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Change 2 - 08/18

Preparing Activity: NAVFAC | Superseding
UFGS-23 35 19.00 20 (July 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 35 19.00 20

INDUSTRIAL VENTILATION AND EXHAUST

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****
NOTE: This guide specification covers the requirements for blower and exhaust systems for removal of flammable vapors including paint spraying residue, corrosive fumes, dust, and stock conveying.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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NOTE: This guide specification also includes plastic duct systems for removal of nonflammable corrosive fumes and vapors. Materials must be selected by the designer to suit project requirements. The system must be designed in accordance with NFPA 91. Ventilation and exhaust systems and components for removal of smoke and grease laden vapors from commercial type cooking equipment are covered in Section 11 05 40 COMMON WORK RESULTS FOR FOODSERVICE EQUIPMENTand 23 30 00 HVAC AIR DISTRIBUTION. Laboratory fume hoods are covered in Section 11 53 00 LABORATORY EQUIPMENT AND FUME HOODS. The design agency (EFD, OICC, PWC, etc.) must ensure review of the ventilation system design by the appropriate Naval Medical Command

(NAVMEDCOM) activity in accordance with NAVOSH requirements. For high temperature applications, the designer must specify special fans and duct material as required for the particular application.

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NOTE: The following information must be shown on the project drawings:

1. Arrangement plan and details for fans, ducts, and accessories.

2. Duct pressure classes or duct operating pressures. Design duct for maximum negative pressure practical to accommodate improper operation or poor maintenance.

3. Equipment schedules.

4. Equipment foundations and supports.

5. Structural supports for ducts where required.

6. The design of industrial ventilation systems and the editing of this section should be performed by professional engineers or industrial hygienists with a sound knowledge of industrial ventilation. Design should conform to the ACGIH-2092S Industrial Ventilation: A Manual Of Recommended Practice; ASSE Z9.2, Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems; AIHA Z9.3, Spray Finishing Operations - Safety Code for Design, Construction and Ventilation; UFC 3-410-04N, "Industrial Ventilation"; and other references as applicable. Fan arrangements should be selected to eliminate system effects identified in ANSI/AMCA 201.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically

be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 99	(2016) Standards Handbook
AMCA 99-0401	(1986) Classifications for Spark Resistant Construction
AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 211	(2013; Rev 2017) Certified Ratings Program Product Rating Manual for Fan Air Performance
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA CRP	(Online) Directory of Products Licensed Under the AMCA International Certified Ratings Program

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1060 I-P	(2014) Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Heat Equipment

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH-2092S	(2004) Industrial Ventilation: A Manual of Recommended Practice

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1011/A1011M	(2023) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM C582	(2023) Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1330	(2004; R 2010) Rubber Sheet Gaskets
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive

	Environments
ASTM D1927	(1981; R 1988) Rigid Poly(Vinyl Chloride) Plastic Sheet
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D4167	(2015) Fiber-Reinforced Plastic Fans and Blowers

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2017; Version 1.2) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 65	(1993) Processing and Finishing of Aluminum
NFPA 70	(2023) National Electrical Code
NFPA 91	(2020) Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
NFPA 664	(2020) Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

RUBBER MANUFACTURERS ASSOCIATION (RMA)

RMA IP-20	(2007) Specifications for Drives Using Classical V-Belts and Sheaves. Specifications for A, B, C, and D Cross

	Sections
RMA IP-22	(2007) Specifications for Drives Using Narrow V-Belts and Sheaves (Joint RMA/MPTA), 4th Edition

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1378	(1995) Thermoplastic Duct (PVC) Construction Manual, 2nd Edition
SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1520	(1999) Round Industrial Duct Construction Standards, 3rd Edition
SMACNA 1922	(2004) Rectangular Industrial Duct Construction Standards, 2nd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 11	(1992; E 2000) Paint Specification No. 11Red Iron Oxide, Zinc Chromate, Raw Linseed Oil and Alkyd Primer
SSPC Paint 20	(2019) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)
SSPC SP 5/NACE No. 1	(2007) White Metal Blast Cleaning

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-12276	(2006; Rev E; Notice 1 2011; Notice 2 2016; Notice 3 2021) Varnish, Phenolic, Baking
MIL-DTL-24441	(2009; Rev D; Notice 1 2021) Paint, Epoxy-Polyamide, General Specification for
MIL-P-21035	(1991; Rev B; Notice 2 2003; Notice 3 2021) Paint, High Zinc Dust Content, Galvanizing Repair (Metric)
MIL-PRF-23236	(2009; Rev D; Notice 1 2023) Coating Systems for Ship Structures

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-272	(Rev B; Notice 1) Caulking Compounds

FS TT-S-001543	(Rev B; Notice 1) Sealing Compound: Silicone Rubber Base (For Calking, Sealing, and Glazing in Buildings and Other Structures)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 33	(2010; Reprint Apr 2020) Heat Responsive Links for Fire-Protection Service
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 214	(1997; Rev thru Aug 2001) Tests for Flame-Propagation of Fabrics and Films
UL Bld Mat Dir	(updated continuously online) Building Materials Directory

1.2 GENERAL REQUIREMENTS

1.2.1 SMACNA Duct Construction Manuals

The recommendations in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) duct construction manuals must be considered mandatory requirements. Substitute the word "must" for "should" in these manuals.

1.2.2 Fan Data

[For fans include fan curves or rating tables and derating factors.]Provide certified performance curves showing total pressure, power, and mechanical efficiency versus flow rate of the operating density and fan speed. All areas of unstable operation must be indicated. For fans equipped with adjustable capacity controls such as variable inlet or vaneaxial fans with adjustable blade settings, minimum and maximum performance must be indicated along with performance for fire intermediate settings.

1.2.3 Natural Ventilation

Evaluate natural ventilation for appropriate spaces, and design air distribution systems to operate in the same direction as natural ventilation to reduce energy cost of pumping outdoor air.

1.2.4 Industrial Ventilation and Exhaust Systems

Submit drawings including fan installation drawings; duct systems[, including welding and vehicle exhaust]; supports and anchor location and load imposed.

1.2.5 Start-Up Tests

Submit start-up tests reports in accordance with the paragraph TESTING,

ADJUSTING, AND BALANCING. Submit final test report for [the] system[s] tested, describing all test apparatus, instrumentation calculations, factors, flow coefficients, sound levels, and equipment data based on ACGIH-2092S recommended forms or reasonable facsimiles thereof to suit project conditions. Adjustment and setting data must be included in test report. Submit sound level test reports for high noise level equipment.

1.2.6 Related Requirements

Conform to Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS as well as additional requirements specified herein.

1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Industrial Ventilation and Exhaust Systems; G[, [_____]]

SD-03 Product Data

Fans; G[, [_____]]

Dampers; G[, [_____]]

Flexible Connectors

Flexible Duct; G[, [_____]]

Gaskets

Protective Coating Materials

Sealants

Access Ports; G[, [_____]]

Damper Regulators; G[, [_____]]

Blast Gates; G[, [_____]]

Vibration Isolators; G[, [_____]]

Ductwork, Dust [and Fume] Collection

Steel Ducts; G[, [_____]]

Fiberglass Ductwork; G[, [_____]]

Thermoplastic Ductwork; G[, [_____]]

Vehicle Tail Pipe Exhaust System; G[, [_____]]

Welding Fume Exhaust System; G[, [_____]]

Recycled Content of Ductwork Steel Components; S

Recycled Content of Protectively Coated Steel Ducts; S

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Fan Tests, including Sound Power Level Tests; G[, [_____]]

Ventilation and Exhaust System Start-Up Tests; G[, [_____]]

Sound Level Tests; G[, [_____]]

SD-07 Certificates

Welding Procedures; G[, [_____]]

Welding Test Agenda; G[, [_____]]

Welding Test Procedures; G[, [_____]]

Welders' Identification; G[, [_____]]

Fiberglass Fan Servicer Experience Information; G[, [_____]]

SD-10 Operation and Maintenance Data

Fans, Data Package 2; G[, [_____]]

Vehicle Tail Pipe Exhaust System, Data Package 2; G[, [_____]]

Welding Fume Exhaust System, Data Package 2; G[, [_____]]

Industrial Ventilation and Exhaust Systems, Data Package 2; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions

Submit text of posted operating instructions for ventilation and exhaust systems.

1.4 QUALITY ASSURANCE

1.4.1 Welders' Identification

Submit a listing of the names and identification symbols to be used to identify the work performed by the welder or welding operator who after completing a welded joint must identify it as his work by applying his assigned symbol for a permanent record.

1.4.2 Fiberglass Fan Servicer Experience Information

Submit text.

1.4.3 Qualified Personnel

Operations involving joining thermoplastic ductwork by solvent or hot gas and joining fiberglass ductwork by laminating must be performed by personnel certified by the manufacturer as qualified for the work.

1.4.4 Qualification of Welders

Qualify each welder or welding operator by tests using equipment, welding procedures and a base metal and electrode or filler wire from the same compatible group number that will be encountered in the applicable welding test procedures. Welders or welding operators who make acceptable procedure qualification test welds will be considered performance qualified for the welding procedure used. Determine performance qualification in accordance with AWS D1.1/D1.1M. Notify the Contracting Officer 24 hours in advance as to the time and place of tests[and wherever practical perform the tests at the work site].

1.4.5 TAB Requirements

Requirements are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING and Section 23 08 01.00 20 TESTING INDUSTRIAL VENTILATION SYSTEMS.

1.5 POSTED OPERATING INSTRUCTIONS

Provide for ventilation and exhaust system. In addition, permanently mark, drill, and pin as an integral part of device, final adjustment and settings pursuant to testing, adjusting, and balancing.

1.6 SAFETY PRECAUTIONS

1.6.1 Guards and Screens

Provide metal personnel safety guards for normally accessible unducted fan inlets and discharges and moving power transmission components in accordance with OSHA 29 CFR 1910.219.

1.6.2 Welding

Conform to AWS Z49.1 for safety in welding and cutting.

PART 2 PRODUCTS

2.1 FANS, GENERAL REQUIREMENTS FOR

2.1.1 General Performance, Component, and Other Requirements

Fans must have certified performance ratings as evidenced by conformance to the requirements of AMCA 211, and must be listed in AMCA CRP, or must be currently eligible for such listing. Fans must generally be in accordance with AMCA 99 unless superseded by other requirements stated elsewhere herein. Determine performance data for fans in accordance with AMCA 210. Select fans to minimize the exposure of personnel working in or occupying the immediate installation area. The total sound power level of the fan tests must not exceed 90 dBA when tested per AMCA 300 and rated per AMCA 301, or it must be provided with an appropriate attenuation device or devices. Scheduled fan performance is the performance required under specified or indicated installation conditions with specified or indicated accessories. The net installed air performance of the fan, with accessories/appurtenances in place, must be sufficient to meet the scheduled performance within the limits of the fan rating certification tolerance. Affix the manufacturer's product identification nameplate to each unit. Apply additional requirements for specific service or generic type or class of fan. If nonuniform air flow conditions are likely to be encountered, contact the fan manufacturer to ensure that the fan is rated for the additional fan inlet and outlet effect. Install fans to minimize fan system effect in accordance with AMCA 201. Fans must be listed in the Directory of Products licensed to use AMCA seal.

2.1.2 Bearings and Lubrication

****

NOTE: Sleeve type bearings should be specified or indicated on drawings where low noise levels are required.

