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USACE / NAVFAC / AFCEC	**UFGS-23 51 43.03 20 (February 2010)**
	Change 1 - 11/24

Preparing Activity: NAVFAC	**Superseding**
	UFGS-23 51 43.03 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025

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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 51 43.03 20

FABRIC FILTER DUST COLLECTOR OF FLY ASH PARTICLES IN FLUE GAS

02/10, CHG 1: 11/24

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SECTION 23 51 43.03 20

FABRIC FILTER DUST COLLECTOR OF FLY ASH PARTICLES IN FLUE GAS
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NOTE: This guide specification covers the requirements for providing, installing, adjusting, and testing of fabric filter type dust collectors (baghouses).

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: The baghouse is intended to be used for flue gas particulate removal and collection associated with coal fire boilers or incinerators. Coal fired boilers applicable to this specification are those designed for pulverized coal firing, spreader traveling grate stoker firing, chain traveling grate stoker firing or underfeed stoker firing with capacities ranging between 3.78 and 31.50 kilogram 30,000 and 250,000 pounds of steam per second hour. Incinerators applicable to this specification are those designed for burning wastes having firing capacities between 454 kilograms 1,000 pounds per hour and 182 Mg 200 tons per day. For engineering and design assistance on baghouses applied close to or outside these capacities, contact:

Commanding Officer (ESC Code 43)
NAVFAC Engineering Service Center
560 Center Drive
Port Hueneme, CA 93043-4340
Telephone: (805) 982-4984

Indicate on drawings who supplies compressed air cleaning and control system components, piping, valves, and fittings.

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PART 1 GENERAL

1.1 REFERENCES

****

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.

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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 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines
AMCA 802	(2019) Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	(2024) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2024) 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 A242/A242M	(2024) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A580/A580M	(2023) Standard Specification for Stainless Steel Wire
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B443	(2019) Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625)and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219)* Plate, Sheet, and Strip
ASTM C533	(2017; R 2023) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C592	(2024) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM D578/D578M	(2005; E 2011; R 2011) Glass Fiber Strands
ASTM D737	(2018) Standard Test Method for Air Permeability of Textile Fabrics
ASTM D1682	(1964; R 1975e1) Test for Breaking Load

	and Elongation of Textile Fabrics
ASTM D1777	(1996; E 2011; R 2011) Thickness of Textile Materials
ASTM D2176	(1997a; R 2007) Folding Endurance of Paper by the M.I.T. Tester
ASTM D3775	(2017; E 2018) Standard Test Method for End (Warp) and Pick (Filling) Count of Woven Fabrics
ASTM D3776/D3776M	(2009a; R 2017) Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
ASTM D3887	(1996; R 2008) Standard Specification for Tolerances for Knitted Fabrics

INSTITUTE OF CLEAN AIR COMPANIES (ICAC)

ICAC F-2	(1972) Fundamentals of Fabric Collectors and Glossary of Terms
ICAC F-3	(2002) Operation and Maintenance of Fabric Filters
ICAC F-5	(1991) Types of Fabric Filters

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.90.1	(2023; ERTA) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MBG 531	(2017) Metal Bar Grating Manual

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

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

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-I-24092	(1993; Rev D; Supp 1993; NOtice 1 2021) Insulating Varnishes and Solventless Resins for Applications by the Dip Process

MIL-T-152	(1961; Rev B; Am 2 1966; Notice 2 2000; Notice 3 2006; Notice 4 2011; Notice 5 2019) Treatment, Moisture and Fungus Resistant, of Communications, Electronic, and Associated Electrical Equipment
MIL-V-173	(1969; Rev C; Am 2; CANC Notice 3) Varnish, Moisture and Fungus Resistant (For Treatment of Communications, Electronic, and Associated Equipment)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA AP-42	(1995) Compilation of Air Pollution Emission Factors

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-P-28	(Rev H) Paint, Aluminum, Heat Resisting (1200 Degrees F.)

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

40 CFR 60	Standards of Performance for New Stationary Sources

1.2 QUALITY ASSURANCE

Section 01 45 00 QUALITY CONTROL, applies to this section.

1.2.1 Experience

Manufacturers and contractors must have constructed not less than three fabric filter type dust collectors (baghouses) of the type to be provided in this contract collecting flyash produced by [pulverized coal fired boilers][[_____] stoker fired boilers] [incinerators] and operating under the following conditions:

****
NOTE: Use plus or minus 30 percent for inlet gas volumes up to and including 23,595 L/s 50,000 acfm and plus or minus 10 percent for gas volumes over 23,595 L/s 50,000 acfm.
****

a. Treating an inlet gas volume within plus or minus [_____] percent of the inlet gas volume specified in paragraph entitled "Design Criteria."

b. Operating in continuous duty, normal maintenance downtime included, for not less than two years at a minimum efficiency of 98 percent.

1.2.2 Model Study

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NOTE: Choose model dust which will follow trajectories and depositions geometrically similar to those of the flyash characteristics as specified in paragraph entitled "Design Criteria." Proper

scaling must include centrifugal and gravity force effects. Refer to Electric Power Research Institute Report C5-2427, Development of Guidelines for Optimum Baghouse Fluid Dynamic System Design, June 1982. In this report, EPRI determined that finely ground cork dust (200/0 mesh) with a mass mean diameter of 38.3 um effectively simulates flyash with a 24.4 um mass mean diameter.

****

Conduct a three-dimensional model study to analyze and optimize pressure losses, velocity profiles, and dust flow distribution through the baghouse system. Model must represent the system from the [air heater] [economizer] [_____] outlet to the stack inlet, reduced to not less than 1:100 1/8 scale. Construct model from transparent thermoplastic; dimensional tolerances must be plus or minus 1.50 mm 1/16 inch. Perform tests at 30, 50, 75, 100, and 125 percent of maximum continuous flow rating using [_____]. Modify the model to minimize system pressure losses and to provide uniform, within plus or minus 10 percent of the mean, gas flow and dust flow distribution at baghouse inlet flange, inlet manifold, outlet manifold, hoppers, and the inlet and outlet of each compartment including the bag region. Retest to prove minimum system pressure losses, and uniform gas flow and dust flow distribution. Notify Contracting Officer or designated Government representative of test dates in writing no less than 15 working days prior tests so that Contracting Officer or designated Government representative may witness both tests.Incorporate modifications into final design.

1.2.3 Bag Fabric Guarantee

Prior to manufacturing bags, test finished material lots to ensure fabric meets paragraph entitled "Design Criteria." Material lot tests must include:

a. Yarn weight: ASTM D578/D578M

b. Permeability: ASTM D737

c. Tensile strength: ASTM D1682

d. Thickness: ASTM D1777

e. M.I.T. flex: ASTM D2176

f. Count: ASTM D3775

g. Fabric weight: ASTM D3776/D3776M

h. Bursting strength: ASTM D3887

1.2.4 Bag Guarantee

Bags and hardware must as specified in paragraph entitled "Design Criteria" and paragraph entitled "Bags and Hardware," and must be guaranteed for two calendar years from startup during which time bags which have abrasions, holes or tears, and hardware which have corrosion, sharp edges, bends, bad welds, or burrs must be replaced free of charge to the Government. Damage to bags and hardware due to obvious operator negligence is not covered by this guarantee. Do not use spare bags and

hardware as replacements. Should replacements exceed 10 percent in any compartment during the two year period, replace bags and hardware in that compartment free of charge to the Government. Guarantee replacement bags and hardware for an additional two years.

1.2.5 Certificate

1.2.5.1 Certificate of Experience

Include:

a. List of not less than three baghouses at separate facilities meeting the conditions as specified in paragraph entitled "Quality Assurance."

b. Each installation owner's name, location, point of contact for operation and maintenance, address, and telephone number.

c. Date of owner's acceptance and startup of each installation.

d. Baghouse design conditions at each installation: Inlet gas volume, L/s acfm; inlet gas temperature, degrees C degrees F; inlet dust loading, grams per liter grains per acf; efficiency, percent; and net gas to cloth ratio, m/s fpm.

e. Baghouse actual operating conditions at each installation: Inlet gas volume, L/s acfm; inlet gas temperature, degrees C degrees F; inlet dust loading, grams per liter grains per acf; efficiency, percent; and net gas to cloth ratio, m/s fpm.

f. Type of [incinerator] [coal fire boiler] at each installation.

1.2.5.2 Factory Test Completion Certification

Submit certificate of completion for factory tests on control circuits, mechanical draft equipment, materials, and dampers except poppet dampers, as required in paragraph entitled "Source Quality Control."

1.2.5.3 Baghouse Installation

Submit certification from the field representative that the baghouse has been installed as recommended by the manufacturer.

1.2.6 Smoke Test

Prior to installing insulation, perform smoke tests on installed baghouse [including pulse jet weather enclosure] to identify leaks. Use forced draft fan to pressurize baghouse. Notify Contracting Officer or designated Government representative of test date in writing not less than 15 working days prior test so that Contracting Officer or designated Government representative may witness test. Repair leaks before installing insulation.

1.2.7 Particulate Emissions Test

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NOTE:

1. Emissions must comply with local, state, and federal standards for particulate and visible

emissions. Note that compliance with particulate emission standards does not guarantee compliance with opacity standards; nor does compliance with federal or state standards guarantee compliance with local standards.

2. Opacity is influenced by particulate size distribution. For example, approximately 25 percent of the emissions from stoker fired boilers are below 10 microns, thus a visually acceptable stack may result in a particulate emissions loading of 0.09s g/m3 0.04 grains per cu ft. However, approximately 45 percent of the emissions from pulverized coal fired boilers are below 10 microns, thus a visually acceptable stack may result in an emissions loading of 0.046 g/m2 0.02 grains per cu ft.

****

Prior to baghouse acceptance, provide simultaneous particulate emissions tests at the baghouse inlet and at the baghouse outlet. Test to ensure particulate emissions loadings does not exceed [_____] gram per dry std cubic meter grains per dry std cu ft when operating at maximum continuous flow rating and to ensure accuracy of inlet grain loading estimate. Perform three tests using procedures and equipment as in 40 CFR 60, EPA AP-42, Appendix A and local regulations. Operate the system in automatic without system failure or tripout, for 30 days prior to performing tests. Notify Contracting Officer or designated Government representative of test date in writing not less than 15 working days prior test so that Contracting Officer or designated Government representative may witness test. Should particulate emissions loading exceed [_____] gram per dry std cu meter grains per dry std cu ft, Contractor must modify baghouse to meet emission limits. Retest baghouse, free of charge to the government, to provide compliance with emission limits.

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 and Air Force 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.

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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. Submittals not having a "G" or "S" classification are 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

Dust Collector System Components

Dust Collector System Layout

Electrical and Pneumatic Circuit Diagrams

SD-06 Test Reports

Dust Collector Model Tests

Bag Tests

Baghouse Controls Tests

Particulate Emissions Tests

Mechanical Draft Equipment Tests

Damper Tests

Baghouse Inspection

SD-07 Certificates

Certificate of Experience

Dust Collector Model Study Procedures

Particulate Emissions Test Procedures

Factory Test Completion Certification

Baghouse installation

SD-10 Operation and Maintenance Data

Baghouse, Data Package 3

Instrumentation and Control Systems, Data Package 3

Bypass System, Data Package 3

Dampers, Data Package 2

Fans, Data Package 3

Valves, Data Package 2

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include procedures for:

a. Bag precoating.

b. Baghouse startup; initial and routine.

c. Baghouse shutdown; short duration, long duration, and emergencies.

