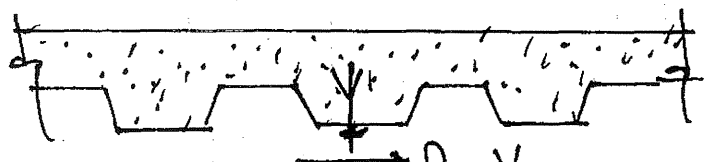
Search θ _max from 0° to 359° to get max Ω_0V(i) at each A.B.

#	θ _max	M_p*d/I_{polar}	$\Omega_0 Fh/(n*m)$	$\Omega_0 V$
1	0.0	0.0	116.5	116.5
2	0.0	0.0	116.5	116.5
3	0.0	0.0	116.5	116.5
4	0.0	0.0	116.5	116.5

kpff
117 E. Colorado Blvd, Suite 200
Pasadena, CA 91105
(626) 578-1121

project HOOVER 11000		by DO	B.5 sheet no.
location GLENDALE, CA		date 1/20/2017	
client NAC		job no. 1600283	

ANCHOR CAPACITY IN UNDERSIDE OF SOFFIT:



$\Omega_o V_{MAX} = 116\ \#$

$\Omega_o T_{MAX} = 710\ \#$

} SEE OUTPUT FROM ANALYSIS SPREADSHEET.

TRY ½"Φ x 3¼" EMBED HILTI KB-TZ (ICC ESR-1917)

CHECK CONCRETE BREAKOUT:

- PER ICC REPORT SEC. 4.1.3, CALCULATION OF CONCRETE BREAKOUT IN TENSION IS NOT REQ'D IN SOFFIT.

- PER ICC REPORT SEC. 4.1.6, CALCULATION OF CONCRETE BREAKOUT IN SHEAR IS NOT REQ'D IN SOFFIT.

CHECK STEEL FAILURE MODES:

STEEL SHEAR:

$V_{SA,DECK,EQ} = 4{,}065\ \#$ (ICC TBL 5, FIG 5E)

$\Phi = 0.65$

$\Phi V_{SA,DECK,EQ} = 0.65 \times 4{,}065\ \# = 2642\ \# > 116\ \#$ √OK.

STEEL TENSION:

$N_{SA} = 10{,}705\ \#$ (ICC TBL 3)

$\Phi = 0.75$

$\Phi N_{SA} = 8{,}028\ \# > 710\ \#$ √OK.

kpff
117 E. Colorado Blvd, Suite 200
Pasadena, CA 91105
(626) 578-1121

project HOOVER 11000	by DO	B.6 sheet no.
location GLENDALE, CA	date 1/20/2017	
client NAC	job no. 1600283	

CHECK PULLOUT TENSION FAILURE MODE:

$N_{p,DECK,CR} = 2,620\#$ (ICC TBL 5, FIG 5B)

$\phi = 0.65$

$\phi N_{p,DECK,CR} = 1,703\# > 710\#$ √OK.

CHECK COMBINED TENSION & SHEAR:

SINCE $\dfrac{\Omega_o V_{MAX}}{\phi V_s} \leq 0.20$

&

$\dfrac{\Omega_o T_{MAX.}}{\phi N_{sa}} \leq 0.20$

∴ FULL VALUES FOR BOTH TENSION & SHEAR MAY BE USED.

∴ USE ½" ϕ × 3¼" EFF EMBED HILTI KB-TZ ANCHORS (ICC ESR-1917) AT FANCOIL HANGER TO DECK CONNECTIONS.

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.7
301 North Lake Avenue, Suite 550	Location:	LOS ANGELES, CA				
Pasadena, CA 91101	Client:	NAC	Job No.:	114931		
(626) 578-1121 Fax (626) 578-9121	Equip ID:	HP-1				

EQUIPMENT ANCHORAGE

Floor Mounted with Unsymmetrical or Rectangular Multiple Bolt Group Pattern (2013-CBC).