****

Precision anti-friction or sleeve type with provisions for self-alignment and for radial and thrust loads imposed by the service. Provide water-cooled bearings where required for the service or recommended by the manufacturer.

2.1.2.1 Anti-friction Bearings

****

NOTE:

Continuous 8-hour service	**20,000**
Continuous 24-hour service	**40,000**
Continuous 24-hour service (extreme reliability)	**80,000**

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Constructed of steel alloys with a certified L-10 minimum rated life of [20,000] [40,000] [80,000] hours under load conditions imposed by the service. Rated and selected in accordance with ABMA 9 and ABMA 11. Provide with dust-tight seals suitable for environment and lubricant pressures encountered; cast ferrous metal housing, bolted-split pillow block type where located within fan casings; grease lubricated with provisions to prevent overheating due to excess lubricant; surface ball check type grease supply fittings. Provide manual or automatic grease pressure relief fittings visible from normal maintenance locations. Include lubrication extension tubes where necessary to facilitate safe maintenance during operation and fill tubes with lubricant prior to equipment operation. Prelubricated, sealed, anti-friction bearings, which conform to above specified materials and L-10 life requirements, may be provided for fans requiring less than 0.37 kW 1/2 horsepower.

2.1.2.2 Sleeve Bearings

Premounted, self-aligning, continuous oil supply, single or double ring lubricated, insert type, with suitable provisions for shaft expansion and such thrust as may be imposed by service loads. Provide water cooling for shaft surface speed exceeding 6.1 meters per second 1200 feet per minute. Provide each sleeve bearing with approximately 473 mL 16 ounce capacity constant level oiler and oil level gage. Include on sleeve bearing submittal data: Bearing manufacturing source, type, lubricant, clearances, "L/D" ratio, antifriction metal, belt angle, shaft speed, shaft critical speed, Brinell hardness at journal, and shaft surface finish at journal in micro-inches.

2.1.3 Motors and Motor Starters

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NOTE: The motor control requirements should be coordinated with the Electrical Section and will depend on field conditions. The following types of motor starters should be used as a guide only. When electrical power circuits to which ventilation and exhaust equipment are connected are heavily loaded, the full voltage across the line starting may result in excessive voltage drop on the circuits.

Power (kW)	Voltage	Type Starter
Up to 5 1/2	208-230	Across-the-line magnetic
5 1/2 to 11	208-230	Across-the-line magnetic part winding or wye delta
11 to 22 3/8	460	Across-the-line magnetic part winding or wye delta
Above 11	208-230	Part winding or wye delta
Above 22 1/2	460	Part winding or wye delta

Motor H.P.	Voltage	Type Starter
Up to 7 1/2	208-230	Across-the-line magnetic
7 1/2 to 15	208-230	Across-the-line magnetic part winding or wye delta
15 to 30	460	Across-the-line magnetic part winding or wye delta
Above 15	208-230	Part winding or wye delta
Above 30	460	Part winding or wye delta

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Conform to NEMA MG 1 and NEMA ICS 1 and NEMA ICS 2. Motors less than 3/4 kW one hp must meet NEMA High Efficiency requirements. Motors 3/4 kW one hp and larger must meet NEMA Premium Efficiency requirements. Motors must not exceed 1800 rpm, unless otherwise indicated, and must be variable-speed, [[open] [dripproof] enclosure] [totally enclosed fan cooled] [explosion proof] type. Provide [manual] [magnetic-across-the-line] [reduced voltage] [part-winding] [wye-delta] type motor starters with [general-purpose NEMA 1] [weather resistant NEMA 3R] [watertight NEMA 4] [moisture and dusttight NEMA 12] enclosure in accordance with NEMA ICS 6. Provide single-phase motors with inherent thermal overload protection with manual reset. Provide three-phase motors with thermal overload protection in the control panel. Provide permanently lubricated or grease-lubricated ball or roller bearings; auxiliary lubrication and relief fittings on outside of fan casing; arrange grease lines to minimize pressure on bearing seals. Motor power must not be less than brake power required with blades set at maximum pitch angle at any air delivery from the indicated amount down to 50 percent thereof.

2.1.4 Guards and Screens

Construct guards and screens to provide, as applicable: required strength and clearance with minimal reduction in free area at fan inlets and discharges; cooling; access panels for tachometer readings; ease of sectional disassembly for maintenance and inspection functions where guard total weight exceeds 22.70 kg 50 pounds; weather protection where components are weather exposed. Installed guards and screens must not

negate noise control and vibration isolation provisions.[For burn protection, insulate surfaces when service temperatures exceed 60 degrees C 140 degrees F as part of work under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.]

2.1.5 Power Transmission Components

2.1.5.1 Fan Drives

[Direct] [or] [V-belt] type as indicated. V-belt drives must conform to RMA IP-20 and RMA IP-22. Drives must be applied in accordance with the manufacturer's published recommendations, unless specified otherwise. Base power rating of a V-belt drive on maximum pitch diameter of sheaves. Provide classical belt section adjustable sheave type, with a minimum service factor of 1.5 for drives with motors rated up to and including 22 kW 30 hp.[Provide classical section or narrow section, fixed sheave or adjustable sheave type with a minimum 1.5 service factor for drives with motors rated over 22 kW 30 hp.][Provide at least two belts for drives with motors rated one hp and above.]

2.1.5.2 Sheaves

Statically and dynamically balanced, machined cast ferrous metal or machined carbon steel, bushing type, secured by key and keyway. Pitch diameter or fixed sheaves and adjustable sheaves, when adjusted to specified limits, must not be less than that recommended by NEMA MG 1. Select adjustable sheaves that provide the required operating speed with the sheave set at midpoint of its adjustment range. The adjustment range for various size and type belts must be: 16 percent, minimum for Classical section belts; 12 percent, minimum for Narrow section belts. [Belt deflection in adjustable sheave drives must not exceed 1 1/2 degrees.] Provide companion sheaves for adjustable sheave drives with wide groove spacing to match driving sheaves, except that standard fixed pitch spacing may be used for all two-through-four groove drives whose center-to-center dimensions exceed the following: "A" and "B" Section 406 mm 16 inches; "C" Section 635 mm 25 inches; "D" Section 914 mm 36 inches. Furnish endless, static dissipating, oil-resistant, synthetic cloth or filament reinforced elastomer construction belts.

2.1.6 Special Construction for Hazardous Areas

2.1.6.1 Spark-Resistant

Construct [_____] [specified or indicated] units in accordance with AMCA 99-0401; Type [A] [B] [C]. Provide [Type B] [or] [Type C] construction and electrical grounding of fan parts and grounding to building structure where fume or vapor handling systems conforming to NFPA 91 are specified. Do not place bearings in the air stream.

2.1.6.2 Explosion Proof

Construct fans to AMCA 99-0401, Type [A] [B] [C] spark-resistant requirements where explosion-proof electrical components are specified or indicated to conform to NFPA 70, Class [_____], Group [_____], Division [_____] requirements.

2.1.7 Protective Coating for Fans

Prepare and coat fans as follows: Replace bolts required to provide

access or adjustment and normally threaded into the coated surface with studs or bolts having heads continuously welded inside. Omit sharp edges, self-tapping screws, and permanent threads protruding into the coated surface. Eliminate hairline cracks and sharp inside corners by continuous welding, brazing, or filling with high melting point solder. Seal impeller hub to the shaft. Construct housing split to use external throughbolts. Flange inlet and outlet and consider as fan interior. Peen or grind welds smooth, and grind outside corners to approximately 1.60 mm 1/16 inch radius. Sandblast metal surfaces to white metal in accordance with SSPC SP 5/NACE No. 1. Coat interior surfaces of housing in contact with airstream, including inlet, impeller and shaft, flange faces, shaft seal, [exterior surfaces of housing] [, and bearing and motor pedestal]. Do not coat bearings, coupling, motor, drive, or other auxiliaries.[Prepare and coat stainless steel shaft.][Finish fan in accordance with the manufacturer's standard practice.][Coat fan with [phenolic] [epoxy] [_____].][Coat fan as indicated.] Statically and dynamically balance the fan in two planes after coating and finishing, and where material has been removed, refinish and rebalance the fan as specified herein.

2.2 CENTRIFUGAL FANS

2.2.1 General Requirements for Centrifugal Fans

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NOTE: See Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL for guidance given in guide specification technical notes. Definite requirements should be specified in contract specification for bidders' information.

****

Provide fan of [forward-curved] [radial] [backward inclined] [airfoil] type blades with [manual] [or] [automatic inlet vanes [as indicated]]. Arrange fans for indicated service, and construct for the applicable AMCA 99Class pressure ratings as indicated for system design pressure and temperature. Fan shaft must be solid steel, ground and finished as required for the service, with first critical speed a minimum 25 percent higher than cataloged fan speed. Select fan for maximum efficiency, minimum noise, and stability during all modes of system operation. [Vibration isolation mountings must be spring type and limit vibration transmissibility to a maximum [_____] [5] percent of the unbalanced force at lowest equipment speed, unless otherwise specified or indicated.] Arrangement and drives must be as indicated.

2.2.2 Industrial Exhauster[s]

****

NOTE: Use industrial exhausters for high particulate loading applications.

****

Single-width, single-inlet type arranged for indicated service and constructed for duty at indicated system design pressure and temperature not to exceed [66] [93] [177] [260] [371] degrees C [150] [200] [350] [500] [700] degrees F. Continuously welded [carbon] [alloy] [copper bearing alloy] [Type [_____] [304L] [316L] stainless] [steel] [[_____] alloy aluminum] scroll with required reinforcement, flanged inlet and outlet connections, [cone] inlet [bolted] [welded] to scroll side sheet, threaded and plugged scroll drain, [quick] [or] [bolted] access door with

gasket; [Carbon] [alloy] [Type [_____] stainless] steel shaft, [fitted with] [heat slinger] [shaft seal] [grease lubricated stuffing box]; continuously welded [carbon] [alloy] [copper bearing alloy] [Type [_____] [304L] [316L] stainless] [steel] [_____ alloy aluminum] impeller assembly. [_____] [radial] [paddle type (open radial)] [backplated paddle] type impeller blades [with inlet shroud].[Provide protective coating of [_____].] on fan surfaces exposed to [air] [fume] [vapor] stream; [Motor must be totally enclosed type.] Mount complete assembly including motor, power transmission components, and guards on a common vibration isolation base with spring mountings [conforming to requirements indicated].

2.2.3 Utility Set[s]

Single-width, single-inlet, nonoverloading scroll type. Scroll must be [intermittently] [or] [continuously] welded [carbon] [Type [304L] [316L] stainless] [steel] [_____ alloy aluminum] with required reinforcement, [flanged inlet and outlet connections], streamline orifice inlet bolted [and gasketed] to scroll side sheet, [threaded and] [plugged] [piped] [scroll drain,] [access door with gasket].[Carbon] [Type [304] [316] stainless] [steel] [monel] shaft finished as required [and fitted with] [heat slinger] [shaft seal] [grease lubricated stuffing box]; welded [carbon] [Type [304L] [316L] stainless] [steel] [_____ alloy aluminum] impeller assembly; [backward inclined] flat or single thickness airfoil type impeller blades. Provide protective coating of [_____] for [fan surfaces exposed to [air] [fume] [vapor] stream and weather.] Motor and power transmission components must be enclosed in ventilated weathertight hood. [Discharge must be fitted with an automatic gravity shutter constructed from [specified stainless steel] [aluminum].][Mount complete assembly from individual points of support on rails and vibration isolated by double-rubber-in-shear mountings] [conforming to requirements indicated].