1.4 DELIVERY AND STORAGE

Ship equipment as shop welded, factory assembled modules, except when physical size, arrangement, equipment configuration, or shipping limitations, make the shipment of assembled equipment impracticable. Do not ship modules with bags installed. Package bags separately to prevent damage during shipping, handling, and during outdoor storage at the job site. Handle, store, and protect equipment and materials to prevent damage before and during installation as recommended by the manufacturer. Replace damaged or defective items free of charge to the Government. Describe sectional shipments in proposal, otherwise it must be understood that equipment must not require field assembly. The manufacturer must pay field assembly costs of sections, accessories, or appurtenances not listed in the proposal as requiring field assembly.

1.5 DESIGN CRITERIA

1.5.1 Detail Drawings

Obtain approval of dust collector model tests prior drawing submittal. Submit drawings for dust collector system components, dust collector system layout, and electrical and pneumatic circuit diagrams. For each component, indicate kind, size, design, arrangement, assembly, breakdown for shipment, and weight. Include locations for external connections, controls, remote control panels, anchorages, and supports. Indicate dimensions for installation and correlation with other materials and equipment. Include foundation and loading information.

[1.5.2 Boiler Data

****
NOTE: Select this paragraph or the paragraph below entitled "Incinerator Data."
****

****
NOTE: Insert appropriate Section number and title in the blanks below using format per UFC 1-300-02.
****

Design baghouse(s) for operation with [manually] [automatically] controlled [boiler(s) specified in [_____]] [boiler(s) manufactured by [_____], Type [_____], Model Number [_____]]. The boiler is a [new] [existing] [pulverized coal fired boiler] [[_____] grate spreader stoker fired boiler] [[_____] retort underfeed stoker fired boiler] rated [_____] kg/s lbs/hr steam at [_____] kPa psi. Boiler gross heat input is expected to be [_____] kW MBtu/hr and boiler steam output is expected to be between [[_____] and [_____]] kg/s lb/hr. Boiler must burn coal meeting the following criteria. The standby fuel is [_____].

a. Proximate analysis, as received, percent by weight:

	Range
Moisture	[_____]
Ash	[_____]
Volatile Matter	[_____]
Fixed Carbon	[_____]
Total	100.00
Sulfur	[_____]
Heating Value, Btu/hr	[_____]

b. Ultimate analysis, as received, percent by weight:

	Range
Moisture	[_____]
Carbon	[_____]
Hydrogen	[_____]
Sulfur	[_____]
Nitrogen	[_____]
Oxygen	[_____]
Ash	[_____]
Total	100.00

][1.5.3 Incinerator Data

****

NOTE: Waste standard classifications are as follows:

Type	Description	Principle Components	Noncombustible Solids (Max. Percent	Moisture Content (Max. Percent)	Heating Value (kJ per kg)
0	(Trash)	Highly combustible waste, wood, cardboard cartons, paper, rubber and plastic scrap, commercial and industrial sources	5	10	19,805
1	(Rubbish)	Combustible waste, wood scraps, cardboard cartons, paper, rags, and combustible floor sweepings. Domestic, commercial, and industrial sources.	10	25	15,145
*2	(Refuse)	Rubbish and garbage	7	50	10,019
*3	(Garbage)	Animal and vegetable waste, restaurants, hotels, markets,institutional, commercial, and industrial sources	5	70	5825
*4	(Animal solids and organic wastes)	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds, and similar sources	5	85	2330
Loose Paper			-	-	23,300
Loose Wood			-	-	23,300

Type	Description	Principle Components	Noncombustible Solids (Max. Percent	Moisture Content (Max. Percent)	Heating Value (kJ per kg)
0	(Trash)	Highly combustible waste, wood, cardboard cartons, paper, rubber and plastic scrap, commercial and industrial sources	5	10	19,805
Classified Material		Highly-combustible waste, paper, cardboard cartons including up to 10 percent plastics and treated paper	-	-	23,300
* Types 2, 3 and 4 are not suitable for baghouse applications. Include ash analysis if available.					

Type	Description	Principle Components	Noncombustible Solids (Max. Percent	Moisture Content (Max. Percent)	Heating Value (Btu/lb)
0	(Trash)	Highly combustible waste, wood, cardboard cartons, paper, rubber and plastic scrap, commercial and industrial sources	5	10	8,500
1	(Rubbish)	Combustible waste, wood scraps, cardboard cartons, paper, rags, and combustible floor sweepings. Domestic, commercial, and industrial sources.	10	25	6,500
*2	(Refuse)	Rubbish and garbage	7	50	4,300
*3	(Garbage)	Animal and vegetable waste, restaurants, hotels, markets,institutional, commercial, and industrial sources	5	70	2,500
*4	(Animal solids and organic wastes)	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds, and similar sources	5	85	1,000
Loose Paper			-	-	10,000
Loose Wood			-	-	10,000

Type	Description	Principle Components	Noncombustible Solids (Max. Percent	Moisture Content (Max. Percent)	Heating Value (Btu/lb)
0	(Trash)	Highly combustible waste, wood, cardboard cartons, paper, rubber and plastic scrap, commercial and industrial sources	5	10	8,500
Classified Material		Highly-combustible waste, paper, cardboard cartons including up to 10 percent plastics and treated paper	-	-	10,000
* Types 2, 3 and 4 are not suitable for baghouse applications. Include ash analysis if available.					

****

****

NOTE: Insert appropriate Section number and title in the blanks below using format per UFC 1-300-02.

****

Design baghouse(s) for operation with [manually] [automatically] controlled [incinerator(s) specified in [_____]] [incinerator(s) manufactured by [_____], Type [_____]] capable of burning [_____] [kg/s lb/hr] [Mgtons per day] of Type [0], [1], [2], [3], [4], [loose paper] [loose wood] [classified material] wastes. Operation is expected to be between [_____] and [_____] [kg/slb/hr] [Mgtons per day] of wastes. The auxiliary fuel is [_____].

]1.5.4 Mechanical Collector Data

****

NOTE: Avoid using a mechanical collector upstream of a baghouse. Since mechanical collectors are most effective on particulate greater than 5 microns, baghouse inlet gas conditions would be skewed towards a finer particulate size distribution. However, an excess of fine particulates tends to cause baghouse pressure drop and bag life problems. Not only is there an increased pressure drop in the baghouse due to the finer particulates but the

mechanical collector will add 498 to 747 Pa 2 to 3 inches WC to the overall system pressure drop. Use a mechanical collector upstream of a baghouse only if necessary to prevent glowing embers (from incinerators) from burning bags.

****

Design baghouse(s) for operation with [Section 23 51 43.01 20 MECHANICAL CYCLONE DUST COLLECTOR OF FLUE GAS PARTICULATES] [mechanical cyclone dust collector(s) manufactured by [_____], Type [_____], Model Number [_____]]. The mechanical dust collector [is specified to have] [was designed for] an outlet particulate emissions loading no greater than [_____] grams per dry std cu meter grains per dry std cu ft.

1.5.5 Inlet Gas Conditions

****

NOTE:

1. Baghouse manufacturer must know the expected range of inlet gas conditions. For operation sensitive at reduced load applications, eg. stokers and incinerators, include upset partial load conditions. This information can best be supplied by the boiler or incinerator manufacturer; compensate for system component effects between the baghouse inlet and boiler, or incinerator, outlet.

2. For existing installations, conduct source testing to determine baghouse inlet gas conditions. Use EPA, 40 CFR 60, Appendix A, Method 1 through Method 4, to determine gas volume flowrates. Use ASME PTC 28 to determine particulate size distribution. For particulate loading only, use EPA, 40 CFR 60, Appendix A, Method 5, or Method 17.

3. For new installations, obtain inlet gas conditions from the manufacturer. If this is not possible, estimate using EPA AP-42 emission factors. Make corrections for expected combustible content.

****

Baghouse inlet gas conditions, at [_____] meter feet above sea level, are:

	Maximum	Minimum	Peak
a. Inlet gas volume, L/s:	[_____]	[_____]	[_____]
b. Inlet gas temperature, degrees C:	[_____]	[_____]	[_____]
c. Gas temperature, degrees C	[_____]	[_____]	[_____]
d. Gas density, kg/m3	[_____]	[_____]	[_____]

	Maximum	Minimum	Peak
a. Inlet gas volume, L/s:	[_____]	[_____]	[_____]
e. Gas moisture, percent by weight	[_____]	[_____]	[_____]
f. Particulate size distribution:			

	Maximum	Minimum	Peak
a. Inlet gas volume, acfm:	[_____]	[_____]	[_____]
b. Inlet gas temperature, degrees F:	[_____]	[_____]	[_____]
c. Gas temperature, degrees F	[_____]	[_____]	[_____]
d. Gas density, lb/ft3	[_____]	[_____]	[_____]
e. Gas moisture, percent by weight	[_____]	[_____]	[_____]
f. Particulate size distribution:			

Size, Microns	Maximum Percent by Weight Less Than Particle Size
60	[_____]
40	[_____]
30	[_____]
20	[_____]
15	[_____]
10	[_____]
7.5	[_____]
1.0	[_____]
Total	[_____]

	Maximum	Minimum
g. Particulate loading, grams per liter		
h. Flyash specific volume (loose) for hopper volume design, m3/kg	[_____]	[_____]
i. Flyash density (compacted) for hopper weight design, kg/m3	[_____]	[_____]
j. Excess air, percent	[_____]	[_____]

	Maximum	Minimum
g. Particulate loading, grains per acf		
h. Flyash specific volume (loose) for hopper volume design, ft3/lb	[_____]	[_____]
i. Flyash density (compacted) for hopper weight design, lb/ft3	[_____]	[_____]
j. Excess air, percent	[_____]	[_____]

1.5.6 Fabric Filter Type Dust Collector (Baghouse)

****

NOTE:

1. Review projects to determine feasibility of purchasing an additional compartment for out-of-service maintenance.

2. Provide a manual flue gas bypass system for oil firing startup and provide also an automatic flue gas bypass system for use during operational upsets, should flue gas temperature exceed the bag material temperature limit or should baghouse pressure drop exceed paragraph entitled "Design Criteria" by 10 percent. This is particularly important if the standby fuel is oil. Local environmental regulations may require a waiver to permit this necessary feature.

3. The air-to-cloth ratio effects the baghouse pressure drop, bag failure rate, and bag life. It is dependent upon the bag cleaning system, frequency of cleaning, and dust loading. Most reverse air baghouses have a net air-to-cloth ratio of 2-2.5 to 1. The Navy recommends use 2 to 1. Most pulse jet baghouses will have a net air-to-cloth ratio of 4-4.5 to 1, based on a continuous cleaning cycle. The Navy recommends use 4 to 1.

4. Pressure drop across the baghouse, measured after the bags have had time to season in service, is a function of the air-to-cloth ratio, inlet dust loading, and dust particulate characteristics. For

a 2 to 1 air-to-cloth ratio and 4.60 g/m3 2 grains per acf inlet dust loading, the flange to flange pressure drop should be approximately 1245 Pa 5 inches WC.

5. Use a 55 degree hopper valley angle unless the ash is "sticky" as for Western coal, or if moisture content is high; then use a 60 degree angle. Ash hopper collection capacity should be approximately 8 to 10 hours using 1/3 of the hopper volume.