Equipment Description	=	HEAT PUMP, HP - 1			
Base	=	(E) 6" CONC. EQUIP. PAD. ON STL FRM'G			
W = weight of equipment	=	200	lb		
l = overall length	=	44.5	in	z = 31.5	ft
w = overall width	=	17	in	h_r = 31.5	ft
h = height of C.G. above base	=	15.88	in		

Center of Mass Location

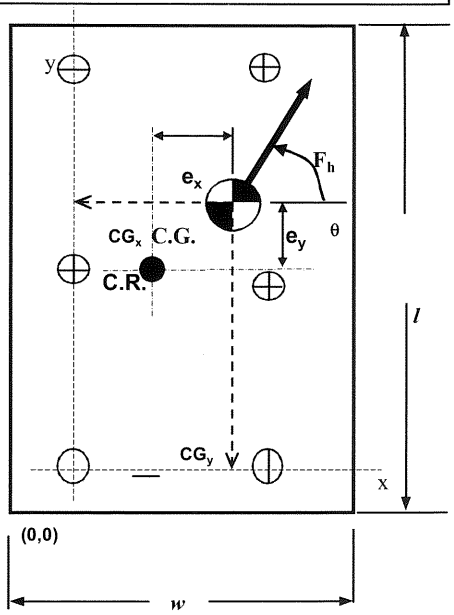
CG_x = dist. in x-dir from Origin	=	8.13	in
CG_y = dist. in y-dir from Origin	=	22.25	in
n = # of anchors	=	6	
m = # of bolts @ each anchor	=	1	

Seismic Accelerations

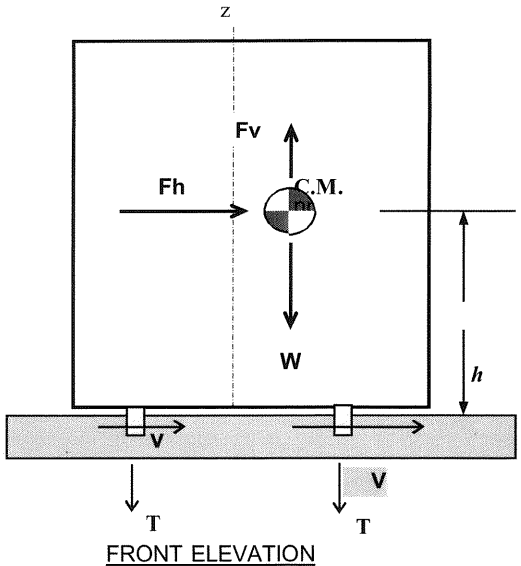
a_p = amplification factor	=	2.5	Ip = Imp. Factor =	1
R_p = response factor	=	2.5	Ω_0 = Factor =	2.5
S_{DS} = spectral acceleration	=	1.837		
$\Omega_0 F_h$ = from (13.3-1, 13.2-2, 13.3-3)	=	1,102 lb	= 5.52 Wp	
F_v = vertical force = $0.2 S_{DS} W_p$	=	73 lb	= 0.37 Wp	

Bolt Group Properties

x_{bar} = x-dist. of C.R.from Origin	=	8.50	in
y_{bar} = y-dist. of C.R.from Origin	=	25.953331	in
e_x = x-eccen. of C.G.from C.R.	=	0.37	in
e_y = y-eccen. of C.G.from C.R.	=	3.70	in
I_x = Sum (dx_i^2)	=	1620	in^2
I_y = Sum (dy_i^2)	=	507	in^2
$I_{polar} = I_x + I_y$	=	2127	in^2



PLAN AT BASE



FRONT ELEVATION

BOLT LOCATIONS (up to 20 anchors)

#	X	Y	dx^2	dy^2	d^2
1	-0.69	41.12	84.5	230.03	314.5
2	17.69	41.12	84.5	230.03	314.5
3	-0.69	33.62	84.5	58.78	143.2
4	17.69	33.62	84.5	58.78	143.2
5	-0.69	3.12	84.5	521.36	605.8
6	17.69	3.12	84.5	521.36	605.8
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

kpff Consulting Engineers
3131 Camino Del Rio North, Suite 1080
San Diego, CA 92108
(619) 521-8500 Fax (619) 521-8591

Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.: B.8
Location:	LOS ANGELES, CA	Date:	1/20/2017	
Client:	NAC	Job No.:	114931.00	
Equipment:	HEAT PUMP, HP - 1			

Bolt Forces

Tension(i) = $[M_x \cdot dy/I_x + M_y \cdot dx/I_y - (0.9W - F_v)/(n*m)]$

$M_x = \Omega_0 F_h * \sin\theta * h + (0.9W - F_v) * e_y$

$M_y = \Omega_0 F_h * \cos\theta * h + (0.9W - F_v) * e_x$

Search θ _max from 0° to 359° to get maximum Tension(i) at each A.B.

Note: Negative sign means force is in compression.

#	θ _max	M_x*dy/I_x	M_y*dx/I_y	(0.9W-Fv)/n*m	$\Omega_0 T$
1	332.5	-79.3	-280.8	17.8	342.4
2	207.5	-79.3	-282.3	17.8	343.9
3	345.5	-22.6	-306.6	17.8	311.5
4	194.5	-22.6	-308.0	17.8	312.9
5	38.0	-146.3	-249.4	17.8	378.0
6	142.0	-146.3	-250.9	17.8	379.4

Notes for Tension Calculations Below:

(1) Use Tmax for Connection of Angle to Equipment at Vertical Angle Leg (i.e. Screws)

*(2) Use Tmax*EF for Connection of Angle to Base at Horizontal Angle Leg (i.e. Hilti KB TZ)*

(3) Eccentricity factor (EF) arises from indirect connection (EF = 1 through equipment, 2.5 single angle, ~3 channel-plate

This connection is: single angle

Tension

(1) $\Omega_0 T_{max}$ = MAX (Tension(i)) = **379** lb/support

Base Connx Eccentricity Factor (EF) = **2.5**

(2) $\Omega_0 T_{max} * EF$ = **948** lb/support

Shear

$M_p = \Omega_0 F_h (\sin\theta * e_x + \cos\theta * e_y)$

$\Omega_0 V(i) = |Mp*d/I_{polar} + \Omega_0 Fh/(n*m)|$

$\Omega_0 V_{max}$ = Maximum(Ω_0V(i)) = **231** lb/support

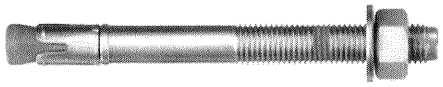
Search θ _max from 0° to 359° to get max Ω_0V(i) at each A.B.

#	θ _max	M_p*d/I_{polar}	Ω_0Fh/(n*m)	Ω_0V
1	5.5	34.2	183.7	217.9
2	174.5	34.2	183.7	217.9
3	5.5	23.1	183.7	206.8
4	174.5	23.1	183.7	206.8
5	5.5	47.5	183.7	231.2
6	174.5	47.5	183.7	231.2

Company:		Page:	1
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	1/20/2017
E-Mail:			