2.2.4 In-line Centrifugal Fans

Welded steel casings, centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards and adjustable motor mounts. Inlet and outlet connections for fan casings to duct work and equipment casings, may be of the slip fit or flanged type. [Provide guards for discharges. Rate fans with guards in place.] Air must enter and leave the fan axially. Inlet must be streamlined and conversion vanes must eliminate turbulence and provide smooth discharge air flow. Enclose fan bearings and drive shafts, and isolate from the air stream. Fan bearings must be mechanically sealed against dust and dirt and must be self-aligning, pillow block ball or roller type. Motor and drive must be provided by fan manufacturer.

2.2.5 Fiberglass Centrifugal Fans

****

NOTE: Show intended service on drawing fan schedule or specify here. Revise paragraph if special chemical or corrosion resistance is required in accordance with manufacturer's recommendations.

****

ASTM D4167. Construct of fire retardant fiberglass with a flame spread rating at least equal to or less than that of the duct system. Housing and fan impeller must be fiberglass. Shaft and fan support stand must be steel with protective coating. Provide exterior gel coat, coating, or

paint with ultraviolet light inhibiting properties for fans exposed to sunlight. Fiberglass fans must be suitable for [the intended service.] [use in [_____]]. Provide with flanged outlet [and inlet] connections, [threaded [and plugged]] scroll drain, bolted access and inspection doors, and epoxy coated steel fan base and motor mount.

2.3 [VANEAXIAL] [TUBEAXIAL] FANS

Direct-connected with adjustable blade impeller or V-belt driven. When direct connected, fans must be driven by totally-enclosed, air-over (TEAO), flanged or end mounted motors. When belt-driven, provide internal and external belt guards and adjustable motor mounts.

2.3.1 Fan Impeller Blades

Air-foil type [with stationary guide vanes], designed to provide the efficiency [and sound level] indicated. In fan selection, consider and account for any losses due to the size of the motor in relation to the fan hub diameter. Impeller blades of direct-driven fans must be adjustable to permit varying performance over a range of volume and pressure. Index the hub to facilitate setting the angle of the blades uniformly and accurately from minimum to maximum angle; provide stops to avoid overloading motor. Furnish motor with the factory blade maximum setting included in the fan nameplate data.

2.3.2 Fan Casings

Cylindrical, or welded steel construction, with flanged inlets and outlets. Assemble motor support [and guide vanes] by welding. Provide casings with bolted or hinged access plates adequate for inspection and servicing of internal parts.

2.4 BATHROOM AND KITCHEN FANS

****
NOTE: Quiet operation will increase the likelihood that occupants will use fans.
****

Power used must be a maximum of 13 watts for 50 cfm fans; 15 watts for 70 cfm fans; 17 watts for 90 cfm fans; and 20 watts for 100 cfm fans. Noise levels must not exceed 0.5 sones for 50 to 70 cfm fans; 1.0 sones for 90 cfm fans; and 1.5 sones for 100 cfm fans. Fan lights must be compact fluorescent.

2.5 BASIC MATERIALS

2.5.1 Coated and Uncoated Carbon Steel Sheets, Plates, and Shapes

2.5.1.1 Mill Galvanized Steel Sheet

ASTM A653/A653M, lock forming quality, Coating G-90[, 204 degrees C 400 degrees F, maximum].

2.5.1.2 Mill Galvanized Steel Shapes

ASTM A36/A36M galvanized in accordance with [ASTM A123/A123M] [ASTM A653/A653M].

2.5.1.3 Uncoated (Black) Carbon Steel Sheet

ASTM A1011/A1011M.

2.5.1.4 Uncoated (Black) Carbon Steel Plates and Shapes

ASTM A36/A36M.

2.5.2 Corrosion Resistant (Stainless) Steel

ASTM A167, Type 304L or Type 316L with mill finish, except as otherwise specified.

2.5.3 Corrosion Protection

Treat equipment fabricated from ferrous metals that do not have a zinc coating conforming to [ASTM A123/A123M] [ASTM A653/A653M] for prevention of corrosion with a factory coating or paint system that will withstand 125 hours in a salt-spray fog test except that equipment located outdoors must withstand 500 hours. Perform salt-spray fog test in accordance with ASTM B117. Each specimen must have a standard scribe mark as defined in ASTM D1654. Upon completion of exposure, evaluate and rate the coating or paint system in accordance with procedures A and B of ASTM D1654. The rating of failure at the scribe mark must be not less than six (average creepage not greater than 3 mm 1/8 inch). The rating of the unscribed area must be less than ten (no failure). Thickness of coating or paint system on the actual equipment must be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness.

2.6 HEAT RECOVERY SYSTEMS

Heat recovery systems must be utilized in ventilation units (100 percent outside air units) where the temperature differentials between supply air and exhaust air is significant. Heat recovery systems must operate at a minimum of 70 percent efficiency. The heat recovery systems must have factory-installed microprocessor controller that in turn can be connected to a Direct Digital Control (DDC) Building Automation System to monitor temperatures, [wheel operation,] filter cleanliness, defrost control, and other critical conditions. Prefilters must be provided in all heat recovery systems before the heat recovery equipment.

2.6.1 Unit Casing

****
NOTE: Include bracketed sentences unless condensate drain is not needed or cross contamination is prevented by other methods.
****

Provide a self supporting unit casing constructed of minimum 1.1 mm 0.04 inches thick extruded aluminum profiles and aluminum zinc sheet steel that create a double wall.[The base of the casing must be constructed as a continuous condensate drain with a total of four connection possibilities.] The casing bottom, top, and sides must be insulated with 50 mm 2 inch thick fibrous glass insulation with a minimum density of 96 kg per cubic meter 6 lb per cubic foot or another material with equivalent insulating value.[Provide a partition to isolate the exhaust and supply airstreams from each other to avoid cross contamination.] Partition must

be a minimum of [1.9][_____] mm [0.075][_____] inches [galvanized steel] [aluminum]. Provide stainless steel casing for corrosive air streams. The casing must be designed for diagonal mounting of the heat exchanger access from the side for maintenance and cleaning. The casing must be designed with an integral defrost control damper on the heat exchanger section for defrost control. Provide full size access doors for checking the heat exchanger section.

2.6.2 Heat Exchanger Section

[2.6.2.1 Enthalpy Wheel

A desiccant-impregnated enthalpy wheel with variable speed rotary wheel must be used in the supply and exhaust systems. Wheels must contain media made of a lightweight polymer that is coated with a corrosion-resistant finish. Etched or oxidized surfaces are not acceptable. Heat transfer surfaces must be coated with a non-migrating (permanently bonded) absorbent.[Desiccant must be silica gel for maximum latent energy transfer.] Wheel must allow laminar flow but not radial, and prevent leakage, bypassing, and cross contamination by cross flow within wheel. The wheel must have rotor seals specifically designed to limit cross-contamination, and a rotation detector. Should rotation stop, the rotation detector must alarm the HVAC control system. Wheel must not condense water directly or require a condensate drain for summer or winter operation. Performance rating must be in accordance with AHRI 1060 I-P.

][2.6.2.2 Heat Pipe

For sensible heat recovery a run-around type heat pipe must use refrigerant to absorb heat from the air stream at the air intake and reject the heat back into the air stream at the discharge of the air-handling unit. The heat transfer between air streams must take place in a counterflow arrangement. The unit must have no moving parts and must be one piece construction. Tube core must be [18][25][_____] mm [5/8][1][_____] inch OD seamless aluminum tubing permanently expanded into the fins to form a firm, rigid and complete metal pressure contact between the tube and fin collar of all operating conditions. Provide copper tubes and copper fins for corrosive air streams. Secondary surfaces must be of continuous plate type aluminum fins, [0.18][_____] mm [0.007][_____] inch thick, and of corrugated design to produce maximum heat transfer efficiencies. System must have solenoid valve control to operate under partial load conditions.

][2.6.2.3 Run-around Coil

The run-around coils must be used at the exhaust discharge from the building and at the fresh air intake into the building.[A glycol run-around coil must be used with control valves and a pump for part load conditions.]

][2.6.2.4 Sensible Heat Recovery Unit

[A cross-flow, air-to-air (z-duct) heat exchanger must recover the heat in the exhaust and supply air streams. Z-ducts must be constructed entirely of sheet metal.] [Heat wheels must be used for sensible heat recovery. Unit must have variable speed drive for controlling the temperature leaving the unit. Wheels must contain media made of a lightweight polymer that is coated with a corrosion-resistant finish. Etched or oxidized surfaces are not acceptable. Wheel must allow laminar flow but not

radial, and prevent leakage, bypassing, and cross contamination by cross flow within wheel. The wheel must have rotor seals specifically designed to limit cross-contamination, and a rotation detector. Should rotation stop, the rotation detector must alarm the HVAC control system. Wheel must not condense water directly or require a condensate drain for summer or winter operation. Performance rating must be in accordance with AHRI 1060 I-P.]

]2.6.3 Defrost Control Damper Section

Provide an integral defrost control damper section with electric damper motor for defrost control of the heat exchanger section. The defrost control dampers must be mounted upstream of the heat exchanger section and must be capable of preventing frost build-up on the plates of the heat exchanger. Drain pan must be stainless steel. The damper motor must be located outside of both airstreams.

2.6.4 Angle Filter Box

Provide a side access, galvanized steel duct mounted filter box assembly with integral holding frames suitable for accommodating [50 mm2 inch][_____] thick filters with a minimum efficiency reporting value of 13. Provide filter box constructed of minimum 1.3 mm 0.05 inch thick galvanized steel with extruded aluminum tracks and individual universal holding frames with polyurethane foam gaskets and positive sealing clips designed to accommodate various standard size filters in various efficiency ranges. Provide access doors with positive sealing, heavy duty quick opening half-twist latches and sponge neoprene gasketing on each side of filter box for removal and replacement of filters. For each filter box provide one magnehelic gauge or inclined manometer with static pressure taps, shut-off and vent cocks, and aluminum tubing with range 50 to 1470 Pa 0.0073 to 0.21 psi.

2.7 FIRE DAMPERS

****
NOTE: Use 1 1/2 hour rated damper for up to 2 hour fire walls. Use 3 hour rated damper only for 3 hour or 4 hour fire walls.
****

Provide [_____] [single leaf] [guillotine] [recessed] [hinged] [type] [curtain type with interlocking blades] [with frame and operating mechanism housed out-of-[air] [fume] [vapor] stream,] constructed and rated in accordance with AMCA 500-D. Furnish dampers for indicated stream flow, to equal or exceed fire resistance rating of [1 1/2 hours] [3 hours]. Fire damper must be rattle-free and must cause a minimum [5] [10] percent increase in stream velocity or system static pressure.[For [_____] system[s], stream exposed materials of construction must be [_____].] Provide building penetration collars in accordance with AMCA 500-D [and NFPA 91], [unless otherwise indicated]. Provide one spare fusible link for testing of each fire damper operation and one spare fusible link for each [10] fire dampers, but not less than two.