****

Design baghouse(s) complete with structural supports, weather enclosure, manifolds, ductwork, dampers, bags, bag cleaning system, hoppers, and accessories to meet OSHA regulations, ICAC F-2, ICAC F-3, ICAC F-5, and the following criteria. Base applicable criteria on maximum flow conditions specified in the above paragraph with two compartments out of service; one out of service for cleaning and one out of service for maintenance.

a. Maximum outlet particulate emissions loading, grams per dry std cu meter grains per dry std cu ft [_____]

b. Maximum gas velocity, m/s fps [_____]

c. Minimum number of online compartments ____4____

d. Maximum net air-to-cloth ratio, L/s per sq meter acfm per sq ft (at maximum continuous rating, including volume used for reverse air) [_____]

e. Minimum system pressure drop, Pa inches WC (from inlet flange to outlet flange) [_____]

f. Maximum system pressure drop, Pa inches WC (from inlet flange to outlet flange) [_____]

g. Minimum individual hopper storage capacity, hours [_____]

h. Minimum individual hopper storage capacity, cu m cu ft[_____]

i. Minimum hopper valley angle, degrees from horizontal ___55___

j. Maximum negative pressure, Pa inches WC [_____]

k. Maximum snow load, kg/m2 psf [_____]

l. Maximum wind load, kg/m2 psf [_____]

m. Maximum live load, kg/m2 psf [_____]

[1.5.7 Bags--Reverse Air Cleaning System

****

NOTE: Select this paragraph or the following paragraph entitled "Bags--Pulse Jet Cleaning System."

****

a. Maximum bag diameter, 305 mm 12 inches

b. Maximum bag length, 10.70 m 35 feet

c. Minimum tensile strength (warp direction), kPa psi [_____]

d. Minimum tensile strength (fill direction), kPa psi [_____]

e. Minimum yarn weight, g per sq m oz per sq yd [_____]

f. Minimum permeability, L/s per sq m cfm per sq ft (clean at 125 Pa 1/2 inch WC) [_____]

g. Minimum thickness, mm mil [_____]

h. Minimum M.I.T. flex (warp direction), cycles [_____]

i. Minimum M.I.T. flex (fill direction), cycles [_____]

j. Minimum count, ends per 25 mm inch by picks per 25 mm inch [_____]

k. Minimum fabric weight, 2894 g per sq m 9.5 oz per sq ft

l. Minimum bursting strength, kPa psi [_____]

][1.5.8 Bags--Pulse Jet Cleaning System

a. Maximum bag diameter, 152 mm 6 inches

b. Maximum bag length, 4.25 m 14 feet

c. Minimum tensile strength (warp direction), kPa psi [_____]

d. Minimum tensile strength (fill direction), kPa psi [_____]

e. Minimum yarn weight, g per sq m oz per sq yd [_____]

f. Minimum permeability, L/s per sq m cfm per sq ft (clean at 125 Pa 1/2 inch WC) [_____]

g. Minimum thickness, mm mil [_____]

h. Minimum M.I.T. flex (warp direction), cycles [_____]

i. Minimum M.I.T. flex (fill direction), cycles [_____]

j. Minimum count, ends per 25 mm inch by picks per 25 mm inch [_____]

k. Minimum fabric weight, 4874 g per sq m 16 oz per sq ft

l. Minimum bursting strength, kPa psi [_____]

]1.5.9 Test

1.5.9.1 Particulate Emissions Test Procedures

Include:

a. Name, address, and telephone number of testing organization.

b. Procedures and equipment description.

c. Analytical techniques.

1.5.9.2 Dust Collector Model Tests Report

Submit the model study report within 45 days of test completion. Model study report must include:

a. Scale drawing of the model showing actual dimensions and modifications, and devices required as a result of the model study.

b. Photographs and videotape recordings of model during air flow tests.

c. Uniform gas velocity diagrams and histograms indicating the root mean square deviation, standard deviation, and mean velocity, at locations including the inlet and outlet to the baghouse, and the inlet and outlet to each baghouse compartment.

d. Test procedures including flow rates, pressures, calculations, and assumptions.

e. List of and justifications for dynamic or geometric similitude deviations in the model from the full size unit.

f. Pressure drop data at each pressure tap during each test run, including data from initial runs used for identifying gas flow distribution problems and test data from runs made after the addition of supplemental gas flow distribution devices.

g. Recommendations for test port locations, instrumentation monitor locations, and for providing uniform gas flow; breeching configuration changes, gas flow vaning, straightening, or gas distribution devices.

h. Name and resumes of test personnel.

1.5.9.3 Bag Tests Data

Submit test certification and sample for each finished material lot. Test certification data must include, for each material lot analysis:

a. Yarn weight.

b. Permeability.

c. Tensile strength.

d. Thickness.

e. M.I.T. flex.

f. Count.

g. Fabric weight.

h. Bursting strength.

1.5.9.4 Particulate Emissions Tests Report

Submit the particulate emission test report within 45 days of test completion. Test report must include:

a. Process description.

b. Schematic drawings.

c. Test procedures including chain of custody and analytical techniques.

d. Test results including inlet loading, emission rates, and isokinetic sampling rates.

e. Raw data for each test run, including calculations, load sheets, and calibration data.

f. Name and resumes of test personnel.

1.5.9.5 Damper Tests Reports

Submit test reports in accordance with the paragraph entitled "Dampers." In lieu of poppet damper factory tests include field testing results for poppet dampers at similar installations.

1.5.9.6 Baghouse Inspection

Submit a written inspection report from the baghouse manufacturer's service engineers within 15 days after inspection.

1.6 EXTRA STOCK

Provide ten percent of total bags and two percent of total cages as spares. Provide fluorescent powder for one year of normal inspections and provide a portable ultraviolet light to leak test the bags.

1.7 MODEL

1.7.1 Dust Collector Model Study Procedures

Include:

a. Name, address, and telephone number of testing organization.

b. Procedures and equipment to be used.

c. Model design and construction.

d. Model dust use justification.

1.7.2 Delivery

Deliver model used during model study, including a support table, [to the Contracting Officer] within one year of startup of the full size unit.

PART 2 PRODUCTS

2.1 MATERIALS

****
NOTE: This guide specification presents nonpropriety materials and equipment. When the guide specification is edited or supplemented to suit project requirements, exercise care to present a project specification section which contains no proprietary materials or equipment.
****

Provide materials suited for the intended service. The material of parts exposed to the flue gas must withstand chemical action of flue gas and flyash.

2.1.1 General

Provide the following materials and minimum thicknesses:

a. Ductwork (6 mm 1/4 inch): ASTM A36/A36M

b. Hoppers (6 mm 1/4 inch): ASTM A36/A36M

c. Housing (6 mm 1/4 inch): ASTM A36/A36M

d. Structural steel (6 mm 1/4 inch): ASTM A36/A36M

e. Tube sheet (6 mm 1/4 inch): ASTM A36/A36M

f. Weather enclosure (6 mm 1/4 inch): ASTM A36/A36M

g. Floor grating: NAAMM MBG 531

h. Stair tread grating: NAAMM MBG 531

i. Weather enclosure roof and top surface of appurtenant structures (6.40 mm 1/4 inch): ASTM A242/A242M, Type I, raised pattern plate.

2.1.2 Insulation

Insulate baghouse ductwork including [reverse air ductwork,] inlet manifold ductwork, and outlet manifold ductwork, hoppers, housing, and weather enclosure. Do not use materials containing asbestos, magnesium oxide, or Mica. Provide the following materials and minimum thicknesses:

a. Ductwork (80 mm 3 inches): ASTM C592, mineral fiber blanket; or ASTM C612, mineral fiber block.

b. Hoppers (100 mm 4 inches) (with 50 mm 2 inchair gap): ASTM C533, calcium silicate block; ASTM C592, mineral fiber blanket; or ASTM C612, mineral fiber block.

c. Housing (100 mm 4 inches): ASTM C533, calcium silicate block; ASTM C592, mineral fiber blanket; or ASTM C612, mineral fiber block.

d. Weather enclosure (80 mm 3 inches): ASTM C533, calcium silicate.

2.1.3 Casing

Case baghouse ductwork including [reverse air ductwork,] inlet manifold ductwork, and outlet manifold ductwork, hoppers, housing, and weather enclosure. Provide the following materials and minimum casing thicknesses:

a. Top ductwork surface and weather enclosure roof (2 mm 0.080 inch): ASTM B209M ASTM B209, flat aluminum sheet supported to permit use as a walking surface without causing distortion or damage.

b. All other surfaces (100 mm 4 inch rib) (1.25 mm 0.050 inch): ASTM B209M ASTM B209, unpainted aluminum panel and stucco embossed.

2.2 BAGS AND HARDWARE

[2.2.1 Bags and Hardware, Reverse Air Cleaning System

****
NOTE: Select this paragraph or the paragraph below entitled "Bags and Hardware, Pulse Jet Cleaning System."
****

Provide glass fiber bags, 3 kg per sq m 9.5 oz per sq ft, 3 by 1 twill weave, as specified in paragraph entitled "Design Criteria." Coat bags with 100 percent Teflon B lubricant for 10 percent add on weight. Bags 305 mm 12 inches in diameter and maximum 10.70 meters 35 feet in length must have not less than eight 3 mm 1/8 inchsewn-in cadmium plated welded steel anti-collapse rings. Bags 200 mm 8 inches in diameter and maximum 7.30 meters 24 feet in length must have not less than five 3 mm 1/8 inch sewn-in cadmium plated welded steel anti-collapse rings. Provide leakproof quick release Type 301 stainless steel clamps to attach the lower portion of the bags to the caps and thimbles. Provide an adjustable suspension system without using nuts and bolts to attach the upper portion of the bags. Cadmium plate bag caps and suspension hardware which come into contact with the bag fabric. Provide ten percent of total bags as spare bags. Stitch bags using [_____] thread. Provide fluorescent powder for one year of normal inspections and provide a portable ultraviolet light to leak test the bags.

][2.2.2 Bags and Hardware, Pulse Jet Cleaning System

Provide glass fiber bags, 4874 gram per sq m 16 oz per sq ft, 3 by 1 twill weave, as specified in paragraph entitled "Design Criteria." Coat bags with 100 percent Teflon B lubricant for 10 percent add on weight. Provide the manufacturer's standard cage design including venturis, provided it has a reliable service record with the bags proposed. Attach bags and cages to the tub sheet to provide proper air seal, bag tension, and cage alignment. Clamp bags at top between the cage and tube sheet so that the bags may be readily removed without special tools yet not sway.

]2.3 STRUCTURAL SUPPORTS

Provide structural and miscellaneous steel to frame and support the baghouse, ductwork, weather enclosure, component parts, and equipment. Structural steel includes columns, beams, trusses, baseplates, girts, bracing, purlins, girders, and hangers. Miscellaneous steel includes edge plates, handrails, stairs, grating, and ladders. Provide steel supports for paragraph entitled "Access Provisions." Provide concrete foundations,

anchor bolts, and grouting. Allow 50 mm 2 inches for grout so that bottom of baseplates are at an elevation of [_____] meters feet. Design structural steel support of baghouse to withstand differential thermal expansion and to support its own dead weight plus insulation, the maximum weight of accumulated flyash, and the maximum loads as specified in paragraph entitled "Design Criteria," or 4.8 kPa 100 psf, whichever is greater. Design to support equipment from the top of concrete foundations set an elevation of [[_____] metersfeet] [150 mm6 inches above grade]. Platform live loads may be excluded. Design for a roof dead load of one kPa 20 psf and a live load of 1.50 kPa 30 psf. Design supports in accordance with Section 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS and earthquake regulations. Use site periods between [[_____] and [_____]] [0.8 and 1.2] seconds for Zone [_____] structures, whichever results in the highest lateral force. Use the normal operating weight of the unit including dead loads as "W."

2.3.1 Girts and Opening Frames

Provide doors, door frames, and ventilators. Provide structural subframing for doors and ventilators located above grade [_____] meters feet. Provide girts to support outside face of metal wall panel, spaced at maximum 2.10 meters 7 feet center-to-center. Locate lowest girt above grade [[_____] meters feet] with support at the wall base. Design girt line or outside edge distance from the supporting column centerline for 0.56 meter one foot 10 inches. Provide closed ends or miter cut girts at corners.