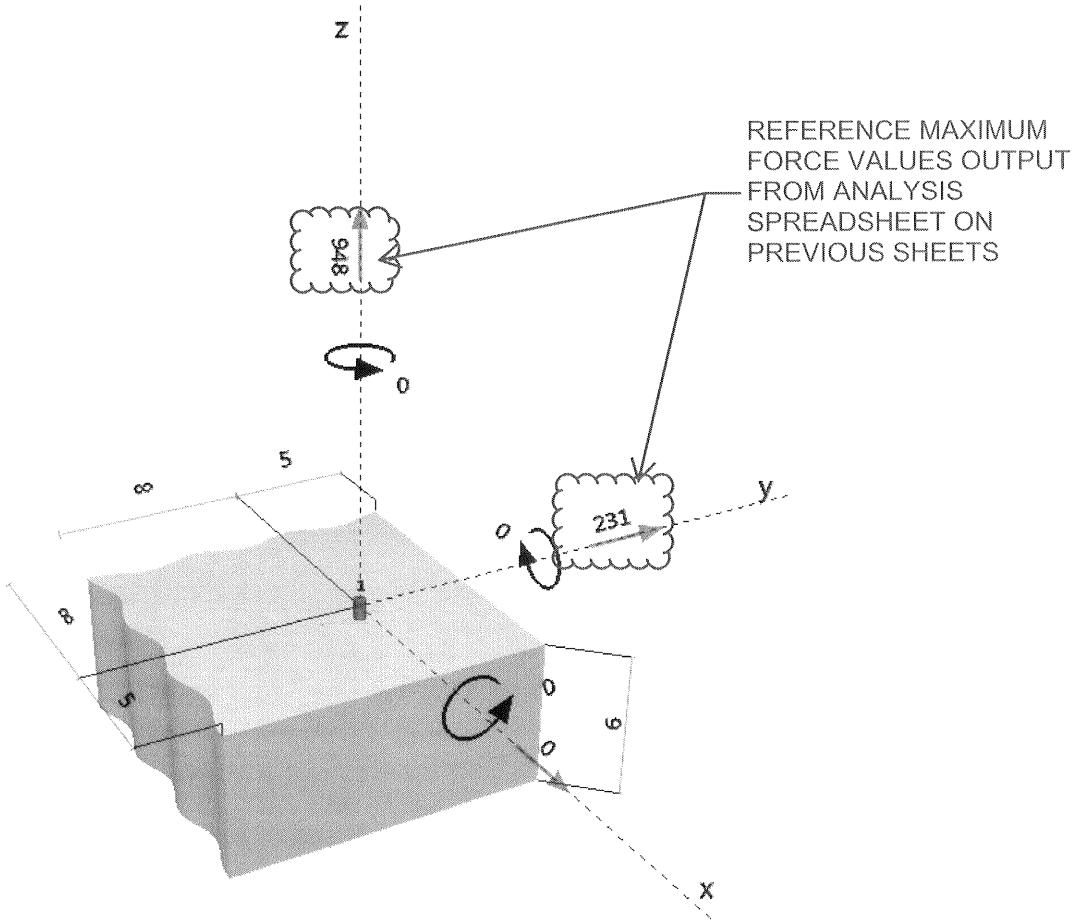
Specifier's comments:

1 Input data



Anchor type and diameter:	**Kwik Bolt TZ - SS 304 1/2 (3 1/4)**
Effective embedment depth:	$h_{ef,act}$ = 3.250 in., h_{nom} = 3.625 in.
Material:	AISI 304
Evaluation Service Report:	ESR-1917
Issued I Valid:	6/1/2016 | 5/1/2017
Proof:	Design method ACI 318-14 / Mech.
Stand-off installation:	- (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 3000, f_c' = 3000 psi; h = 6.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

Geometry [in.] & Loading [lb, in.lb]



Company:		Page:	2
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	1/20/2017
E-Mail:			

2 Proof I Utilization (Governing Cases)

		Design values [lb]		Utilization	
Loading	**Proof**	**Load**	**Capacity**	**β_N / β_V [%]**	**Status**
Tension	Concrete Breakout Strength	948	2660	36 / -	OK
Shear	Concrete edge failure in direction y+	231	2070	- / 12	OK

Loading	β_N	β_V	ζ	**Utilization $\beta_{N,V}$ [%]**	**Status**
Combined tension and shear loads	0.356	0.112	5/3	21	OK

3 Warnings

- Please consider all details and hints/warnings given in the detailed report!

Fastening meets the design criteria!