2.8 MISCELLANEOUS MATERIALS

2.8.1 Filler Metal, Welding

AWS filler metal specification and grade compatible with base materials to

develop full joint strength.

2.8.2 Flashing Materials

[Mill galvanized, phosphatized, steel sheet with minimum spangle, conforming to ASTM A653/A653M, Coating G90, 24 gage minimum thickness. Mill No. 1 or 2D finished, stainless steel, fully annealed, soft temper, conforming to ASTM A167, Type 304, 0.38 mm 0.015 inch minimum thickness. Mill finished copper, conforming to ASTM B152/B152M, minimum 1487 gram per square meter 16 ounces per square foot.][As specified in Section [07 60 00] FLASHING AND SHEET METAL.]

2.8.3 Flexible Connectors

2.8.3.1 General Service

Airtight, fire-retardant, fume and vapor resistant, chloroprene or chlorosulfonated polyethylene impregnated, woven fibrous glass fabric, rated for continuous service at 121 degrees C 250 degrees F, conforming to UL 214, with 678 gram per square meter 20 ounce per square yard weight for service at 498 Pa 2 inches water gage and under and 1017 gram per square meter 30 ounce per square yard weight for service over 498 Pa 2 inches water gage. Provide with or without integral 24 gage mill galvanized sheet metal connectors.

2.8.3.2 Acoustic Service

Provide as second layer for nonpressure service to 60 degrees C 140 degrees F, leaded sheet vinyl, a minimum 1.40 mm 0.055 inches thick, weighing a minimum 20.60 kg per square meter 0.87 pounds per square foot, capable of 10 dBA attenuation in 10 to 10,000 Hz range, suitable for solvent seam or overlap joining and banding.

2.8.3.3 [Fume] [Dust Collection] Service

[3 mm][1/8 inch] [_____] thick, single-ply, synthetic fabric reinforced chloroprene suitable for 107 degrees C 225 degrees F.

2.8.3.4 High Temperature Service

a. Bellows type metal expansion joints, temperature range minus 29 degrees C to [427] [538] degrees C 20 degrees F to [800] [1000] degrees F, plus or minus 25 kPa 100 inches water gage [with interior liner [and exterior cover]].

b. Fabric reinforced, insulated, elastomeric cover expansion joint for operating temperature up to [204 degrees C] [400 degrees F][_____] [belt] [or] [flange] type for [10 kPa gage] [40 inches water gage] [_____] positive or negative pressure [, with interior liner or baffle].

2.8.4 Flexible Duct

****
NOTE: The designer must indicate on the drawings the types of flexible duct required.
****

2.8.4.1 Metallic Type

Single-ply [zinc-coated carbon steel] [mill galvanized carbon steel] [Type 316 stainless steel] [two-ply aluminum], [self-supporting to 2.50 meters 8 foot spans] with corrugated and interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius approximately 10 times the duct diameter, airtight, rated for positive or negative working pressure of 3735 Pa 15 inches water gage at [177 degrees C350 degrees F for aluminum] [343 degrees C650 degrees F for galvanized steel and stainless steel] UL 181, Class 1 rated, conforming to NFPA 91.

2.8.4.2 Wire Reinforced Fabric Type

Elastomer impregnated woven synthetic fabric, bonded to and supported by corrosion protected or corrosion resistant spring steel helix, rated for positive or negative working pressure of [3735 Pa gage at 121 degrees C] [15 inches water gage at 250 degrees F] [_____] UL 181, Class 1 labeled. Provide with manufacturer's standard metallic connection collar and clamping fastener assembly [fitted with] [dampers] [and] [extractors] [as indicated].

2.8.4.3 Ball Joints

Fabricated from cast iron or formed sheet metal with outer sections secured with bolts. Provide each half of the ball joint with tubular stubs for connecting ducts.

2.8.4.4 Slip Joints

Fabricated from tubular sheet metal sections. Provide outer tube with formed steel flat bar clamps. Where required or indicated, provide a chain or other means to fix relative longitudinal position of outer and inner joint sections.

2.8.5 Gaskets

2.8.5.1 Elastomer Buna N

Sheet, 3 mm 1/8 inch thick, conforming to ASTM D2000, Type 2BG410B14.

2.8.5.2 Elastomer Chloroprene

Sheet, 3 mm 1/8 inch thick, conforming to ASTM D2000, Type 2BE410B14.

2.8.5.3 Rubber

Sheet, 3 mm 1/8 inch thick red or black, natural, reclaimed, synthetic rubber or mixture thereof, conforming to ASTM D1330.

2.8.6 Protective Coating Materials

2.8.6.1 Baked Unmodified Phenolic

MIL-DTL-12276, Type II.

2.8.6.2 Epoxy Coating

Conform to MIL-PRF-23236, Type I, Class 1 or MIL-DTL-24441 system, Formula

150 green primer 0.076 mm 3 mils, Formula 151 haze gray 0.076 mm 3 mils, and Formula 152 white 0.076 mm 3 mils.

2.8.6.3 Inorganic Zinc Coating

SSPC Paint 20, Type I-C (Self-cure type).

2.8.6.4 Galvanizing Repair Paint

Conform to MIL-P-21035.

2.8.7 Sealants

2.8.7.1 Elastomeric

Sealant specified in these specifications or referenced standards as elastomeric or without further qualification, must be silicone, polyurethane, polysulfide, polyisobutylene, or acrylic terpolymer suitable for the service. For sealing of nongasketed duct joints during fabrication or assembly, sealant must be polyurethane, acrylic terpolymer or polysulfide. Sealants must conform to the following:

a. Silicone: Conforming to FS TT-S-001543, single component type, not requiring primed substrate, with manufacturer published estimated life of 30 years and a maximum 5 percent shrinkage when cured.

b. Polyurethane: Conforming to ASTM C920, Type 2, Class A, single component type, not requiring primed substrate, with manufacturer published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

c. Polysulfide: Conforming to ASTM C920, Type 2, Class A, single component type, not requiring primed substrate, with manufacturer published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

d. Polyisobutylene/Butyl: Conforming to CID A-A-272, Type 1, single component type, not requiring primed substrate, with manufacturer published estimated life of 10 years and a maximum 15 percent shrinkage when cured.

e. Acrylic Terpolymer: Conforming to ASTM C920, single component type, not requiring primed substrate, with manufacturer's published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

f. Provide sealants and non-aerosol adhesive products meeting either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants must be classified in the "Other" category within the SCAQMD Rule 1160 sealants table). Provide validation of indoor air quality for duct sealants.

2.8.7.2 Heat Shrinking over Round Exterior Duct

High molecular weight, irradiated polyethylene band with interior heat activated epoxy adhesive coating for heat shrinking and epoxy extrusion over round, exterior, duct joints.

2.8.7.3 Hard Cast Caulking for Exterior Ducts

Mineral and adhesive impregnated woven fiber tape with adhesive activator for exterior round or rectangular duct joints.

2.8.7.4 Caulking of Building Surface Penetration

Foamed silicones, two-component, fire-resistant, [gamma radiation resistant], low-exotherm, room temperature vulcanizing silicone.

2.9 SPECIALTIES

Steel, cast iron, stainless steel, nonferrous metal, or plastic to match duct construction, or as indicated.

2.9.1 Access Ports, Test

With gasketed screw cap and flange, to suit exhaust service[, 25 mm one inch nominal pipe size].

2.9.2 Damper Regulators

Incremental position indicating and locking type, with satin finish chrome plated, flush surface mounting cover and regulator box where concealment is required in finished spaces. For splitter dampers, provide splitter tip mounted trunnion brackets with self-locking screw regulator or rods with external swivel joint brackets.

2.9.3 Blast Gates

Provide means for locking in adjusted position with bolt and nut.

2.9.4 Cast Iron Access Door

Cast iron frame, [hinged and] gasketed cast iron door, quick closing clamps for watertight sealing[, size as indicated][, 152 by 229 mm 6 by 9 inches minimum size].

2.10 SUPPORTS AND HANGERS

****

NOTE: The designer must design all supports, including wind bracing for stacks, and show all important details on the drawings. SMACNA Accepted Industry Practice for Industrial Duct Construction is illustrative and does not fix sizes of supports or allowable loads. Refer to SMACNA round and rectangular duct construction standards for design tables and other information.

****

2.10.1 General Requirements for Supporting Elements

Provide ducting systems and equipment supporting elements including but not limited to building structure attachments; supplementary steel; hanger rods, stanchions and fixtures; vertical duct attachments; horizontal duct attachments; anchors; supports. Design supporting elements for stresses imposed by systems, with a minimum safety factor of 4.0 based on duct

being 50 percent full of particulate conveyed. Supporting elements must conform to SMACNA 1403, SMACNA 1922, SMACNA 1520, [SMACNA 1378,] and NFPA 91, as applicable, and modified and supplementary requirements specified herein. Do not use weld studs and powder actuated anchoring devices to support mechanical systems components without prior approval.

2.10.2 Vertical Attachments

Provide in accordance with SMACNA Standards, except mill galvanized iron straps must be a minimum of 25 mm one inch wide, 16 gage thick.

2.10.3 Horizontal Attachments

Provide as indicated in accordance with SMACNA Standards.

2.10.4 Supplementary Steel

Provide where required to frame structural members between existing members or where structural members are used in lieu of commercially rated supports. Such supplementary steel must be fabricated in accordance with the AISC 360.

2.10.5 Vibration Isolators

****
NOTE: See Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL for guidance given in guide specification technical notes. Definite requirements should be specified in contract specification for bidders' information.
****

[Provide vibration isolators with in-series, contained, steel springs, chloroprene elastomer elements, and fasteners for connecting to building structure attachments. Devices must be loaded by support system in operating condition to produce required static spring deflection without exceeding 75 percent of device maximum load rating.] [Conform to Section [22 05 48.00 20] MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.]

2.11 DUCTWORK, DUST [AND FUME] COLLECTION

2.11.1 General Requirements for Dust [and Fume] Collection Ductwork

****
NOTE: Delete all welded seams and flanged joints when not required. However, factors such as water intrusion under negative pressure in weather exposure should be considered when construction which is not leak-tight is permitted for the project. Duct conveying fumes subject to condensation should be leak-tight.
****

****
NOTE: Use materials with recycled content where appropriate for use. Verify suitability, availability within the region, cost effectiveness and adequate competition before specifying product recycled content requirements.

Research has shown that products are available meeting the recycled content requirements stated below.
****

[Where specified or indicated] [_____] fabricate system ductwork from black carbon steel [, with welded seams and flanged and gasketed joints]. Provide steel with a minimum of 70 percent recycled content. Provide data identifying percentage of recycled content of ductwork steel components. Construct duct to handle [_____] [wood dust] particulate with an influent loading of [15,000 grains per [standard liter per second (L/s)] [actual L/s]] [7,000 grains per [standard cubic feet per minute (scfm)] [actual cubic feet per minute (acfm)] [_____]]. Provide ductwork in accordance with best practice recommendations and requirements of SMACNA 1922 and SMACNA 1520, for [Class I] [Class II] [Class III] [Class IV] duct and requirements specified or indicated.