2.3.2 Slide Bearings

Provide structural slide bearings using fluoroplastic self-lubricating bearing elements to ensure correct alignment and to prevent equipment damage and stress. Use slide bars to prevent ash and dirt from accumulating on the bearings.

2.4 DUCTWORK SYSTEM

Provide insulated weather-tight ductwork system from the [economizer] [air heater] [_____] outlet to the stack inlet including [reverse air ductwork,] bypass ductwork, and manifolds complete with transitions, structural steel, structural slide bearings, turning vanes, expansion joints, dampers, test ports, and mechanical draft equipment. Weld by continuous fillet or complete penetration groove welds. Design ductwork system for temperatures of minus 12 to plus 204 degrees C 10 to 400 degrees F, internal pressures of positive 5 kPa to negative 7.60 kPa 20 to negative 30 inches Water Column (WC), velocities of [_____] m/s fps, and for flyash fallout of 1171 kg/m2 240 lb/sq ft. Provide penetrations for control instruments.

2.4.1 General Ductwork

Provide insulated weather-tight ductwork. For ductwork sections greater than [_____] meters feet in length, provide hoppers, clean-out doors, and additional structural support. Do not apply loads at interface points. Provide 9.50 mm 3/8 inch thick turning vanes for turns greater than 45 degrees and where indicated by the model study. Brace turning vanes with pipes and angles but do not brace with rods. Brace ductwork maintaining bolt hold tolerances of 0.8 mm 1/32 inchbetween adjacent holes and 1 .50 mm 1/16 inch between two holes on the same side. Provide bolts, nuts, and ethylene propylene terpolymer (EPDM) gaskets for flanged connections.

2.4.2 Manifolds

Provide insulated weather-tight inlet and outlet manifolds supported from the baghouse structure. Include expansion joints. Locate manifolds, minimum 6 mm 1/4 inch stiffened ASTM A36/A36M of welded construction, between two rows of compartments and design to minimize pressure drop yet avoid low velocities which may allow flyash fallout. Base structural design on the assumption that manifolds are 30 percent full of flyash. Taper inlet manifold and provide take-offs to each compartments at or near the manifold bottom to assist flyash into the compartments. Provide a replaceable, abrasion resistant baffle plate at each compartment inlet.

2.4.3 Expansion Joints

Provide nonmetallic belt expansion joints with minimum 80 by 80 by 6 mm 3 by 3 by 1/4 inch carbon steel angle flanges. Belt material must be minimum 6 mm 1/4 inch thick, two-ply, aramid or fiberglass reinforced, solid fluoroelastomer polymer, spliced to form an endless belt without sewn joints. Provide nuts and bolts to attach fabric to the flanges and to attach expansion joints to the ductwork. Flange bolt holes must be factory punched and located at maximum 100 mm 4 inchcenters.

2.4.4 Dampers

****

NOTE: Provide items in brackets for reverse air cleaning system baghouses only.

****

Provide automatically controlled damper units, including framing, operators, and accessories, for the induced draft fan inlet, [the reverse air fan inlet,] the inlet manifold, the outlet manifold, the inlet of each compartment, [the outlet of each compartment,] [the inlet reverse air ductwork,] and the bypass ductwork. Dampers must conform to AMCA 500-D, AMCA 801, and AMCA 802 and must withstand, without affecting damper operation, differential thermal expansion, 1464 kg/m2 300 lb/sq ft flyash load at the bottom of the damper frame, 908 kg 2,000 pound concentrated load at the maximum frame deflection point, and maximum loads specified in paragraph entitled "Design Criteria."Damper frame must support the damper unit including controls, motors, drive mechanisms, and seal air system, with only one flange bolted to the ductwork without swaying or without causing the blade to blind. Bearings, bearing mount, and linkage system including connections must withstand three times the damper blade load plus the operator output torque, at worst case design conditions. Damper units must include:

a. Pneumatic operators; except guillotine dampers which must have the manufacturer's standard motor operators. Locate outside of the gas stream and within access for maintenance during baghouse operation.

b. Control drive units with permanently mounted handwheels which may be disengaged during pneumatic or motor operation; exclude poppet damper actuators.

c. Limit switches to show damper position (opened or closed).

d. Mechanical position indicator, at the damper, to show percent of damper opening.

e. Flanged frames for bolting to connecting ductwork.

f. Lifting lugs for transportation and installation handling.

g. External, locally mounted audible alarms to signal loss of seal air. Upon loss of power or air, dampers must fail in [failshut] [failopen] position.

h. Bearings. Permanently lubricated, self-aligning bearings located outside of the damper unit, insulation, and lagging, so that leaking packing must not contaminate the bearing with flyash.

i. Sealing strips, bolting materials and backing strips: ASTM B443. Not required for induced draft fan dampers.

j. Nuts, bolts, and washers. Use self-locking Type 316 stainless steel, Unified Numbering System Number S31600 (0.03 to 0.08 percent carbon) bolts, so that damper unit vibrations do not cause bolts to back out.

2.4.4.1 Louver Dampers

Provide the induced draft fan inlet [and the reverse air fan inlet] with parallel or opposed airfoil louver damper units. Frame length must be 25 mm one inch greater than the blade width; blade width must be maximum 610 mm 24 inches. Provide a minimum of two blades. Dampers having an open area of 3.72 to 7.43 sq meter 40 to 80 sfmust have a minimum of three blades. Dampers having an open area over 7.43 sq meter 80 sf must have a minimum of four blades. Allowable bending stresses must not exceed 60 percent of yield at design conditions. Provide louver damper units with the following:

a. Damper blade shaft assembly. Limit deflections at maximum damper seal conditions to L/360 (L = blade length in mm inches) or 6 mm 1/4 inch, whichever is less, and to deliver the full operator torque to a blade without exceeding one-third of the shaft yield stress when operating at the worst case design conditions.

b. Stuffing boxes. Provide dust-tight stuffing boxes, to seal shaft openings, so that fluoroplastic packing may be adjusted or removed from the outside of the duct without removing bearings or linkage.

c. Linkage system. Provide fully adjustable self-locking linkage system outside of the damper unit. Key arms to the shaft for easy removal. Pin or bolt stub shafts to the through shaft or blade so that individual damper blades may be adjusted or removed. Use Type 304 stainless steel, Unified Numbering System Number S30400 (0.03 to 0.08 percent carbon), linkage pins or bolts to connect carbon steel clevis arm to the stub shaft. Provide two operators on the linkage system, one to operate the top blade, and one to operate the bottom blade. The upper blades must closed first, then the bottom blade must close. Design linkage so that the number of blades operated by each operator may be changed.

d. Lock system. Provide a lock system using heavy-duty padlocks so the damper system can not be operated until the padlocks are removed.

2.4.4.2 Poppet and Butterfly Dampers

Provide each compartment with an inlet [, an outlet, and an inlet reverse air] damper having a maximum air leakage rate of 0.5 percent to provide for essentially zero leakage at maximum baghouse design differential pressure. Dampers must be either poppet dampers or butterfly dampers with adjustable speed and stroke operators, shaft packing glands, replaceable seal plates, and machined steel seating cylinder and guide shaft. Provide a lock system to lock dampers closed to protect service personnel. Locate shafts out of the dirty gas stream, otherwise provide shaft seals.

2.4.4.3 Double Guillotine Dampers

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NOTE: An outlet manifold damper is not required for single baghouse installations. Where two or more baghouses share a single stack, provide dampers at each baghouse outlet manifold to prevent flue gas from exiting one baghouse and entering another.

****

Provide the inlet manifold, [the outlet manifold,] and the inlet bypass, with double plate steel guillotine dampers having a maximum air leakage rate of 0.5 percent to provide for essentially zero leakage at maximum baghouse design differential pressure. One damper must be open while the other damper is closed. Include a mechanical crank for manual operation. Provide dampers with carbon steel bonnets over the top frame, removable side plates for inspection of the damper drive assembly, and a removable bottom plate for access to the frame seal. Design bonnet for continuous seal air purge and provide an air reservoir to activate the damper upon loss of plant air. Design damper drive to lift the damper blade evenly on both sides. Provide damper units with the following:

a. Sealing strips, bolting materials and backing strips: ASTM B443. Provide both the upstream and downstream side of blade with sealing strips around the periphery of the blade and on the seating surfaces of the frame.

b. Control interlocks: Provide control interlocks to prevent dampers from simultaneously closing when the induced draft fan is operating.

2.4.4.4 Seal Air Systems

Provide each guillotine damper with a seal air system, consisting of an isolation damper or valve and a fan system, mounted onto the frame and located within access for maintenance. Mount so that condensation between the dampers flows into the ductwork. If installation on the damper frame is not possible, provide a platform to support the equipment. Fan, at design conditions, must supply two times the guaranteed L/s cfmleakage rate through the dampers and must maintain not less than 747 Pa 3 inches WC between the seal chamber and the flue gas. Control the seal chamber pressure using a mild steel manual control damper or a minimum 55 percent nickel, 20 percent chromium and 8 percent molybdenum gate or butterfly valve. Valve must operate on 552 to 862 kPa (gage) 80 to 125 psig instrument air using a pneumatic piston operator. Should the air supply fail, the piston actuator must remain in the last position. Provide instrumentation to monitor seal air system operation; tube and mount a 4-way dual-coil solenoid valve, with Class H coils rated for 120 VAC service. Provide two dual-pole dual-throw limit switches, one to actuate

in the open position, one to actuate in the closed position, and house within a NEMA ICS 6, Type 4 enclosure.

2.4.5 Test Ports

ASTM A167, Type 316 stainless steel pipe, Schedule 40. Provide three 50 mm 2 inch pipe nipples with caps and rod-out on the topside of each guillotine damper seal chamber and provide one 50 mm 2 inch port with rod-out on the ductwork adjacent to each guillotine seal chamber, to attach seal chamber pressure measurement tubing. Provide 150 mm 6 inch diameter test ports on the horizontal side of the ductwork for air pollution sampling; locate the test ports upstream baghouse and downstream baghouse. Ports on ductwork must extend 150 mm 6 inches beyond stiffeners to clear insulation and lagging. Provide a screw plug for each test port. Coat each plug with an antiseize lubricant appropriate for the design inlet temperatures. Determine number, arrangement, and location of air pollution sampling test ports using 40 CFR 60, EPA AP-42, Appendix A, Method 1. Final number, location, and arrangement of test ports is subject to Contracting Officer approval.

2.4.6 Mechanical Draft Equipment

Provide mechanical draft equipment complete with operators, accessories, and field service.

2.5 HOPPERS

Provide insulated gas tight pyramidal hoppers as specified in paragraph entitled "Design Criteria." Design to withstand vibration due to vibrators and differential thermal expansion. Hoppers must span no more than one compartment. Weld hoppers to the baghouse compartments using continuous fillet or complete penetration groove welds. Provide a minimum 300 mm 12 inch diameter flanged flyash outlet connection on each hopper.

2.5.1 Poke Hole

Provide each hopper with a 100 mm 4 inch diameter poke hole extending a minimum of 150 mm 6 inches beyond the stiffeners and the hopper side, to clear insulation and lagging. Include a screwed cap. Locate the poke hole near the hopper outlet flange, orient to be accessible from the platform, and position to permit downward thrusts into hopper throat.

2.5.2 Vibrators

Provide each hopper with both mechanical and manual vibrators. Mechanical vibrators must consist of two automatically controlled vibrators, with manual override control, set at mid height and on opposite sides of the hopper. Interface vibrator controls with the ash evacuation system so that vibrators operate at the inception of and during an ash evacuation cycle. Enclose controls in cases to prevent accidental energizing of system. Place a warning over the vibrator manual override control, "WARNING; VIBRATOR CONTROL. DO NOT ACTIVATE UNLESS HOPPER EVACUATION SYSTEM IS OPERATING." Manual vibrators must consist of two uninsulated reinforced strike plates set at mid height and on opposite sides of the hopper. Provide strike plates, 300 by 300 by 25 mm 12 by 12 by one inch ASTM A36/A36M steel, within hinged insulated panels. Provide space around strike plate to swing a small sledge hammer. Provide a work platform with stairs for strike plates greater than 1.50 meters 5 feet above ground.