THEREFORE ANCHORAGE IS OK

4 Remarks; Your Cooperation Duties

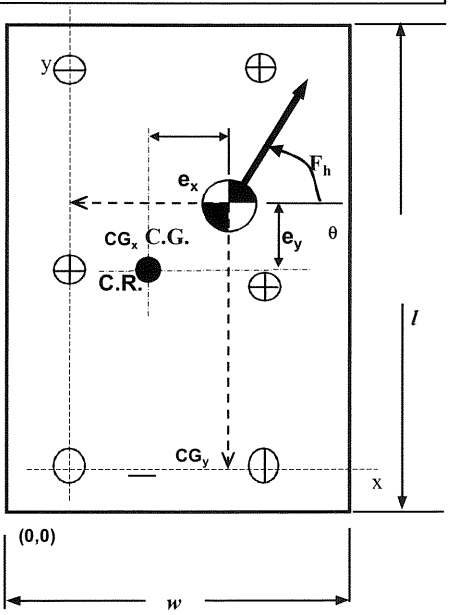
- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.11
301 North Lake Avenue, Suite 550	Location:	LOS ANGELES, CA				
Pasadena, CA 91101	Client:	NAC	Job No.:	114931		
(626) 578-1121 Fax (626) 578-9121	Equip ID:	HP-2_TO_HP-19				

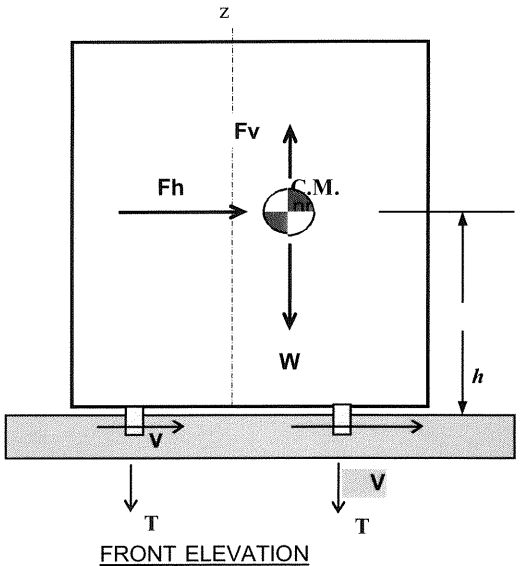
EQUIPMENT ANCHORAGE

Floor Mounted with Unsymmetrical or Rectangular Multiple Bolt Group Pattern (2013-CBC).

Equipment Description	=	HEAT PUMPS, HP-2_TO_HP-19				
Base	=	(E) 6" CONC. EQUIP. PAD. ON STL FRM'G				
W = weight of equipment	=	250	lb			
l = overall length	=	44.5	in	z =	31.5	ft
w = overall width	=	17	in	h_r =	31.5	ft
h = height of C.G. above base	=	18.88	in			
Center of Mass Location						
CG_x = dist. in x-dir from Origin	=	8.5	in			
CG_y = dist. in y-dir from Origin	=	22.25	in			
n = # of anchors	=	6				
m = # of bolts @ each anchor	=	1				
Seismic Accelerations						
a_p = amplification factor	=	2.5		Ip = Imp. Factor =	1	
R_p = response factor	=	2.5		Ω_0 = Factor =	2.5	
S_{DS} = spectral acceleration	=	1.837				
$\Omega_0 F_h$ = from (13.3-1, 13.2-2, 13.3-3)	=	1,378	lb	= 5.52 Wp		
F_v = vertical force = $0.2 S_{DS} W_p$	=	92	lb	= 0.37 Wp		
Bolt Group Properties						
x_{bar} = x-dist. of C.R.from Origin	=	8.50	in			
y_{bar} = y-dist. of C.R.from Origin	=	25.953331	in			
e_x = x-eccen. of C.G.from C.R.	=	0.00	in			
e_y = y-eccen. of C.G.from C.R.	=	3.70	in			
I_x = Sum (dx_i^2)	=	1620	in^2			
I_y = Sum (dy_i^2)	=	507	in^2			
$I_{polar} = I_x + I_y$	=	2127	in^2			



PLAN AT BASE



FRONT ELEVATION

BOLT LOCATIONS (up to 20 anchors)