2.11.2 Fabrication of Dust [and Fume] Collection Ductwork

****
NOTE: Delete all welded seams and flanged joints when not required. However, factors such as water intrusion under negative pressure in weather exposure should be considered when construction which is not leak-tight is permitted for the project. Duct conveying fumes subject to condensation should be leak-tight.
****

Provide indicated sizes, lengths and configuration without deviation unless otherwise approved. Assemble ductwork airtight [as defined under paragraph DUCTWORK STRUCTURAL INTEGRITY AND LEAKAGE TESTING in this section] and include necessary reinforcements, bracing, supports, framing, gasketing and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion, and excessive deflection. For [_____] system, provide SMACNA Class 1 construction with any of the reference standard seams and connections being acceptable [, except [_____]]. For [_____] system, provide SMACNA Class [2] [3] [4] construction with welded duct and fitting seams and welded companion angle or Van-Stone flanges. Welding must conform to requirements specified herein. Provide flanges at [branches] [hoods,] [equipment] [and] [enclosure connections,] where necessary for ease of access to equipment or maintenance disassembly, and where indicated. Provide elbows and fittings a minimum 2 gages heavier than straight ducts of equal diameter.

2.11.3 Radius Elbows

Fabricated from butt welded specified piece gore sections or from formed welded or seamless tubing to a minimum centerline radius of [2.0] [2.5] [_____] diameters. Assemble, weld, and finish ground gore sections to eliminate internal projections. Construct gored elbow in accordance with the following:

400 mm diameter and less 16 inches diameter and less	Over 400 mm diameter Over 16 inches diameter
90 degree - 5 piece minimum	90 degree - 7 piece minimum
60 degree - 4 piece minimum	60 degree - 6 piece minimum
45 degree - 3 piece minimum	45 degree - 5 piece minimum
30 degree - 3 piece minimum	30 degree - 4 piece minimum
15 degree - 2 piece minimum	15 degree - 3 piece minimum

2.11.4 Flanged Joints

Gasketed with full face gaskets 3 mm 1/8 inch thick red or black rubber as specified under paragraph MISCELLANEOUS MATERIALS in this section.

2.11.5 Access Doors

Provide hinged, gasketed, and fitted with snap-action closures access doors. Equip access door with gaskets of common weather stripping type, foamed, closed-cell, elastomer with pressure sensitive adhesive back. Provide cleanout adjacent to every bend and vertical riser. In horizontal duct runs, locate cleanout door with maximum of spacing of 4 meters 12 feet for ducts 300 mm 12 inches or less in diameter and 6 meters 20 feet for larger ducts.

2.11.6 Flexible Connectors

[Provide drawband secured flexible connectors, conforming to requirements specified under paragraph MISCELLANEOUS MATERIALS in this section, utilizing 3 mm 1/8 inch thick reinforced elastomer, fabricated into a cylindrical shape by vulcanizing or otherwise bonding longitudinal seam.] [Provide flange secured flexible connectors, conforming to requirements specified under paragraph MISCELLANEOUS MATERIALS in this section, utilizing bellows type metal expansion joint. Where service temperature exceeds 149 degrees C 300 degrees F, insert 25 mm one inch thickness of mineral wool.]

2.12 PROTECTIVELY COATED STEEL DUCTS

Ductwork, Protectively Coated Steel, For Corrosive Fume and Vapor Exhaust:

2.12.1 General Requirements for Protectively Coated Steel Ductwork

****

NOTE: Use materials with recycled content where appropriate for use. Verify suitability, availability within the region, cost effectiveness and adequate competition before specifying product recycled content requirements.

Research has shown that products are available meeting the recycled content requirements stated below.

****

Fabricate [_____] system ductwork from black carbon steel with welded seams, flanged and gasketed joints and protectively coated interior surfaces including flange faces, provide steel with a minimum of 70 percent recycled content. Provide data identifying percentage of recycled content of protectively coated steel ducts. Construct ductwork to handle [_____] [fumes] [condensing] [noncondensing] [vapors] containing [_____]. Spiral welded duct is prohibited. Provided ductwork in accordance with best practice recommendations and requirements of SMACNA 1922 and SMACNA 1520, for Class [IV] [_____] duct.

2.12.2 Protective Coating

Provide [_____] [and] [_____] protective coatings as specified under PROTECTIVE COATING MATERIALS, a subparagraph of MISCELLANEOUS MATERIALS in this section. Provide [_____] coating to interior of duct [and related fan] surfaces. Coat exterior duct [and related fan] surfaces with same protective coating as specified for exterior surfaces [primed with] [inorganic zinc coating] [_____].[Exterior fan surfaces must be finished [protectively coated] [primed] [as specified under paragraph, "_____".]][Field finish exterior surfaces which have only been primed, as specified in Section 09 90 00 PAINTS AND COATINGS.]

2.12.3 Fabrication of Protectively Coated Ductwork

Construct protectively coated ductwork for corrosive fume and vapor exhaust in accordance with SMACNA 1922 and SMACNA 1520 and as specified herein. Provide indicated sizes, lengths and configuration without deviation, unless otherwise approved. Spiral welded duct is prohibited. Install ductwork to be water washable, watertight, self-draining, and airtight [as defined under paragraph DUCTWORK STRUCTURAL INTEGRITY AND LEAKAGE TESTING in this section]. Provide necessary reinforcements, bracing supports, framing, gasketing, and drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion, and excessive deflection. Rigid construction is required to prevent damage to or failure of protective coating during construction, transport, erection, and on-off system operation. Only companion angle flanged joints must be permitted. Weld ducting and fittings seams. Avoid seams in bottom 80 mm 3 inchesof ducting and in corners wherever practical by bending of corners and arranging seams high in the side sheets or top sheet. Cracks, laps, sharp inside corners, sharp sheared edges, weld "icicles," flux, pits, weld spatter, burrs, and similar defects which contribute to coating discontinuities must be eliminated by the following: a) welding continuously, b) grinding of metal flush with surface or to 0.8 mm 1/32 inch radius or to maximum radius permitted by thinner metals, c) Utilizing other fabrication techniques and subsequent surface preparation abrasive blasting. Removed from the job site for repair rejected ducting not conforming to these requirements and which exhibit coating thickness deficiency. Welding must conform to requirements specified herein. Continuously weld companion flange angles to the inside of the duct and intermittently weld with 25 mm one inch welds every 100 mm 4 inches on outside of duct. Intermittently weld girth and transverse reinforcements to duct surface for 25 mm one inch on 152 mm 6 inch centers or spot welded on 100 mm 4 inch centers. Weld and grind flange and reinforcement angles at corners or ends to form continuous frames. Provide flanges at [branches,] [hoods,] [equipment] [and] [enclosure connections,] where necessary for ease of access to equipment or maintenance disassembly, and where indicated. Limit duct lengths in accordance with size, to permit complete and ready access for

welding, grinding, blasting, coating, coating continuity checking and testing, and visual inspection during fabrication and immediately prior to erection.

2.12.4 Radius Elbows

Fabricated radius elbows from butt welded specified piece gore sections or from formed welded or seamless tubing to a minimum centerline radius of [2.0] [_____] diameters and preferably 2.5 times the duct diameter. Assemble, weld, and finish ground gore sections to prevent internal crevices and projections. Construct gored elbow in accordance with the following:

400 mm diameter and less 16 inches diameter and less	Over 400 mm diameter Over 16 inches diameter
90 degree - 5 piece minimum	90 degree - 6 piece minimum
60 degree - 4 piece minimum	60 degree - 5 piece minimum
45 degree - 3 piece minimum	45 degree - 4 piece minimum
30 degree - 3 piece minimum	30 degree - 3 piece minimum
15 degree - 2 piece minimum	15 degree - 2 piece minimum

2.12.5 Flanged Joints

Gasketed with full-face gaskets which are one-piece, heat, adhesive or solvent vulcanized, or bonded and assembled to prevent drainage and limit extrusion or cavity at joint.

2.12.6 Access and Cleanout Door Openings

Provide access plates upstream and downstream of equipment installed in ductwork, at locations to facilitate duct cleaning (such as in horizontal runs, near elbow junctions, and vertical runs), and where indicated. For ducts 300 mm 12 inches diameter or less, locate cleanout or access openings a minimum of 3.70 meters 12 feet apart. Provide 250 by 300 mm 10 by 12 inches minimum size access opening; unless otherwise indicated or prevented by duct dimension. Locate opening a minimum of 80 mm 3 inches from bottom of duct. Frame access openings by welded and ground miter joint 5 mm 3/16 inch thick strap iron, or angle iron, with 6 mm 1/4 inch stainless steel bolt or stud assembly to duct on 100 mm 4 inch centers. Fabricate plates out of 300 series corrosion-resistant steel or polyvinyl chloride faced sheet backed by 16 gage sheet metal, reinforced as required for larger sizes, or constructed of heavier gage metal. Ensure only corrosion resistant materials are expose to duct interior. Provide one "U" handle on access plates through 250 by 300 mm 10 by 12 inches and two "U" handles on larger sizes. Locate access openings at points which will permit ready access to duct internals with no duct cutting. Where access through equipment or access doors specified herein is not available at a specific point, provide 200 mm 8 inch diameter gasketed access plates spaced on maximum 3 meters 10 foot centers. Where penetration of duct surfaces is approved or specified, provide 300 series corrosion resistant steel fastener assemblies. Provide hex type, cadmium plated flange fastener bolts and nuts and [3 mm1/8 inch thick acid resistant

chloroprene] [3 mm1/8 inch thick Buna N] joint gaskets.

2.13 THERMOPLASTIC DUCTWORK

****
NOTE: Duct systems of plastic material may be used to handle only nonflammable corrosive fumes and vapor when conventional metal duct systems will not be adequate.
****

****
NOTE: SMACNA Thermoplastic Duct (PVC) Construction Manual is applicable to fume exhaust systems construction and installation requirements for round and rectangular PVC ductwork for positive and negative pressure systems operating in environments up to 27 degrees C at 498 Pa, 1493 Pa, and 2488 Pa 80 degrees F at 2 inches, 6 inches, and 10 inches water gage. The requirements of this standard are applicable specifically to Classes 12454-B and 12454-C PVC compounds as defined in ASTM D1784, Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds. The designer must indicate on the drawings the static pressure classification (498 Pa, 1493 Pa, or 2488 Pa2 inches, 6 inches, or 10 inches water gage positive or negative) to which each duct system (or each portion of a duct system) is to be constructed.
****

2.13.1 Ductwork

Construct ductwork, fittings, hoods, and accessories in accordance with SMACNA 1378 and NFPA 91. Fabricate supplementary steel in accordance with the AISC 360.

2.13.2 Product Requirements

Provide duct system from a manufacturer recognized in the field of fabrication of PVC material. Fabricating personnel must be certified by the manufacturer as qualified to perform the work in accordance with the specified requirements.

2.13.3 Basic Ductwork Materials

Fabricate ducts, hoods, accessories and components in sheet form from materials conforming to ASTM D1927, [Type I, Grade 1] [Type I, Grade 2]. Utilize extrusions of the same compounds as specified for duct. Solvent cement must conform to ASTM D2564. Construct metal components, when permitted to be located interior to the duct, of [Type] [304 or 304L] [316 or 316L] [_____] [corrosion resistant steel] [_____].

2.13.4 Fasteners

Where penetration of duct surfaces is approved or specified, provide Type 316 corrosion resistant steel fastener assemblies encapsulated with polyester on duct interior, unless total disassembly is intended. Provide flange fastener bolts and nuts of hex type only, cadmium plated, unless

exposed to corrosive fumes; in which case provide Type 316 stainless steel. Equip bolted assemblies with two oversized washers, except where assembled with metallic reinforcement contact. Plastic bolting is prohibited.