2.5.3 Flyash Level Alarm System

Provide each hopper with a flyash level alarm system consisting of a nuclear flyash level detector and alarm relays to indicate the 50 percent hopper capacity level and the empty level. The nuclear detector must be an explosion proof, Cesium 137 single point gamma source detector having a lockable shutter mechanism operated by an external handle. Reproducibility must be within one inch. Design to withstand vibration and temperatures up to 427 degrees C 800 degrees F. Interlock with hopper access doors to prevent entry into the hopper when the source is activated. Provide one access key per hopper door. The alarm relays must be rated at 10 A, 120 VAC, or 125 VDC continuous duty. House flyash level detector controls in a [explosion proof] [dustproof] enclosure and mount in an easily accessible location. System must be operational at outdoor temperatures between minus 40 and 93 degrees C 40 F and 200 degrees F.

2.5.4 Hopper Heater System

Provide each hopper with an automatically controlled hopper and hopper throat heater system able to withstand 454 degrees C 850 degrees F, the maximum expected mechanical (normal operation) vibrations, and manual (strike plate use) vibrations. Design using a minimum 1.1 heating safety factor and a minimum 1.12 wind loss. Hopper and hopper throat heaters with insulation in place, at minimum ambient temperature of [_____] degrees C F, must maintain an internal skin temperature of 121 degrees C 250 degrees F while offline and during startup, and must maintain an internal skin temperature of 177 degrees C 350 degrees F or acid dew point temperature while online.

2.5.4.1 Hopper Heaters

Hopper heaters must cover not less than 33 percent of the total hopper area and must extend not less than 70 percent up the hopper height. Provide modular hopper heaters having a flexible heating face to conform to the irregularities of the hopper surface to provide maximum heat transfer. Where modular heaters do not fit, provide tape heaters or flexible blanket heaters. Heaters must be maximum 0.0046 W/mm2 3 W/in2 of resistance element, with a minimum 6 parallel resistance path, rated at 2.7 kw/m2 250 W/ft2 but designed to operate at 2.2 kW/m2 200 W/ft2. Use Series 600 stainless steel alloy or nickel-chrome heating elements and encase in a minimum 20 Gage aluminum or aluminized-steel mounting pan or casing. Provide heaters with attached metal labels listing the heater's wattage and voltage.

2.5.4.2 Throat Heaters

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NOTE: The hopper throats are normally part of the ash evacuation valve connected to the hopper outlet flange. This cast iron valve housing creates a restrictive outlet, a common area for pluggage unless the flyash is heated; thus the hopper throat heaters are intended for the inlet of the ash evacuation valve housing. Insulate the hopper throats with a 50 mm 2 inch air gap with 80 mm 3 inches of insulation.

****

Provide tape heaters or flexible blanket heaters having a single Series

600 stainless steel alloy or nickel-chrome heating element, rated at 2.7 kW/m2 250 W/ft2. Design heaters to operate at 2.2 kW/m2 200 W/ft2 and to remain on during startup, offline, and online operating conditions. Encase in a minimum 20 Gage aluminum or aluminized-steel mounting pan or casing. Provide attached metal labels listing the heater's wattage and voltage.

2.6 WEATHER ENCLOSURES--REVERSE AIR CLEANING SYSTEM

****
NOTE: Select the applicable paragraph(s) from the following:
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[Provide a weather-tight enclosure, including lighting, to enclose the top and the bottom of the baghouse. Enclose hoppers within the bottom weather enclosure. Conform to SMACNA 1793. Seal joints by continuous fillet or complete penetration groove welds. Do not use caulking. Design enclosures to withstand differential thermal expansion between housing and weather enclosures. Design weather enclosure roof to support minimum 4.8 kPa 100 psf. Space roof purlins so that roof deck span will not exceed 2.12 m 7 feet. Provide additional support for equipment placed on the roof. Slope and extend top surface and top surfaces of appurtenant structures, but not less than 25 mm one inch beyond side insulation, to allow water runoff and to prevent pooling. Provide a safety rail around the top perimeter surface, a 80 mm 3 inch fascia rain barrier of 6 mm 1/4 inch ASTM A242/A242M steel plate, a 80 mm 3 inch kickplate of 6 mm 1/4 inch ASTM A242/A242M steel plate, and drain holes to permit water runoff.

][WEATHER ENCLOSURE--PULSE JET CLEANING SYSTEM

Provide an insulated clean gas outlet plenum directly above the bags. Since the outlet plenum must enclose the entire top of the baghouse, do not provide a weather enclosure above the outlet plenum. However, enclose hoppers within a bottom weather enclosure. Plenum height must be \7[minimum\^ 305 mm^\\~ one foot~\ greater in height than bags] [minimum 4.50 meters 15 feet when using 4.30 meters 14 feet bags] to provide an indoor bag replacement area. Conform to SMACNA 1793. Include lighting. Seal joints by continuous fillet or complete penetration groove welds. Do not use caulking. Design enclosure to withstand differential thermal expansion between housing and weather enclosure. Design plenum to support minimum 4.8 kPa 100 psf. Space roof purlins so that roof deck span will not exceed 2.13 meters 7 feet. Provide additional support for equipment placed on the roof. Slope and extend top surface and top surfaces of appurtenant structures, by not less than 25 mm one inch beyond side insulation, to allow water runoff and to prevent pooling. Provide a safety rail around the top perimeter surface, a 80 mm 3 inch fascia rain barrier of 6 mm 1/4 inch ASTM A242/A242M steel plate, a 80 mm 3 inch kickplate of 6 mm 1/4 inch ASTM A242/A242M steel plate, and drain holes to permit water runoff.

]2.7 BAG CLEANING SYSTEM

2.7.1 General

Clean bags by [reverse air] [pulse jet]. Clean one compartment at a time on a predetermined adjustable programmed cycle or when the differential pressure across the bags reaches a set point. Provide 50 mm 2 inch capped pressure taps with rod-outs on each side of the tube sheet, accessible

from the access platforms, to measure differential pressure. Connect pressure taps to remote indicators in the control room using minimum 10 mm 3/8 inch stainless steel tubing. Provide tubing with three-way valves, adjacent to the pressure indicators within the control room panel, to allow cleaning of the pressure lines with compressed air.

[2.7.2 Reverse Air Cleaning System

Provide each baghouse with a reverse air cleaning system including two reverse air fans, connecting ductwork, dampers, valves, and automatic controls. Bags must gradually reinflate after cleaning. Use air from the outlet manifold for reverse air cleaning and to maintain the reverse air ductwork temperature above the dewpoint temperature. Thimbles for 200 mm 8 inch diameter bags must be of 12 Gage carbon-steel plate, one nominal bag diameter in length, and spaced not less than 241 mm 9 1/2 inch on centers. Thimbles for 300 mm 12 inch diameter bags must be of 12 Gage carbon-steel plate, one nominal bag diameter in length, and spaced not less than 356 mm 14 inch on centers. Thimbles must be inline, not staggered. Tubesheet and bag alignment must be within 3 mm 1/8 inch for plumb.

2.7.2.1 Reverse Air Fans

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NOTE: One fan is sufficient for most applications. However, two fans, each rated at 100 percent of required capacity, may be required where increased reliability, logistics, or service dictate.
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Provide two heavy duty 100 percent capacity industrial reverse air fans; one fan must be placed on standby while the other fan is operational. Each fan must have a single flanged inlet, a single flanged outlet, and an automatically operated louver damper. Louver dampers must be as specified in paragraph entitled "Ductwork System" and must be designed for staged closing. Minimum reversing air flow must be 10 L/s per sq m 2 acfm per sf of net cloth area in a single compartment. Fan must be V-belt driven by a constant speed motor through an adjustable speed sheave, rated for flow, pressure, power, speed of rotation, and efficiency as in AMCA 210, AMCA 201, and AMCA 99. Mount the motor, Section 16, Electrical, on a slide motor base designed to allow belt tension adjustment from a screw mechanism. Provide motor with a belt guard. Provide a heat slinger for temperatures above 177 degrees C 350 degrees F.

2.7.2.2 Reverse Air Dampers

****
NOTE: Specify air pressure available for pneumatic installation and location. Include control wiring installation as part of this section or as part of Division 26, Electrical. If included in this section, it must comply with Division 26, Electrical. A duplicate control timer may be specified if increased reliability is desired.
****

Provide each compartment with dampers for the dirty gas inlet, the clean gas outlet, and the reverse air inlet, as specified in paragraph entitled "Ductwork System." The dirty gas inlet damper must be a manually operated

poppet or butterfly damper with the operator located within access for maintenance. The clean gas outlet damper and the reverse air inlet damper must be [air cylinder] [electrical motor] operated, adjustable speed poppet or butterfly dampers arranged for manual lockout capability with position indicating switches at both ends of travel. The clean gas outlet damper must fail-safe in the open position and the reverse air damper must fail-safe in the closed position.

Pulse Jet Cleaning System

Provide each compartment with a pulse jet cleaning system including compressed air dryer and filter system, isolation valves, pulse valves, and piping. Provide tube sheet arrangement and bag clearance to limit gas velocity between bags to a maximum 1.27 m/s 250 fpm at design conditions. Bag to bag clearance and bag to wall clearance must be minimum 50 mm 2 inches. Provide additional space between rows of bags, if necessary, to clear access door supports crossing the tube sheet. Arrange tube sheet for individual top bag and cage removal, and reinforce for minimum 488 kg/m2 100 psf pedestrian traffic.

Dryer and Filter System

Provide a dryer and filter system to remove moisture and particulate from compressed air for pulse jet cleaning. Size dryer and filter system for maximum 2 degrees C 35 degrees F dewpoint temperature at 690 kPa (gage) 100 psig, 120 percent of design air flow, and for 90 days of operation without service under normal operating conditions. Locate filters to be easily accessible for inspection and service.

Valves and Piping

Provide each compartment with an isolation valve to isolate the compartments for offline cleaning. When offline, individually pulse each row of bags with 483 to 690 kPa (gage) 70 to 100 psig dry, filtered compressed air. Provide each row with a compressed air header including heavy duty, stainless steel, internal, diaphragm pulse valves and solenoid actuators to distribute the compressed air to the bags. Diaphragm valves must be factory wired to a junction box and must be no louder than 84 dBA, 1.50 meters 5 feet from the valve. After the bags are cleaned, the compartment must remain offline for [_____] seconds to allow the dust to settle into the hoppers. Provide the distribution piping with couplings to allow removal of piping for bag replacement.

]2.8 BAGHOUSE CONTROLS

2.8.1 Control Functions

Provide main baghouse control from the boiler plant control room panel board. The main control system must include the following operational and monitoring functions:

a. Automatic and manual startup and shutdown. Provide manually initiated automatic startup sequence.

b. Automatic baghouse control.

****

NOTE: For pulse jet cleaning systems both off line cleaning (normal) and on-line cleaning are available.