#	X	Y	dx^2	dy^2	d^2
1	-0.69	41.12	84.5	230.03	314.5
2	17.69	41.12	84.5	230.03	314.5
3	-0.69	33.62	84.5	58.78	143.2
4	17.69	33.62	84.5	58.78	143.2
5	-0.69	3.12	84.5	521.36	605.8
6	17.69	3.12	84.5	521.36	605.8
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

kpff Consulting Engineers	Project:	HOOVER BLDG 11000 HVAC	By:	DO	Sheet No.:	B.12
3131 Camino Del Rio North, Suite 1080	Location:	LOS ANGELES, CA	Date:	1/20/2017		
San Diego, CA 92108	Client:	NAC	Job No.:	114931.00		
(619) 521-8500 Fax (619) 521-8591	Equipment:	HEAT PUMPS, HP-2_TO_HP-19				

Bolt Forces

Tension(i) = $[M_x \cdot dy/I_x + M_y \cdot dx/I_y - (0.9W - F_v)/(n*m)]$

$M_x = \Omega_0 F_h * \sin\theta * h + (0.9W - F_v) * e_y$

$M_y = \Omega_0 F_h * \cos\theta * h + (0.9W - F_v) * e_x$

Search θ _max from 0° to 359° to get maximum Tension(i) at each A.B.

Note: Negative sign means force is in compression.

#	θ _max	M_x*dy/I_x	M_y*dx/I_y	(0.9W-Fv)/n*m	$\Omega_0 T$
1	332.5	-117.0	-418.4	22.2	513.3
2	207.5	-117.0	-418.4	22.2	513.3
3	345.5	-33.1	-456.7	22.2	467.7
4	194.5	-33.1	-456.7	22.2	467.7
5	38.0	-218.7	-371.7	22.2	568.3
6	142.0	-218.7	-371.7	22.2	568.3

Notes for Tension Calculations Below:

(1) Use Tmax for Connection of Angle to Equipment at Vertical Angle Leg (i.e. Screws)

*(2) Use Tmax*EF for Connection of Angle to Base at Horizontal Angle Leg (i.e. Hilti KB TZ)*

(3) Eccentricity factor (EF) arises from indirect connection (EF = 1 through equipment, 2.5 single angle, ~3 channel-plate

This connection is: single angle

Tension

(1) $\Omega_0 T_{max}$ = MAX (Tension(i))	=	**568** lb/support
Base Connx Eccentricity Factor (EF)	=	**2.5**
(2) $\Omega_0 T_{max}$*EF	=	**1421** lb/support

Shear

$M_p = \Omega_0 F_h (\sin\theta * e_x + \cos\theta * e_y)$

$\Omega_0 V(i) = |M_p * d/I_{polar} + \Omega_0 Fh/(n*m)|$

$\Omega_0 V_{max}$ = Maximum(Ω_0V(i)) = **289** lb/support

Search θ _max from 0° to 359° to get max Ω_0V(i) at each A.B.

#	θ _max	M_p*d/I_{polar}	Ω_0Fh/(n*m)	Ω_0V
1	0.0	42.5	229.6	272.2
2	0.0	42.5	229.6	272.2
3	0.0	28.7	229.6	258.3
4	0.0	28.7	229.6	258.3
5	0.0	59.0	229.6	288.7
6	0.0	59.0	229.6	288.7