2.13.5 Joint Gaskets

Provide [3 mm1/8 inch thick acid resistant chloroprene.] [3 mm1/8 inch thick Buna N.]

2.13.6 Fabrication

Construct water washable, watertight, self-draining, and airtight ductwork as specified or indicated. Provide required reinforcements, bracing, supports, framing, gasketing, sealing, resilient mounting, drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion and noise, and excessive deflection at specified maximum system pressure and velocity.

2.13.6.1 Flanges

Provide flanges at all branches on maximum 6 meters 20 foot centers in ducting sized 400 mm 16 inches and under, on maximum 2.40 meters 8 foot centers in duct sized over 400 mm 16 inches, where required for ease of access to equipment, at hoods, enclosure connections and where indicated. Furnish one piece, heat, adhesive, or solvent vulcanized or bonded full face gaskets at flange joints.

2.13.6.2 Access Plates

Provide access plates upstream and downstream of equipment in ducts at locations to facilitate duct cleaning, and where indicated. Locate access openings a minimum of 50 mm 2 inches above bottom of duct and externally frame with welded and ground miter joint steel which is isolated from duct interior. Construct access plate with PVC on interior side, backed with steel on exterior side. Provide stainless steel access plate fasteners. For ductwork cleaning access, provide 200 mm 8 inch diameter gasketed access plates on maximum 3 meters 10 foot on centers, except where access is available through an air terminal device or other required access.

2.14 FIBERGLASS DUCTWORK

****

NOTE: Duct systems of plastic material may be used to handle only nonflammable corrosive fumes and vapor when conventional metal duct systems will not be adequate.

****

Ductwork, Fiberglass for Nonflammable [Corrosive] [Fume] [Vapor] Exhaust:

2.14.1 Fiberglass Ductwork

Construct ductwork, fittings, accessories, and material of construction in accordance with NFPA 91, and ASTM C582. Fabricate supplementary steel in accordance with the AISC 360.

2.14.2 Basic Ductwork Materials

****
NOTE: Fill in resin characteristics from ASTM C582 if necessary. Verify suitability of Type 316 stainless steel for the specific chemical exposure; for example, chromic acid attacks Type 316 stainless steel. Revise as required.
****

****
NOTE: Designer must verify that products meeting the indicated minimum recycled content are available, preferably from at least three sources, to ensure adequate competition. If not, write in suitable recycled content values that reflect availability and competition.
****

Fabricate ducts, accessories and components in sheet form from materials conforming to ASTM C582 [, RTP [_____]]. Provide exterior gel coat, coating or paint with ultraviolet light inhibiting properties for ducts exposed to sunlight. Construct metal components, when permitted to be located interior to the duct, of Type 316 corrosion resistant steel.

2.14.3 Fasteners

Where penetration of duct surfaces is approved or specified, provide Type 316 corrosion resistant steel fastener assemblies encapsulated with polyester on duct interior, unless total disassembly is intended. Provide flange fastener bolts and nuts of hex type only, cadmium plated, unless exposed to corrosive fumes; in which case provide Type 316 stainless steel. Equip bolted assemblies with two oversized washers, except where assembled with metallic reinforcement contact. Plastic bolting is prohibited.

2.14.4 Joint Gaskets

Provide [3 mm1/8 inch thick acid resistant chloroprene.] [3 mm1/8 inch thick Buna N.]

2.14.5 Fabrication

Construct water washable, watertight, self-draining, and airtight ductwork as specified or indicated. Provide required reinforcements, bracing, supports, framing, gasketing, sealing, resilient mounting, drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion and noise, and excessive deflection at specified maximum system pressure and velocity.

2.14.5.1 Flanges

Provide flanges at all branches on maximum 6 meters 20 foot centers in ducting sized 400 mm 16 inches and under, on maximum 2.40 meters 8 foot centers in duct sized over 400 mm 16 inches, where required for ease of access to equipment, at hoods, enclosure connections and where indicated. Furnish one piece, heat, adhesive, or solvent vulcanized or bonded full face gaskets at flange joints. Provide flanges at dissimilar material joints, such as between fiberglass reinforced plastic (FRP) and PVC.

2.14.5.2 Access Plates

Provide access plates upstream and downstream of equipment in ducts at locations to facilitate duct cleaning, and where indicated. Locate access openings at least 50 mm 2 inches above bottom of duct and externally frame with welded and ground miter joint steel which is isolated from duct interior. Construct access plate with fiberglass on interior side, backed with steel on exterior side. Provide Type 316 stainless steel access plate fasteners. For ductwork cleaning access, provide 200 mm 8 inch diameter gasketed access plates on not more than 3 meters 10 foot centers, except where access is available through an air terminal device or other required access provision.

2.15 VEHICLE TAIL PIPE EXHAUST SYSTEM

****

NOTE: Specifications included are for maintenance work. Dynamometer applications require revised specifications with special considerations for high temperatures involved. Following are kW/cms horsepower/cfm of exhaust gas recommendations for sizing system and hoses for maintenance work applications.

Maintenance-gasoline: 223 (kW/0.07 m3/s; 261/0.09; 373/0.19 299 (HP)/150 (CFM); 350/200; 500/400

Maintenance-diesel: 224/0.19; 373/0.28; 522/0.47 300/400; 500/600; 700/1000

Turbo-charged diesel: to 373/0.66 500/1400

****

2.15.1 General Requirements for Vehicle Tail Pipe Exhaust System

Provide a hanging [exposed overhead] [disappearing overhead] [disappearing underfloor] [nondisappearing (plug-in underfloor)] type vehicle tail pipe exhaust system. Construct and install in accordance with applicable requirements of NFPA 91.

2.15.2 Ductwork

Construct ducts and miter or stamped fittings with galvanized steel. Duct sheet metal gages must conform to Class I in SMACNA 1922 and SMACNA 1520.

2.15.2.1 Suction Side Ductwork

Construct suction side ductwork with lock groove seam longitudinal joints. Connect circumferential joints between sections with push-on or bead and crimp type, secured with a minimum 4 rivets or screws on ducts up to and including 100 mm 4 inches diameter, and with screws or rivets a minimum 80 mm 3 inches on center on larger sizes of duct. Lap joints in the direction of air flow. On disappearing overhead systems, assemble roller duct sections using pop rivets. Solder all joints or construct ductwork leak-tight as for discharge side ductwork below.

2.15.2.2 Discharge Side Ductwork

Construct ductwork on the discharge side of the fan leak-tight with joints and seams welded, brazed, or soldered. Provide flanges with suitable gaskets, where required. Repair damaged galvanizing with galvanizing repair compound.

2.15.3 Fan

****
NOTE: The criteria for special AMCA construction for protective coating can be further delineated here or incorporated into referenced paragraph, if this is the only fan. Specify welded Class II construction only where required.
****

****
NOTE: See Section 22 05 48.00 20, MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL for guidance given in guide specification technical notes. Definite requirements should be specified in contract specification for bidders' information.
****

Comply with paragraph CENTRIFUGAL FANS in this section [, subparagraph UTILITY SET,] and special requirements for protective coatings.[Provide unit of all welded construction, utilizing minimum 14-gage carbon steel in AMCA Class II construction.] [Internal and external protective coating must be manufacturer's standard, engineered quality type, with properties comparable to [air-dry or baked phenolic,] [or] [epoxy] applied in multiple coats of 0.10 to 0.15 mm 4 to 6 mil dry film thickness.] [Mount entire assembly for vibration isolation on structural steel base and spring or elastomer type isolators with minimum transmissibility of [10] [5] percent.][Provide split sleeve or flexible connection at fan inlet.]

2.15.4 Flexible Tail Pipe Exhaust Tubing and Connectors

Provide interlocking helical seam metallic type construction of 0.3 mm 0.012 inch minimum thickness up to and including 150 mm 6 inch diameter and 0.51 mm 0.020 inch minimum thickness over 150 mm 6 inches diameter Type 302, 304, or 321 corrosion-resistant steel [with inside diameter] [and length as shown.] [of] [80] [100] [125] [150] [200]mm and [_____] meters in length [3] [4] [5] [6] [8] [inches] and [_____] feet in length. Connect to duct by welding or with screws or flanged joint with gasket [and fit with tail pipe adapters constructed of minimum 20 gage Type 300 or 400 Series stainless steel, and which include provisions for secure tail pipe attachment]. Secure hose terminal connections by screws, clamps, or flanged connections.[Provide winch operated hose assembly.]

2.15.5 Supporting Elements

Support ducting [as indicated] with anti-sway bracing to resist perceptible movement in response to forces imposed by flexible tubing location on handling. Suspend tubing from overhead location and provide means to raise and lower for use. Assemble suspension system with rigid pulley restraint, 3 mm 1/8 inch diameter aircraft cable, pulleys, and manually operated winch fitted with safety ratchet lock and slip resistant hand grip.

2.16 WELDING FUME EXHAUST SYSTEM

2.16.1 General Requirements for Welding Fume Exhaust System

Provide a [hanging] [long reach type] welding fume exhaust system as specified and indicated. Construct and install in accordance with applicable requirements of NFPA 91.

2.16.2 Ductwork

Construct ducts and stamped fittings with galvanized steel. Duct sheet metal gages must conform to Class I in SMACNA 1922 and SMACNA 1520.

2.16.2.1 Suction Side Ductwork

Construct suction side ductwork with lock groove seam longitudinal joints. Connect circumferential joints between sections with push-on or crimp and bead type, secured with a minimum 4 rivets or screws up to and including 100 mm 4 inches diameter, and with screws or rivets a maximum 80 mm 3 inches on center on larger sizes of duct. Lap joints in the direction of air flow.

2.16.2.2 Discharge Side Ductwork

Construct ductwork on the discharge side of the fan leak-tight with joints and seams welded, brazed, or soldered. Provide flanges with suitable gaskets, where required. Repair damaged galvanizing with galvanizing repair compound.

2.16.3 Fan

****
NOTE: The criteria for special AMCA construction for protective coating can be further delineated here or incorporated into referenced paragraph, if this is the only fan. Specify welded Class II construction only where required.
****

****
NOTE: See Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL for guidance given in guide specification technical notes. Definite requirements should be specified in contract specification for bidders' information.
****

Comply with paragraph CENTRIFUGAL FANS [, subparagraph UTILITY SET,] in this Section and special requirements for protective coatings.[Provide unit of all welded construction, utilizing a minimum 14-gage carbon steel in AMCA Class II construction.][Internal and external protective coating must be manufacturer's standard, engineered quality type, with properties comparable to [air-dry or baked phenolic,] [or] [epoxy] applied in multiple coats of 0.10 to 0.15 mm 4 to 6 mil dry film thickness.] [Mount entire assembly for vibration isolation on structural steel base and spring or elastomer type isolators with a minimum transmissibility of [10] [5] percent.][Provide split sleeve or flexible connection at fan inlet.]