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c. Automatic bag cleaning. Provide an automatic timer to initiate compartment cleaning when differential pressure across the bags reaches a set point.

d. Programmed bag cleaning. Provide an overriding timer to initiate compartment cleaning on a predetermined adjustable programmed cycle independent of pressure differential. Provide for [adjustable pulse jet duration time,] [adjustable pulse jet sequencing,] adjustable cleaning cycle time, adjustable settling time, and adjustable isolation valve operation.

e. Manual bag cleaning. Provide a manual selector switch to allow manual compartment cleaning.

f. Operations monitoring. Provide graphics and audible alarms to monitor equipment status for abnormal operation, malfunction, failure, or trip.

g. Automatic shutdown of malfunctioning components. Provide automatic and safe shutdown of malfunctioning components with minimal disruption to boiler operational capabilities.

h. Automatic and manual bypass. Provide automatic and manual bypass for out of service compartments or for system upset conditions. Design controls to bypass the baghouse when the inlet temperature is below [_____] degrees C F or above [_____] degrees C F. When a compartment is bypassed, exclude from the automatic cleaning cycle.

i. Compartment lockout. Interlock the automatic timer, overriding timer, and manual selector switch of each compartment with an isolation switch located at the tube sheet access door to isolate the compartment for maintenance.

Provide two position selector switches for the following:

a. Power--ON/OFF

b. Module--ACTIVE/INACTIVE

c. Cleaning Mode--OFFLINE/ONLINE

Provide momentary contact push buttons for the following:

a. System--START (green head)

b. Hopper level alarms

c. Alarm--ACKNOWLEDGE

Provide auxiliary devices for the following:

a. Position indication switches on isolation valves.

b. Hopper level alarms.

c. Temperature indicators, thermocouple alarm, and switch, to initiate bypass, at the baghouse inlet.

d. Temperature indicators and thermocouples at the baghouse outlet.

e. Temperature indicators and thermocouples for each hopper throat.

f. Differential pressure gages with pressure switch and audible alarm for each compartment.

g. Differential pressure gages with pressure switch and audible alarm for the baghouse inlet and outlet.

h. Opacity at baghouse outlet.

2.8.2 Instrumentation and Control Systems

Use solid-state analog circuitry. Assemble circuits using readily available pretested components making maximum use of integrated circuits. Gold plate pins and mating connectors on nickel to withstand chemical attack by ambient atmospheric chemicals. Arrange logic elements on circuit cards in functional groups so that failure of a single logic circuit or compartment must not affect more than one separate functional sequence. Memory must be static. Factory assemble, wire, test, and debug circuit cards using the operating stations and actual plug-in cables for the system. Test circuit card logic in the completed system for a minimum of 170 hours continuous operation. Provide programming aids to permit easy field reprogramming of adjustable parameters. Battery power backup may be approved by the Contracting Officer.

2.8.3 System Electrical Power and Power Supplies

The Government must furnish one 120 VAC power source from the station service. Provide fuses or circuit breakers to protect each source against faults, overloads, and power failures. Fuses, fuse panels, breakers, and breaker panels must be readily accessible and clearly identified. Provide input filters for noise suppression. Provide a full-capacity internal DC power supply for each bus.

2.8.4 Control Drive

Provide adjustable speed pneumatic control drives including handwheels, couplings, adapters, linkage system, drive arms, and damper arms, to respond to signals from the control system. Provide dual-pole dual-throw limit switches to electronically sense open and closed damper positions without using a slide mechanism. The full-stroke travel time of the damper drive piston in either direction must be adjustable from one second to one minute.

2.8.5 Main Baghouse Control Panel

Provide an enclosed control panel cabinet for each baghouse. Baghouse controls and indicators must include meters, recorders, thermocouples, pressure gages, graphics, annunciators, power supplies, power switches, and wiring. The cabinets, 3 mm 1/8 inch hot-rolled steel paneled NEMA ICS 6, Type 12 enclosures, reinforced inside with angles and channels, must have lifting lugs for shipping and handling. Provide a shipping pallet for each control panel cabinet. Cabinets must also include one two-tube 40 W, 120 V fluorescent light fixture, one 120 VAC duplex 3 wire polarized grounded outlet, terminal blocks, interior panels for mounting auxiliary equipment, front and rear hinged access doors with key locks, cutouts with removeable cover plates for items designated as

future, and floor anchoring or a floor foundation. Install cabinet sections side by side and provide bottom side openings to interconnect the cables without routing the cables outside of the cabinets. Do not bring power greater than 120 V into the cabinet. Fill and grind cabinet edges to a 6 mm 1/4 inch radius. Maintain cabinets at minimum 125 Pa 0.5 inch WC using a fan powered by a 120 V, single-phase minimum 0.09 kW 1/8 hp motor. Provide a ventilation system including ventilation louvers, grills, exhaust fans, ductwork, and filters to ensure heat is dissipated. Filter pressurizing air for particulates greater than one micron at a minimum 98.5 percent efficiency.

2.8.5.1 Recorders

Provide each miniature pen strip chart recorder with an engraved scaled legend plate, a rubber legend stamp, internal fluorescent lighting, a set of tools and accessories, and a 12 month supply of charts and ink. Design recorders for 120 VAC power. Miniature pen strip chart recorders must be 100 mm 4 inches in width having a 25 mm one inch per hour chart speed.

2.8.5.2 Thermocouples

Provide Type K ungrounded thermocouples with AWG Size 20 iron-constantan wires for measuring ductwork, and surface temperatures. Provide universal thermocouple heads with screwed covers, chains, terminal connectors, and stainless steel nipples so that head clears insulation by 50 mm 2 inches. Ductwork thermocouples must be spring loaded with two hole insulators, Type 304 stainless steel sleeve sheath, and silver plug tip. Insulate surface thermocouples using a glass fiber insulating jacket to protect thermocouples from high temperatures.

2.8.5.3 Pressure Gages

Provide pressure gages indicating pressures from zero to 2490 Pa 10 inches WC, with high and low pressure rip set points. Pressure gages must withstand up to 172 kPa (gage) 25 psig. Enclose pressure switch elements, 120 VAC, dual-pole dual-throw relays, in a NEMA ICS 6enclosure.

2.8.5.4 Graphics

Provide a graphic subpanel to pictorially describe the flue gas flow path through each baghouse, including through the ductwork, bypass, dampers, fans, and valves, to display the operating status of each fan, and to display the position of each valve and damper. Provide control switches, indicating lights, and meters adjacent to the corresponding graphic equipment symbol. Provide smooth finished display openings for the switches, lights, and meters, in the panel metal behind acrylic sheeting. The graphic symbols, flow lines, nameplates must be:

a. Base material: 6 mm 1/4 inch phenolic or 4.76 mm 3/16 inch solid acrylic sheeting.

b. Letters and symbol material: Laminated phenolic or acrylic sheeting.

c. Equipment symbols, flow arrows, and nameplates thickness: one mm 0.040 inch.

d. Flow line thickness: 0.50 mm 0.020 inch.

e. Color: Solid white core with colored satin finish overlay.

f. Engraving: Engrave through colored overlay to expose solid core. Cut laminate with beveled edges, except flow lines, to expose solid core on perimeter.

g. Mounting: Mount to front face sheet with contact cement. Cement must be removeable using a solvent that will not damage face sheet or symbols. Do not use double-faced adhesive tapes.

Indicating lights must be nominal 15 mm 1/2 inch diameter and rated for 120 VAC. Provide the following indicating lights; lens colors are in parentheses, * indicates items activating an audible alarm:

a. Inlet damper--OPEN (green)

b. Inlet damper--CLOSED (red)

c. Outlet poppet--OPEN (green)

d. Outlet poppet--CLOSED (red)

e. Module--ACTIVE (green)

f. Module--INACTIVE (red)

g. Hopper throat heater--ON (green)

h. Hopper throat heater--OFF (red)

i. High ash level (red)*, one per hopper

j. High inlet gas temperature (red)*

k. High temperature drop across baghouse (red)*

l. Low hopper temperature (red)*, one per hopper

m. Low compressed air pressure (red)*

n. High pressure drop across baghouse (red)*

o. Power--ON (red)

p. SYSTEM START (green)

q. SYSTEM STOP (red)

r. Cleaning mode OFFLINE selected (white)

s. Cleaning mode ONLINE selected (white)

t. Cleaning mode MALFUNCTION (red)*

2.8.5.5 Annunciators

Construct annunciators using factory-tested, burned in solid state electronics. Contact circuitry must meet IEEE C37.90.1. Power equipment from the Government's 120 VAC station service source. Arrange power supplies, circuit breakers, and input terminal blocks in groups to permit

servicing single section of the annunciator system without disabling the entire system. Alarm window must be 50 to 80 mm 2 by 3 inch. Use electronic tone generators with variable pitch and volume controls.

2.8.5.6 Power Supplies and Switches

Provide mechanically interlocked, main circuit breakers mounted in the baghouse panelboard for switching, and for primary and backup power services. Provide a 20 A molded case circuit breaker for each tap from the control bus. Provide one AC alarm relay connected to each AC bus with two sets of contacts to close after a 2 second delay on loss of AC. Provide a 120 VAC control bus and a 120 V utility bus. Provide a 24 VAC power supply for low voltage indicating lights and meters. Use metal position marking nameplates and plastic identification nameplates.

2.8.5.7 Wiring

****
NOTE: Include control wiring installation and amperage ratings as part of this section or as part of Division 26, Electrical. If included in this section, it must comply with Division 26, Electrical. Amperage ratings must comply with load requirements. Provide an automatic transfer switch to switch to the backup source upon primary source failure. Provide a manual reset and provide an alarm contact on transfer.
****

Provide cables, terminal blocks, grounding buses, and fuse boxes as follows:

a. Cables: Prefabricated cables, [_____] meters feet in length, with plug-in connectors at both ends of the interconnecting wire. Provide a mechanical restraint between the cable connector mating halves so that the connecting pin-pair does not separate due to mechanical vibration or cable sag. Design the male connector to protect the pins from cable pulling and to align the two halves during mating. The connector must be rated for 600 V and 90 degree C 194 degrees F conductor temperature, with minimum 18 Gage copper conductors, neoprene or polychlorosulphonate jackets, and shielding.

b. Terminal Blocks: Heavy-duty, sliding-link rated not less than 20 A, 600 V with not less than 13 mm 1/2 inch spacing between terminals. Provide 10 percent spares. Main power supply circuit terminal blocks and control bus termination terminal blocks must be rated not less than 40 A. Design to allow individual circuit testing without disconnecting cabinet wiring. Design terminal to receive ring-tongue cable connectors on the field side. Mount terminal blocks in rows within the panel cabinets at heights greater than 305 mm 12 inches, for connections of remote devices. Group and wire terminal blocks by function. Wire using insulated switchboard wire rated for 600 VAC, 60 Hz, 90 degree C conditions. Use American Wire Gage (AWG) Size 14 or larger for 120 VAC control and indicating circuits, AWG Size 10 or larger for 120 VAC main power supplies and tap circuits, and AWG Size 20 for devices not greater than 28 V. Permanently stamp or mark the marking strip with the terminal designation. Do not use self-adhesive embossed plastic label tape.

c. Grounding Buses: Minimum 25 by 6 mm one inch by 1/4 inchgrounding bus running the full length of the panel cabinet sections. Provide with Number 4, 250 thousand circular mil (MCM) lugs for ground cable connection at each end. Connect internal grounds to the ground bus.

d. Fuse boxes: Provide single-pole and three-pole fuse boxes with fuses for each set of relaying and metering potential circuits. Provide plug-in strips to connect 120 VAC supplies to meters and recording equipment.

2.8.6 Local Hopper Heater Control Panels

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NOTE: Specify parallel alarm contacts within the control panel and connect to a terminal block within the panel to a remote alarm system.