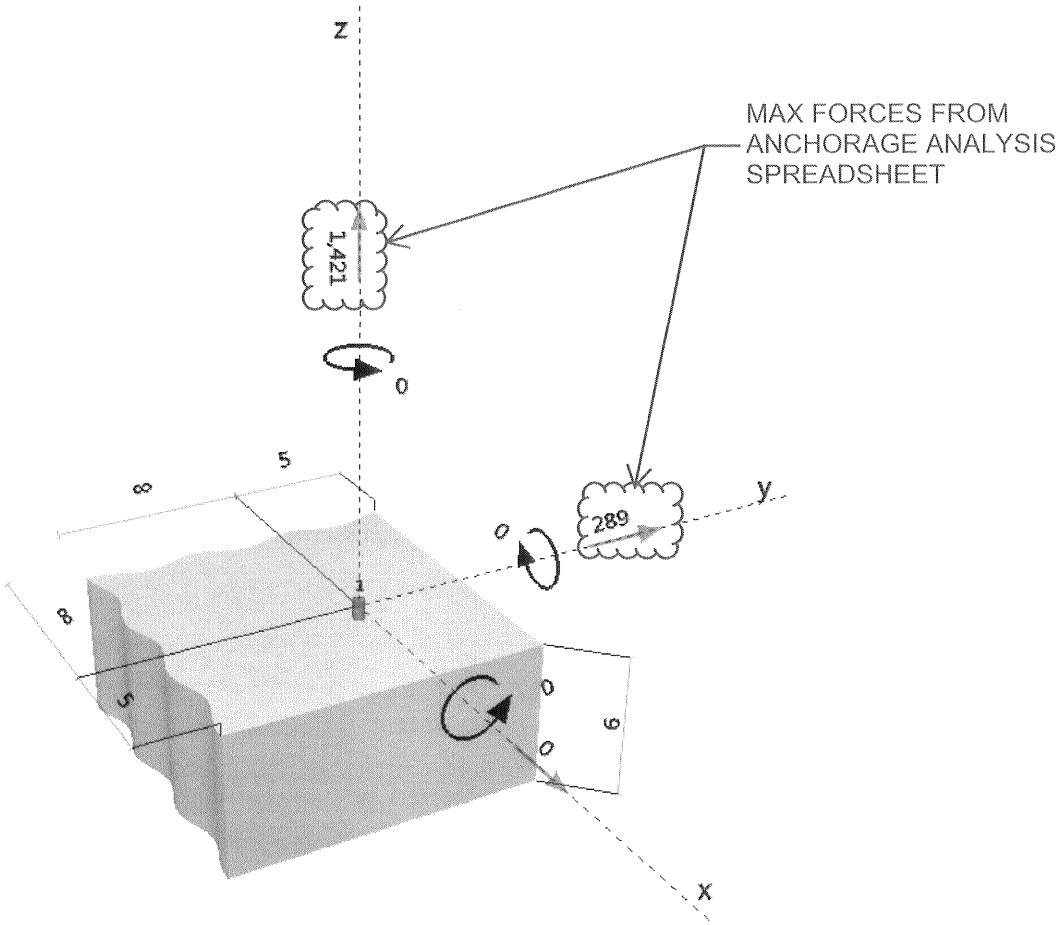
Company:		Page:	1
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	1/20/2017
E-Mail:			

Specifier's comments:

1 Input data

Anchor type and diameter:	**Kwik Bolt TZ - SS 304 1/2 (3 1/4)**
Effective embedment depth:	$h_{ef,act}$ = 3.250 in., h_{nom} = 3.625 in.
Material:	AISI 304
Evaluation Service Report:	ESR-1917
Issued I Valid:	6/1/2016 | 5/1/2017
Proof:	Design method ACI 318-14 / Mech.
Stand-off installation:	- (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 3000, f_c' = 3000 psi; h = 6.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

Geometry [in.] & Loading [lb, in.lb]



Company:		Page:	2
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	1/20/2017
E-Mail:			

2 Proof I Utilization (Governing Cases)

		Design values [lb]		Utilization	
Loading	**Proof**	**Load**	**Capacity**	**β_N / β_V [%]**	**Status**
Tension	Concrete Breakout Strength	1421	2660	54 / -	OK
Shear	Concrete edge failure in direction y+	289	2070	- / 14	OK

Loading	β_N	β_V	ζ	**Utilization $\beta_{N,V}$ [%]**	**Status**
Combined tension and shear loads	0.534	0.140	5/3	39	OK

THEREFORE ANCHORAGE OK

3 Warnings

- Please consider all details and hints/warnings given in the detailed report!

Fastening meets the design criteria!

4 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.