2.16.4 Flexible Welding Fume Exhaust Tubing and Connectors

Provide corrosion protected, spring steel helix reinforced, neoprene impregnated, woven fibrous glass fabric laminate, flexible tubing with cuffed ends or equivalent construction, and with an inside diameter [and length as shown.] of [100] [125] [150] mm [and [_____] meters in length] [4] [5] [6] inches [and [_____] feet in length]. Connect to duct with clamp or gasketed flange [and fit with swivel connected conical fume hood, constructed of minimum 20 gage aluminum [or 26 gage galvanized steel] [or ABS plastic] and fitted with 13 mm 1/2 inch mesh intake screen and magnets for holding receptor in fixed location]. Secure tubing to terminal devices by clamping.[Provide spring or weight counterbalanced supporting arms for flexible hose section of long reach system.]

2.16.5 Supporting Elements

Support ducting [as indicated] with anti-sway bracing to resist perceptible movement in response to forces imposed by flexible tubing location on handling. Suspend tubing from overhead location [and provide means to raise and lower for use].[Assemble suspension system with rigid pulley restraint, 3 mm 1/8 inch diameter aircraft cable, pulleys, and manually operated winch fitted with safety ratchet lock and slip resistant hand grip.] [Support movable portion of long reach system with brackets.] Observe that hood remain in a fixed position after manual adjustment.

2.17 STACKHEADS

Provide SMACNA 1403 no loss type stackheads for vertical discharge to the atmosphere unless indicated otherwise. Weather caps are prohibited. Provide bracing or guy wires for wind loads on stacks as indicated. Discharge stacks should be vertical and terminate at a point where height or velocity prevents reentry of exhaust air.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Installation Requirements

****

NOTE: Ductwork for Class 2, 3, and 4 service and supporting elements must be able to sustain working live loads imposed by ducting 50 percent filled with particulate material being conveyed. Provide supplementary structural steel for the support of system components.

****

Install in accordance to NFPA 91, and SMACNA 1922, and SMACNA 1520. Provide mounting and supports for equipment, ductwork, and accessories, including structural supports, hangers, vibration isolators, stands, clamps and brackets, access doors, blast gates, and dampers. Install accessories in accordance with the manufacturer's instructions. Construct positive pressure duct inside buildings airtight.

3.1.1.1 Wood Facilities

****

NOTE: Include paragraphs when appropriate. For

other projects, edit as required and include appropriate references.
****

For [wood processing] [and] [woodworking] facilities, conform to NFPA 664.

3.1.1.2 Aluminum Facilities

****
NOTE: Include paragraphs when appropriate. For other projects, edit as required and include appropriate references.
****

For aluminum [processing] [and] finishing facilities, conform to NFPA 65.

3.1.2 Electrical Ground Continuity

Where electrical ground continuity is required, provide brazed connection insulated, multi-strand, copper wire jumpers across points of discontinuity. Provide connection to ground and continuity testing as part of the work of Division 16.

3.1.3 Special Installation Requirements

Special installation requirements for protectively coated steel ductwork for corrosive fume and vapor exhaust: Slope horizontal ducts [25] [_____] mm in [12] [_____] meters [one] [_____] inch in [40] [_____] feet in the direction of air flow or [25] [_____] in [3] [_____] meters [one] [_____] inch in [10] [_____] feet in the direction opposite to airflow. Where necessary, slope duct to common drainage point. Provide drains at low points, at internal duct restrictions, at base of risers and where indicated. Provide drain connections of 25 mm one inch pipe size corrosion resistant steel couplings welded to duct and provided with polytetrafluoroethylene paste lubricated PVC plug where drainage piping is not indicated. Provide drain lines with a trap of 25 mm one inch greater depth than the positive or negative pressure in the duct but not less than 50 mm 2 inches. Provide duct support system to include additional weight due to collection or [condensate] [and] washing water in nondrainable deflected surface and other areas. Provide duct supports and building structure attachments in accordance with SMACNA 1922 and SMACNA 1520.

3.1.4 Special Requirements for Installation of Thermoplastic Ductwork

Requirements for installation of thermoplastic ductwork for nonflammable corrosive fume and vapor exhaust:

3.1.4.1 Slope

Slope horizontal ducts [25] [_____] mm in [12] [_____] meters [one] [_____] inch in [40] feet in the direction of airflow or [25] [_____] in [3] [_____] meters [one] [_____] inch in [10] [_____] feet in opposite to the direction of airflow. Where necessary, slope duct to common drainage point.

3.1.4.2 Drains

Provide drains at all low points, at internal to duct drainage restrictions, at base of risers, and where indicated. Provide drain

connections of 25 mm one inch IPS couplings with polytetrafluoroethylene paste lubricated plug where drainage piping is not indicated, and where piping is indicated, provide PVC Type DWV piping conforming to ASTM D2665 to points indicated. Provide trap of 25 mm one inch greater depth than the positive or negative pressure in the duct but not less than 50 mm 2 inches.

3.1.4.3 Duct Supports

Isolate duct support contact surfaces from supporting steel by 6 mm 1/4 inch thick closed-cell foamed cellular elastomer insulation material of a width greater than support. Provide duct support system to include additional weight due to collection of condensate and washing water in nondrainable, deflected surface and other areas.

3.1.5 Special Requirements for Installation of Fiberglass Ductwork

Requirements for installation of fiberglass ductwork for nonflammable corrosive fume and vapor exhaust:

3.1.5.1 Slope

Slope horizontal ducts [25] [_____] mm in [12] [_____] meters [one] [_____] inch in [40] [_____] feet in the direction of airflow or [25] [_____] mm in [3] [_____] meters [one] [_____] inch in [10] [_____] feet in opposite to the direction of airflow. Where necessary, slope duct to common drainage point.

3.1.5.2 Drains

Provide drains at all low points, at internal drainage restrictions, at base of risers, and where indicated. Provide drain connections of 25 mm one inch IPS couplings with polytetrafluoroethylene paste lubricated plug where drainage piping is not indicated, and where piping is indicated, provide PVC Type DWV piping conforming to ASTM D2665 to points indicated. Provide a trap of one inch greater depth than the positive or negative pressure in the duct but not less than 50 mm 2 inches.

3.1.5.3 Duct Supports

Isolate duct support contact surfaces from supporting steel by 6 mm 1/4 inch thick closed-cell foamed cellular elastomer insulation material of a width greater than support. Design duct supporting system to include additional weight due to collection of condensate and washing water in nondrainable, deflected surface and other areas.

3.1.6 Miscellaneous Sheet Metal Work

Provide [_____] and [_____], fabricated from [mill galvanized steel] [black steel and protectively coated] [aluminum] [_____], as indicated. Sheet metal thickness, reinforcement and fabrication, where not indicated, must conform to SMACNA 1403.

3.1.7 Building Penetrations

3.1.7.1 General Penetration Requirements

Provide properly sized, fabricated, located, and trade coordinated sleeves and prepared openings, for duct mains, branches, and other item

penetrations, during the construction of the surface to be penetrated. Provide sleeves for round duct 380 mm 15 inches and smaller and prepared openings for round duct larger than 380 mm 15 inches and square or rectangular duct. Fabricate sleeves, except as otherwise specified or indicated, from 20 gage, 1.00 mm 0.0396 inch thick mill galvanized sheet metal. Sleeves penetrating load bearing surfaces must be standard weight galvanized steel pipe. Provide roof penetrations as shown in SMACNA 1403.

3.1.7.2 Framed Opening

Provide framed openings in accordance with approved shop drawings. Refer to paragraph FIRE DAMPERS in this section, for related work.

3.1.7.3 Clearances

Provide a minimum 25 mm one inch clearance between penetrating and penetrated surfaces. Fill clearance space with bulk fibrous glass or mineral wood [or foamed silicone] and seal and close.

3.1.7.4 Tightness

Penetration must be [weathertight] [fireproof where fire rated surfaces are penetrated] [vaportight to prevent vapor transmission to conditioned spaces] [sound tight to prevent sound transmission to or between normally occupied or finished spaces] [deleterious or hazardous substance-tight where] [toxic] [flammable] [_____] [substances or gases could migrate].

3.1.7.5 Sealants

Provide sealant of [_____] [elastomeric] type [or foamed silicone type], as specified under paragraph SEALANTS in this section. Apply to oil free surfaces to a minimum 10 mm 3/8 inch depth.

3.1.7.6 Closure Collars

Provide a minimum 100 mm 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around penetrating item without contact. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 380 mm 15 inches in diameter or less from 20 gage, 1.00 mm 0.0396 inch nominal thickness, mill galvanized steel. Attach collars a minimum of 4 fasteners to where the opening is 300 mm 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 500 mm 20 inches in diameter or less. Fabricate collars for square and rectangular ducts with a maximum side of 380 mm 15 inches or less from 20 gage, 1.00 mm 0.0396 inch nominal thickness, mill galvanized steel. Fabricate collars for round, square, and rectangular ducts with minimum dimension over 380 mm 15 inches from 18 gage, 1.40 mm 0.0516 inch in nominal thickness, mill galvanized steel. Install collars with fasteners a maximum of 150 mm 6 inchesson center.[Where penetrating items are irregularly shaped and where approved, smoothly finished, fire-retardant, foamed silicone elastomer may be utilized without closure collar.]

3.1.8 Installation of Fire Dampers

Install fire dampers at locations indicated. Provide units and connecting ductwork in accordance with applicable provisions of [NFPA 91,] [UL Bld Mat Dir,] AMCA 500-D [and UL 33], [and as indicated]. Install

retaining angles, sleeves, break-away connections, and duct access doors at each damper, as required. Minimum thickness of sleeves must be 14 gage [, except as otherwise indicated]. Duct access doors must be hinged [and fitted with UL listed glass viewing port assembly]. Prior to acceptance, simulate conditions to cause each unit to function automatically. Apply safe, nonflame, heat source to fusible links and replace test activated fusible links.

3.1.9 Installation of Flexible Connectors

Flexibly connect duct connected and vibration isolated fans [, ducts crossing building expansion joints] and specified or indicated components [, except where direct connections are specified or indicated]. When fans are started, stopped, or operating, flexible connector surfaces must be curvilinear, free of stress induced by misalignment or fan reaction forces, and must not transmit vibration. Leakage must not be perceptible to the hand when placed within 150 mm 6 inches of the flexible connector surface or joint. Provide a minimum of 150 mm 6 inches and a maximum of 610 mm 2 feet active length with a minimum of 25 mm one inch of slack, secured at each end by folding in to 24 gage sheet metal or by metal collar frames.

3.1.10 Installation of Supports

3.1.10.1 Selection

Select duct and equipment support system taking into account the best practice recommendations and requirements of SMACNA 1922, SMACNA 1520, and NFPA 91; location and precedence of work under other sections; interferences of various piping and electrical work; facility equipment; building configuration; structural and safety factor requirements; vibration and imposed loads under normal and abnormal service conditions. Indicated support sizes, configurations, and spacings are the minimal type of supporting component required for normal loads. Where installed loads are excessive for the normal support spacings, provide heavier duty components or reduce the element spacing. After system start-up, replace or correct support elements which vibrate and cause noise or possible fatigue failure. Exercise special care to prevent cascading failure.

3.1.10.2 General Requirement for Supports

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NOTE: See Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL for guidance given in guide specification technical notes. Definite requirements should be specified in contract specification for bidders' information.