****

Provide each hopper with a factory wired local hopper heater control panel containing relays, contactors, circuit breakers, and control transformers. Use non-spliced interconnecting multistrand copper wire with high temperature (454 degrees C 850 degrees F) insulation, from the hopper heater and from the hopper throat heater, to the local hopper heater control panel. Locate local hopper heater control panels near the corresponding hopper. Provide each hopper heater with individual automatic heater controls having adjustable setpoints and proportional bands. Heaters must not operate when access doors are open. Heater voltage must be [_____] VAC. Control voltage must be 120 VAC. Size wiring, circuits, and controls for 2690 W/m2 250 W/ft2. Arrange heater wiring and connections to provide a balanced load on a [_____] V, 3-phase power supply system. Enclose in a NEMA ICS 6 [Type 12] [Type 4] [floor] [wall] mounted enclosure and include the following:

a. One control temperature thermostat (with bulbs and 1524 mm 60 inch flexible cable capillaries).

b. One low temperature alarm thermostat (with bulbs and 1524 mm 60 inch flexible cable capillaries).

c. One high temperature alarm thermostat (with bulbs and 1524 mm 60 inch flexible cable capillaries).

d. One main 3 pole [_____] V circuit breaker.

e. One individual fuse circuit protector for the [_____] V power circuit to each local hopper heater terminal box.

f. One [_____] V/120 V dry control transformer with one secondary lead fused and the other secondary lead grounded.

g. One 600 V contactor with a 120 V operating coil for each thermostatically controlled heater circuit.

h. Magnetic contactor and alarm relay with two normally open contacts.

i. Terminal blocks for termination of control and alarm circuits including 10 percent spares on each block.

j. Auxiliary relays for automatic operation of the heater system terminal

blocks for power, control, and alarm circuits.

k. Throat heater surface thermocouples, one thermocouple per hopper heater.

Provide each local hopper heater control panel cover with the following:

a. "ONLINE," "OFF," "AUTO" selector switch.

b. 120 V "HIGH LEVEL" red light with integral transformer, one each zone.

c. 120 V "ON" green light with integral transformers, one each zone.

d. 120 V "LO TEMP" white light with integral transformer, one each zone.

e. Device and enclosure nameplates screwed or riveted to panel.

Wire the selector switch for the following system operation:

a. "ONLINE": Heaters operating (includes throat heater).

b. "OFF": All elements off.

c. "AUTO": Control functions transfer to Master Hopper Heater Control Panel.

2.8.7 Master Hopper Heater Control Panel

Provide a factory wired master hopper heater control panel containing relays, contactors, circuit breakers, control transformers, and devices for complete control of each hopper heater system, in the control room. Enclosed in a NEMA ICS 6 [Type 12] [Type 4] [floor] [wall] mounted enclosure and include the following:

a. One main circuit breaker.

b. One circuit breaker and contactor alarm relay with two normally open contacts for each hopper zone. The contactor must have a 120 V operating coil.

c. "ONLINE," "OFF," "AUTO" selector switch for each hopper.

d. 120 V "HIGH LEVEL" red light with integral transformer for each hopper.

e. 120 V "ON" green light with integral transformers for each hopper.

f. 120 V "LO TEMP" white light with integral transformer for each hopper.

g. Device and enclosure nameplates screwed or riveted to panel.

h. Auxiliary relays and equipment required for operation of the heating and alarm systems.

i. Fused control transformer having a 120 VAC secondary.

2.9 ACCESS PROVISIONS

2.9.1 Access Requirements

Provide access stairs, walkways, and platforms from boiler to baghouse. Baghouse access must include interior and exterior access, including access to manifolds, bags, tube sheet, weather enclosure, hoppers, valves, conveyors, expansion joints, dampers, gas sampling ports, poke holes, and equipment requiring routine maintenance, repair, or replacement. Access provisions must comply with OSHA regulations. Interconnect walkways and platforms on each side of the baghouse or each side of equipment, at the same elevation, by walkways. Connect walkways, including roof, by stairs. Provide caged ladders at each level for secondary egress. Provide allowance for installing piping, conduit, electrical outlets, and lighting fixtures. Provide 7 feet headroom clearance above walkways, platforms, and stairs. Provide manholes, inspection doors, and access doors with internal and external access walkways, lights, and platforms, at areas requiring access for operation and maintenance. Operation and maintenance access requirements are listed, by Class, below:

2.9.1.1 Class 1

Regularly attended areas including: lubricated equipment, bearings, instruments, valve operators, damper operators, damper linkages, damper drives, test ports, instrument connections, and equipment requiring daily inspection, maintenance, and operation. Provide platforms accessible by stairs. Do not use a ladder or ship ladders.

2.9.1.2 Class 2

Periodic maintenance access areas including expansion joints, ductwork inspection doors, safety valves, valve packing, and equipment requiring access every two years or more. Provide platforms accessible by ladders. Provide not less than two avenues of escape from safety valves or other hazardous equipment.

2.9.1.3 Class 3

Infrequent maintenance access areas, where access is required for painting, reinsulation, or replacement of components which have a service life of 10 years or more. Provide area to erect temporary scaffolding, ladders, platforms, and safety nets. Provide rotating machinery and mechanical equipment components weighing greater than 91 kg 200 pounds with lifting lugs and provide monorails to remove and lower the equipment to grade in a single lift.

2.9.2 Interior Access Provisions

Provide minimum 5 mm 3/16 inch ASTM A36/A36M manholes, inspection doors, and access doors to allow interior access to the hoppers, manifolds, ductwork, bags, and tube sheet. Access openings must have gas-tight, insulated, externally hinged, ethylene propylene terpolymer (EPDM) gasketed doors with 13 mm 1/2 inch diameter smooth hand holds above the inside and outside of each door. Hinges must support the doors when open. Provide safety chains to allow doors to be cracked slightly open before opening completely and padlocks to allow padlocking doors in the open position. Additional requirements are as follows:

2.9.2.1 Access to Hoppers

Provide each hopper with one quick-opening, minimum 610 mm 24 inchdiameter manhole having an access door as specified in the above paragraph. Interlock hopper access doors to level detectors to prevent access when the nuclear level detectors are operational. Provide 13 mm 1/2 inch diameter smooth hand holds inside each hopper, every 460 mm 18 inches down the side of the hopper to the bottom, to serve as a ladder.

2.9.2.2 Access to Manifolds and Ductwork

Provide at least one quick-opening, minimum 610 mm 24 inch diameter manhole or one quick-opening minimum 460 by 610 mm 18 by 24 inchinspection door at the inlet manifold, the outlet manifold, and at ductwork areas greater than [_____] meters feet in length. Provide either a quick-opening, minimum 610 mm 24 inch diameter manhole or a quick-opening minimum 460 by 610 mm 18 by 24 inch inspection door at both sides of dampers, expansion joints, and both sides of gas distribution devices. The doors must be as specified in the above paragraph.

2.9.2.3 Access to Reverse Air System Bags

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NOTE: Select the applicable paragraph(s) from the following:
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[Provide each compartment with interior walkways and access doors to allow access to the bags and both upper and lower bag supports. Interior walkways must be minimum 610 mm 24 inches wide with kickplates. Access doors must be minimum 508 by 1118 mm 20 by 44 inch with external bolt-down lugs and safety interlocks, and as specified in the above paragraph. Space lugs evenly around the door perimeter including the hinged side, minimum one lug per 305 mm foot of door perimeter, to assure uniform gasket pressure around the entire door periphery. Provide permanently attached caution signs and opening instructions at each door for operating personnel. Locate walkways between rows of bags maintaining minimum 13 mm 1/2 inch clearance with the bags inflated, to prevent bags from coming into contact with the walkways and wearing out, and maintaining a maximum three-bag reach. Provide upper access walkways one meter 3 feet below the upper support frame. Provide a minimum 1 .22 meters 4 feet crawl space above the upper support frame.

][Access to Pulse Jet System Bags

Provide each compartment with interior walkways and access doors to allow access to the bags and bag support. Interior walkways must be minimum 610 mm 24 inches wide with kickplates. Access doors must be minimum 508 by 1118 mm 20 by 44 inch with external bolt-down lugs and safety interlocks, and as specified in the above paragraph. Space lugs evenly around the door perimeter including the hinged side, minimum one lug per foot of door perimeter, to assure uniform gasket pressure around the entire door periphery. Provide permanently attached caution signs and opening instructions at each door for operating personnel. Locate lower walkways between rows of bags to maintain a maximum three-bag reach. Locate the lower walkways 152 mm 6 inches below the lower end of the bags to prevent bags from coming into contact with the walkways and wearing out. Provide upper access walkways along the floor of the outlet plenum.

]2.9.3 Exterior Access Provisions

Provide ladders, stairs, walkways, and platforms, including supporting steel, handrails, kickplates, electrical lights, and electrical outlets, to manholes, inspection doors, and access doors. Design ladders, stairs, walkways, and platforms for live loads, as specified in paragraph entitled "Design Criteria." Provide walking surfaces on the roof for periodic equipment maintenance or inspection areas. Provide a 1829 by 2109 mm 72 by 83 inches uninsulated double utility door to each weather enclosure.

2.9.3.1 Ladders

Ladders must be minimum 457 mm 1 foot 6 inches wide with 20 mm 3/4 inch diameter rungs spaced at 305 mm 12 inch on centers and minimum 10 by 65 mm 3/8 by 2 1/2 inch side rails.

2.9.3.2 Stairs

Stairs must be open risers with a minimum 229 mm 9 inch grate tread, minimum 0.91 m 3 foot width, and a maximum 203 mm 8 inch rise. Design for 610 km/m2 125 psf live load or 454 kg 1,000 pound moving concentrated load, whichever is greater. Provide 40 mm 1 1/2 inch diameter black standard weight pipe, ASTM A53/A53M, Type E or Type S, handrails along both sides of stairs. Top handrail must be 762 to 813 mm 2 feet 6 inches to 2 feet 8 inches above edge of tread. Main bars must be 25 by 5 mm 1 by 3/16 inch. Use serrate main bars for outdoor use. Support stairs at bearing bars with tack welded 65 by 5 mm 2 1/2 by 3/16 inch carrier plates.

2.9.3.3 Walkways

Provide minimum 610 mm 2 feet walkways in Class 2 areas. Other walkways must be minimum 0.91 m 3 feet. Design for 488 kg/m2 100 psf live loads plus concentrated equipment loads. Design walkways which are above ductwork or other surfaces, so that the underside of the walkway is a minimum of 150 mm 6 inches above the upper surface of the ductwork including insulation and lagging. Provide 40 mm 1 1/2 inch diameter black standard weight pipe, ASTM A53/A53M, Type E or Type S handrails. Pipe runs must be horizontal at 584 mm and 1.07 m 1 foot 11 inches and 3 feet 6 inches above walk grating.

2.9.3.4 Platforms

Provide minimum 1.11 sq meters 12 sq feet platforms. Design platforms for live loads of 488 kg/m2 100 psf plus concentrated equipment loads. Design platforms which are above ductwork or other surfaces, so that the underside of the platform is a minimum of 150 mm 6 inches above the upper surface of the ductwork including insulation and lagging. Provide minimum 6 mm 1/4 inch thick raised steel floor plate grating of one piece, resistance-welded with 5 mm 3/16 inch diameter main bars, ASTM A108, Grade 1015, spaced at no more than 30 mm 1 3/16 inches on corners. Use serrate main bars for outdoor use. Provide subframing so grating span is no greater than 1.07 m 3 feet 6 inches. Space crossbars, ASTM A108, Grade 1010, at 102 mm 4 inches on centers. Crossbars must be hexagonal of 8 mm 5/16 inch diameter of inscribed circle, 13 by 5 mm 1/2 by 3/16 inch rectangular, 6 mm 1/4 inch square with spiral twist, or 8.33 mm 21/64 inch diameter round. Provide 40 mm 1 1/2 inch diameter black standard weight pipe, ASTM A53/A53M, Type E or Type S handrails and 6 mm 1/4 inch thick steel kickplates. Pipe runs must be horizontal at 584 mm 1 feet 11 inches and 1.07 m 3 feet 6 inches above grating.

2.10 SOURCE QUALITY CONTROL

Conduct standard factory tests and performance tests required by the applicable codes on control circuits, mechanical draft equipment and materials, and dampers, except poppet dampers. Notify Contracting Officer of test dates in writing not less than 45 days before factory tests so that Contracting Officer may witness test.

2.10.1 Baghouse Controls Tests

Perform control system factory tests with control system components connected together. To test, provide control boards with 115 VAC, 60 Hz, and operate each control switch and selector switch to verify that each control circuit operates as shown on the schematic diagrams. Simulate remote contacts and switches with jumpers at the appropriate external terminal blocks to verify proper circuit operation. Test annunciator systems to verify that annunciator points operate correctly by jumpering or operating alarm initiating device or jumpering external terminals for remote alarm inputs.

2.10.2 Mechanical Draft Equipment Tests and Materials

Factory tests must include mechanical balancing of rotary parts.

2.10.3 Dampers

Test each damper following AMCA 500-D, including frame, except poppet dampers, five times in an airtight chamber at design flowrate temperature and pressure to determine gas leakage across the damper and the frame. Provide instruments to determine the amount of leakage and the static pressure against the damper. If a damper is equipped with a seal air system, test the damper both independently and with the seal air system. Operate system at design flowrate, temperature, and pressure.

PART 3 EXECUTION

3.1 COORDINATION

Coordinate design parameters and baghouse collection system controls with manufacturers whose equipment will interface with, or affect, the system operation.

3.2 INSPECTION

The Contractor Quality Control Representative and the Contracting Officer must inspect equipment and materials before, during and after installation at the job site. Correct or replace defective material and equipment as approved by the Contracting Officer.

3.3 INSTALLATION

****
NOTE: Revise this paragraph as necessary when baghouse manufacturer is to install the equipment provided.
****

Install equipment on foundations or structural steel framework as shown on

the drawings, or as specified elsewhere herein.

3.3.1 Insulation

****
NOTE: If a separate insulation section is part of this specification, add a note to that section to indicate that baghouse insulation is covered by this section.
****

Insulate housing, hopper, and ductwork. Provide insulation with interruptions to permit access to the following openings without damaging the insulation system: manholes, inspection doors, access doors, and flanged openings. Provide boxouts around nameplates and code stamping symbols. Install a double layer of insulation with the joints of the two layers staggered. Fill cracks, voids, and depressions of insulation with insulating cements before applying another layer of insulation or jacket application. Provide insulation with expansion joints to withstand differential thermal expansion movements which may cause cracks or tears in the insulation. Install insulation between stiffeners and over stiffeners so that the stiffeners are completely insulated. Install additional insulation or casing spacers between stiffeners so that the surface is level. Securely wire and lace insulation in place using a soft ASTM A580/A580M, Number 14, Type 302 stainless steel wire.

3.3.1.1 Mineral Fiber Block and Board Insulation

Secure mineral fiber and block and board insulation with stud insulation lugs spaced not greater than 432 mm 17 inches on center. Weld lugs in place. Reinforce blocks on the exterior face with expanded metal to prevent sagging or cutting of the insulation by the lacing wire. Secure entire surface of mineral fiber block and board insulation in place using wire threaded lugs. Thread lugs with wire both ways, pull tight, twist ends together with pliers, bend over, and carefully press into the surface of the insulation.

3.3.1.2 Mineral Fiber Blanket Insulation

Secure mineral fiber blanket insulation with speed washers and impaling pins spaced not greater than 305 mm 12 inches on centers. When applying speed washers, do not compress the insulation below the design insulation thickness. Reinforce mineral fiber blanket insulation with expanded metal on the outer surface and wire mesh or expanded metal on the inner surface. Tightly butt blanket sections together and tie at joints to prevent the blanket edges from peeling or bulging, and to provide maximum sealing.

3.3.1.3 Calcium Silicate Insulation

Provide calcium silicate insulation over 12 Gage steel pins studwelded on 610 mm 2 feet centers. Do not place calcium silicate insulation directly in contact with the aluminum casing. Closely fit insulation around penetrations. Hold insulation in place by 65 mm 2 1/2 inchsquare speed washers. Protect calcium silicate on horizontal surfaces by 16 Gage sheet steel coated with a non-slip paint. On other areas, apply 13 mm 1/2 inch thick insulating concrete or cover using 16 Gage sheet steel. Provide access panels with removable insulation panels.

3.3.2 Casing

3.3.2.1 Structural Steel Grid System

Design the structural steel grid system to provide a smooth finished surface of insulation over the stiffeners, access doors, flanges, ribs, and uneven surfaces. Weld the grid system onto the equipment and structural support surfaces. Install aluminum casing onto grid system. Design the roof to transmit an external 114 kg 250 pound walking load from the casing to the structural grid system without compression of the insulation material.

3.3.2.2 Access Openings

Closely fit insulation to manholes, inspection doors, access doors, and flanged openings. Frame and flash to make weather-tight. Provide hinged or lift-off doors with nameplates, code stamping symbols, and non-projecting connections.

3.3.2.3 Weatherproofing

Fabricate and overlap casing to make weather-tight. Provide closures, flashings, and seals. Provide the open ends of fluted sections with tight-fitting closure pieces. Form and install flashing so that water cannot enter and wet the installation. Design and install flashing to readily drain any water that might enter. Weatherproof joints or casing openings which cannot be sealed by flashings or laps with an aluminum pigmented sealer.

3.3.2.4 Convection Stops

Provide convection stop on vertical surfaces over 3.67 meters 12 feet tall. The maximum interval between convection stops must be 3.67 meters 12 feet.

3.3.2.5 Casing Attachment

Attach aluminum casing to the structural steel grid system using Number 14 stainless steel, Series 300, self-tapping screws on 305 mm 12 inch centers. Fasten vertical laps and flashings using 20 mm 3/4 inchNumber 14 stainless steel, Series 300, sheet metal screws on 305 mm 12 inch centers. Provide exposed screws with aluminum or stainless steel backed neoprene washers preassembled to screws. Do not compress insulation below nominal thickness.

3.4 FIELD QUALITY CONTROL

3.4.1 Manufacturer's Field Representative

Furnish the services of a baghouse manufacturer field representatives trained by the manufacturer to assist baghouse installers to ensure that the baghouse is installed in accordance with the manufacturer's recommendations. The field representatives must be at the erection site during installation phases including unloading, hauling, storing, cleaning, erecting, startup, and testing, until the system has been brought online and stabilized. The field representatives must supervise the adjustment of controls, control devices, and components supplied with the baghouse and must instruct the plant operators in the operation, care, and maintenance of the equipment. The field representatives must certify

in writing to the Contracting Officer that the baghouse has been installed as recommended by the manufacturer.

3.4.2 Post-Installation Inspection

The baghouse manufacturer's service engineer must inspect the complete baghouse prior to startup to verify that the unit is installed as the manufacturer recommends.

3.5 IDENTIFICATION

Securely fasten an aluminum, brass, or corrosion resistant steel nameplate to the equipment in a readily visible location using rivet or sheet metal screws. The nameplate must contain the manufacturer's name, model or series number, serial number, design gas inlet volume and temperature, and air-to-cloth ratio. Indent or emboss the information into the metal to avoid nameplate being covered by insulation. Provide plastic engraved nameplates for remote mounted devices. Fabricate nameplates from laminated white phenolic plastic with black engraved letters, 20 mm high and 76 mm long 3/4 inch high and 3 inches long. Attach nameplates with permanent adhesive or screws.

3.6 TRAINING PROGRAM OF OPERATING AND MAINTENANCE PERSONNEL

****

NOTE: CAUTION: There are restrictions on the type and extent of training which can be paid for with various categories of construction funds. The training routinely acceptable under construction contracts is the one- to two-day type where factory representatives or others instruct facility maintenance and operating personnel in the basics of operating and maintaining the equipment, generally on-site. If more extensive types of training are required, particularly where the student is required to travel and where special consultants are required to teach government personnel for extended amounts of time, consult the PA Director, Contact Division and the Head, Comptroller Department, for assistance in determining how to accomplish the training within the regulations. Anything over two- to three-days offsite should be highly suspect.

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Provide classroom instruction, field instruction, and testing to the Government's operating personnel to ensure that operators will be qualified to properly and safely operate and maintain the baghouse system, including individual equipment components. Provide training at job site within 30 days of startup. Provide the operators with a working knowledge of operation theory and principles, operation and control requirements, and technical requirements for maintenance. Provide training manuals and testing materials so that, with the operating and maintenance manuals, the Government may train new operators without Contractor assistance.

3.6.1 Classroom Instruction

Develop and present 40 hours of organized classroom instruction on operation theory and principles, operation and control requirements, and technical requirements for maintenance. Administrate tests at the

conclusion of the course.

3.6.2 Field Instruction

After startup, a service engineer must provide supervision of the system for not less than 8 hours per day for 30 days to assist and instruct Government operators. Instruction must include, but not be limited to the following:

a. Precoating of bags.

b. Actual startup and shutdown.

c. Instrument, gage, and control functions.

d. Deliberate upset of the system and correction instructions.

e. Simulation of induced fan failure.

f. Baghouse maintenance including removal and replacement of bags.

g. Bypass system. When and how to use bypass system.

3.6.3 Testing Program

Provide a written test program to determine individual comprehension levels. Use the testing program in conjunction with the classroom instruction.

3.6.4 Video Recording

Provide color video tapes of field instruction or provide prepared color video tapes covering the field instruction material.

3.7 PAINTING

At the factory, blast clean exterior surfaces of the baghouse system to base metal, SSPC SP 6/NACE No.3, including ductwork, manifolds, hoppers, support structures, and access provisions, and prime and apply two coats of paint, FS TT-P-28. Surfaces exposed to the flue gas flow need not be painted but must be protected during shipment and storage with a rust-protective coating.

3.8 PROTECTION FROM GALVANIC CORROSION

To prevent against galvanic corrosion, prevent permanent contact of aluminum casing with copper, copper alloy, tin, lead, nickel, nickel alloy, and Monel metal. Where it is necessary to attach the casing to carbon steel or to a low alloy steel, first prime the steel with zinc chromate, and then paint with aluminum paint, FS TT-P-28. Do not use lead based paints. Hot-dip galvanize, ASTM A123/A123M, external floor plates, ladders, grating, stairs, platforms, walkways cages, handrails, kickplates, and accessories. Floor plate warpage must not exceed 25 mm one inch for every 3.05 meters 10 feet in any direction.

3.9 PROTECTION FROM INSULATION MATERIALS

Protect equipment and structures from insulation materials. Clean, repair, and restore equipment and structures to their original state after

work is completed. Replace corroded, discolored, or damaged casing.

[3.10 FUNGUS TREATMENT (TROPICAL AREAS ONLY)

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NOTE: Use this paragraph only for projects in tropical areas with considerable moisture.
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Do not treat components and elements inert to fungi, hermetically sealed, or of operations adversely affected by the application of varnish, for moisture and fungus resistance. Treat the electrical connections including terminals, as follows:

a. Starter and solenoid coils, except potted coils: MIL-T-152.

b. Motor coils which rise in temperature 40 degrees C 104 degrees F or less: MIL-V-173.

c. Motor coils which rise in temperatures over 40 degrees C 104 degrees F: Two coats Type AN, Class 105, MIL-I-24092.

Apply coats by the vacuum-pressure, immersion, centrifugal, pulsating pressure, or buildup method to fill coil interstices and to prevent entrapped air or moisture. The sealer coat may be applied by brushing or spraying.

]3.11 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. [_____]	[_____]	[_____]

-- End of Section --