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Securely attach supporting elements to building structural steel or structural slabs. Where supports are required between building structural members provide supplementary structural steel as specified for work under this section. On submittals show location of supports and anchors and loads imposed on each point of support or anchor. Do not hang ductwork or equipment from piping, or other ducts or equipment. Attach supports to structural framing member and concrete slab. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required, between structural framing members, provide suitable intermediate metal

framing. Where C-clamps are used, provide retainer clips. A maximum span of 3 meters 10 feet must exist between any two points, with lesser spans as specified or as required by duct assemblies, interferences, and loads imposed or permitted. Provide a minimum one set of two vertical support elements for each point of support and each length of duct, except as otherwise specified. Install supports on both sides of all duct turns, branch fittings, and transitions. Cross-brace hangers sufficiently to eliminate sway. Perforated strap hangers are prohibited. Where ductwork system contains heavy equipment, hang such equipment independently of the ductwork.[Duct supports must be vibration isolated from structure at points indicated.][Provide vibration isolators in indicated discharge ducting system for a minimum distance of [15 meters] [50 feet] [_____] beyond the fan. Coordinate deflection of duct and equipment mountings and conform to Section [22 05 48.00 20] MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.][The location of supporting elements must be limited by the allowable load on the purlin which must be limited to that no greater than the moment produced by 4450 Newton one Kip load at mid-span of purlin. When the hanger load exceeds these limits, provide reinforcing of purlin[s] or additional support beam[s]. When an additional beam is used, the beam must bear on the top chord of the roof trusses and bearing must be over gusset plates of top chord. Stabilize beam by connection to roof purlin along bottom flange.]

3.1.10.3 Methods of Attachment

Clamp, or weld when approved, attachment to building structural steel in accordance with AWS D1.1/D1.1M. Construct masonry anchors selected for overhead applications of ferrous materials only. Install masonry anchors in rotary, non-percussion, electric drilled holes. Self-drilling anchors may be used provided masonry drilling is performed with electric hammers selected and applied in such a manner as to prevent concrete spalling or cracking. Pneumatic tools are prohibited.

3.1.11 Welding

Welding test agenda must be done in accordance with the applicable provisions of AWS D1.1/D1.1M and AWS D1.3/D1.3M.

3.1.12 Test Ports

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NOTE: The designer must indicate on the drawings the location of test ports required for proper testing, including static pressure, velocity pressure, and test openings for sampling discharge stack or duct. See ACGIH-2092S Industrial Ventilation: A Manual Of Recommended Practice for recommendations in the chapter on testing.

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Provide test access ports at points required for work under paragraph TESTING, ADJUSTING, AND BALANCING in this section. Locate test ports in straight duct as far as practical downstream of fans, change of direction fittings, takeoffs, interior to duct accessories, and like turbulent flow areas.

3.1.13 Ductwork Cleaning

Protect duct openings from construction debris using temporary caps,

flanges, or other approved means. Clean ductwork in accordance with manufacturer's recommendations [and the North American Insulation Manufacturers Association (NAIMA) Guide on Cleaning of Duct Board Materials].[Clean dirty duct interior with high velocity water and oil-free air streams or by vacuum cleaning as required by project conditions.][Test watertight duct work for proper support, leakage, and unacceptable drainage provisions by intermittently spraying interior with garden hose nozzle, at a rate of 0.2 liter per second 3 gallons per minute, exercising care to prevent excessive water accumulation.] After construction is complete but accessible and prior to acceptance, remove all construction debris from exterior surfaces. Do not close duct inspection ports until inspected by the Contracting Officer.

3.1.14 Protective Coating Work

3.1.14.1 General Requirements for Protective Coating Work

Provide protective coating on interior [and exterior] surfaces of [_____] [and] [interior] [and] [exterior] surfaces of [_____] with [_____] system as specified hereafter. Prime coat exterior surfaces of [_____] [and] [_____] with [_____] [inorganic zinc coating as part of work under this section] [.] [, for field finishing of exterior surfaces as part of work under Section [09 90 00] PAINTS AND COATINGS.] Brush primer, or protective coating where no primer is specified, onto corners and into crevices and welds, working the material into irregular surfaces for a holiday free finish.

3.1.14.2 Baked, Unmodified Phenolic System

a. General: The following must govern for a protective coating system based on unmodified phenol-formaldehyde resin intended for shop application to [black carbon steel] [_____] surfaces in [fume] [vapor] exhaust service with possibility of materials concentration by condensation and subsequent evaporation. Shop apply coating by an applicator approved or licensed by the coating manufacturer.

b. Surface Preparation: Clean and blast surfaces with dry abrasive to "White Metal" and critical profile and anchor pattern in accordance with SSPC SP 5/NACE No. 1, and requirements and recommendations of the coating manufacturer.

c. Application: The complete system must include the application of two coats of red pigmented base followed by not less than one coat of the clear finish, to provide a total minimum dry film thickness of [0.15 mm] [6 mils] [_____]. Apply coating materials by conventional industrial pressure spray equipment. Use only those thinners and cleaners in amounts recommended by the manufacturer. Heat-cure each coat between coats and bake surfaces after the last coat in accordance with manufacturer's applicable published instructions and specific instructions for the specified application. Baking time between coats must be a minimum 1 1/2 to 2 hours at 93 to 121 degrees C 200 to 250 degrees F. Baking after top coat must be one hour at 93 to 177 degrees C 200 to 350 degrees F, plus 2 hours final bake at a temperature of [177] [204] degrees C [350] [400] degrees F. Other baking schedules to achieve required quality coating may be proposed.

d. Repair: Return damaged surfaces to the applicator's shop for repair, unless otherwise approved by the Contracting Officer.

3.1.14.3 Inorganic Zinc Coating System

a. General Requirements, Inorganic Zinc Coating System: The following must govern for a protective coating system primer based on inorganic zinc coating intended for shop application to [_____] [specified] black carbon steel surfaces with subsequent field finishing with compatible tie coat and [epoxy] [acrylic latex] [modified acrylic] [chlorinated rubber] top coat [applied as part of work under Section 09 90 00 PAINTS AND COATINGS.]

b. Surface Preparation: SSPC SP 5/NACE No. 1.

c. Application: Apply one coat at [0.05 to 0.10] [0.10 to 0.13] mm [2 to 3] [3 to 5] mils dry film thickness by airless or conventional spray equipment. Use only those thinners and cleaners in amounts recommended by the manufacturer.

d. Repair: Field repair damaged surfaces in accordance with manufacturer's instructions.

3.1.14.4 Field Inspection of Protective Coating Work

Visually inspect coated surfaces from a maximum distance of 1.5 meters 5 feet with special attention given to corners and crevices. Check coating thickness in accordance with SSPC Paint 11. Perform inspection immediately prior to erection of ductwork and equipment and in the presence of the Contracting Officer. Repair coating as required. Apply additional coating if thickness is not sufficient.

3.1.15 Factory and Field Painting and Finishing

3.1.15.1 Factory Work

Factory finish interior ferrous metal and other specified metallic equipment and component surfaces with manufacturer's standard surface preparation, primer, and finish coating. Factory finish exterior to building space ferrous metal surfaces and other exterior to building and interior to building metallic or nonmetallic surfaces with specified protective coating system in accordance with the paragraph PROTECTIVE COATING MATERIAL in this section and otherwise with manufacturer's standard surface preparation, primer and finish which meet the requirements of paragraph CORROSION PREVENTION.

3.1.15.2 Field Work

Touch-up or if necessary, repaint factory applied finishes which are marred, damaged, or degraded during shipping, storage, handling, or installation to match the original finish. Clean and prime field or shop fabricated ferrous metals required for the installation specified under this section in accordance with the applicable provisions of Section [09 90 00] PAINTS AND COATINGS. Painting of surfaces not otherwise specified and finish painting of items only primed at the factory or elsewhere, are specified as part of the work under Section [09 90 00] PAINTS AND COATINGS.

3.2 TESTING, ADJUSTING, AND BALANCING

3.2.1 Ductwork Structural Integrity and Leakage Testing

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NOTE: In addition to significant energy losses, air leakage from HVAC ducts and air handling units can cause significant IAQ problems due to unexpected airflow between indoors and outdoors, and between areas within the building. Air leakage from supply or return duct work contributes to the condensation of humid air in building cavities and/or on the neighboring surfaces. Air leakage can be especially problematic for ducts or AHUs that are located outside the conditioned spaces.

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Inspect and test systems pressure rated higher than 498 Pa 2 inches water gage for structural integrity and leakage as systems or sections during construction but after erection, as work progresses, in system or section lengths not exceeding 30 meters 100 feet. Test for structural integrity at [_____] percent in excess of system fan positive or negative total pressure. Test for leakage at [_____] percent in excess of system fan positive or negative total pressure.[Leakage test procedure and apparatus must be in accordance with SMACNA 1972 CD. Total leakage, prorated to length of duct under test, must not exceed one percent of system capacity.][Confirm that duct leakage is less than three percent of coil airflow for new systems and less than six percent for existing systems.] Do not permit leakage in positive pressure ducts in buildings carrying flammable or toxic materials.

3.2.2 Power Transmission Components Adjustment

Test and adjust V-belts and sheaves for proper alignment and tension preliminary to operation and after 72 hours of operation at final speed, in the presence of the Contracting Officer. Belts on drive side must be uniformly loaded, not bouncing.[Align direct-drive couplings to less than half of manufacturer's allowable range of misalignment.]

3.2.3 Preliminary Tests

Conduct an operational test on the entire exhaust duct systems, components, and equipment for a period of not less than 6 hours after power transmission components are adjusted. Replace filters, if any, after preliminary tests and prior to conducting final acceptance tests.

3.2.4 Testing, Adjusting, and Balancing Work

Perform work in accordance with the applicable and recommended procedures of: ACGIH-2092S. Provide apparatus, certified, calibrated, instrumentation including that to measure sound levels, motor current, and power factor. Unless approved otherwise, instruments must be limited to manometers and approved aneroid type gages (such as a Magnehelic). Velometers may be used for low velocity measurements if approved by the Contracting Officer.

3.2.5 Systems Volume Acceptance Criteria

Systems final volume must be within the following limits:

Fan: Plus 10 percent, minus zero percent of design volume at design temperature

Hood or Equipment: Plus or minus [5] [10] percent of design volume at design temperature

Note: Tolerances must be taken on clean or dirty conditions as indicated on the drawings.

3.2.6 Sound Level Tests

Report to the Contracting Officer in writing, sound levels higher than 84 dBA at hoods or at workers' normal operating positions at equipment in addition to being included in the required test reports.

3.3 SYSTEM[S] OPERATION DEMONSTRATION

After systems and equipment testing, adjusting, and balancing has been completed and accepted, demonstrate the complete and correct functioning of systems equipment and controls by operation through normal ranges and sequences, and by simulation of abnormal conditions, [including the manual tripping of fire dampers]. Manually and automatically cause every device to function as intended. Readjust, as necessary, any settings and after sufficient operating time, but not less than [6] [_____] hours, verify ability of equipment and controls to establish and maintain stable and accurate operation and required system performance. Note any abnormal deviations, such as excessive vibration, noise, and heat, binding damper mechanisms, and incorrect fan rotation. Make any necessary repairs, replacements or adjustments.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

Products	Inch-Pound	Metric
a. Motors: Capacity	= 7 1/2 hp	= 5 1/2 kW
	= 15 hp	= 11 kW
	= 30 hp	= 22 3/8 kW
b. Gaskets: Thickness	= 1/8 inch	= 3 mm

-- End of Section --