
USACE / NAVFAC / AFCEA / NASA UFGS-46 73 00.35 (February 2011)

Preparing Activity: USACE Superseding
UFGS-44 46 19 (October 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2013

SECTION TABLE OF CONTENTS

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

SECTION 46 73 00.35

SLUDGE-DIGESTER GAS, HEATING, AND MIXING SYSTEM

02/11

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 QUALIFICATIONS
- 1.4 DELIVERY, STORAGE, AND HANDLING
- 1.5 SPARE PARTS

PART 2 PRODUCTS

- 2.1 SYSTEM DESCRIPTION
- 2.2 MATERIALS AND EQUIPMENT
 - 2.2.1 Standard Products
 - 2.2.2 Nameplates
 - 2.2.3 Special Tools
 - 2.2.4 Steel Shapes, Plates and Bars
 - 2.2.5 Digester Gas Pipe and Fittings
 - 2.2.5.1 Digester Gas Pipe Smaller Than 100 mm 4 Inch Diameter
 - 2.2.5.2 Digester Gas Pipe 100 mm 4 Inch Diameter and Larger
 - 2.2.6 Sludge Piping
 - 2.2.7 All Other Piping
 - 2.2.8 Valves
 - 2.2.8.1 Angle, Check and Globe Valves
 - 2.2.8.2 Gate Valves
 - 2.2.8.3 Plug Valves
 - 2.2.8.4 Gas Valves
 - 2.2.9 Expansion Joints
 - 2.2.10 Pipe Hangers and Supports
 - 2.2.11 Electric Motors
 - 2.2.12 Motor Controls and Motor Control Centers
- 2.3 DIGESTER GAS HANDLING SYSTEM
 - 2.3.1 Waste Gas Burner
 - 2.3.2 Flame Checks
 - 2.3.3 Flame Traps
 - 2.3.4 Sediment Traps
 - 2.3.5 Drip Traps

- 2.3.6 Gas Meters
- 2.3.7 Pressure Indicating Gauges
- 2.3.8 Pressure Relief Valves
- 2.3.9 Pressure Controls
- 2.3.10 Digester Gas Piping
- 2.3.11 Digester Gas Storage
 - 2.3.11.1 Storage Tank
 - 2.3.11.2 Compressor
 - 2.3.11.3 Pressure Relief Valve
- 2.4 DIGESTER HEATING SYSTEM
 - 2.4.1 System Performance Requirements
 - 2.4.2 Heat Exchanger
 - 2.4.2.1 Sludge Tubes
 - 2.4.2.2 Pressure Relief Valve
 - 2.4.3 Burning Equipment
 - 2.4.4 Electric Control Panel
 - 2.4.5 Digester Temperature Control
 - 2.4.6 Sludge Circulating Pump
 - 2.4.7 Sludge Piping
 - 2.4.8 Water Circulation Pumps
 - 2.4.8.1 Heat Exchanger Water Circulation Pump
 - 2.4.8.2 Building Heat Water Circulation
- 2.5 MECHANICAL SLUDGE MIXING SYSTEM
 - 2.5.1 Motor
 - 2.5.2 Speed Reducer
 - 2.5.2.1 V-Belt Speed Reducer
 - 2.5.2.2 Gear Reducer
 - 2.5.3 Shaft
 - 2.5.4 Bearing and Support Assembly
 - 2.5.5 Seals
 - 2.5.6 Impeller or Propeller
 - 2.5.7 Controls
- 2.6 COMPRESSED GAS SLUDGE MIXING SYSTEM
 - 2.6.1 Compressor
 - 2.6.2 Diffusers
 - 2.6.3 Piping System
 - 2.6.3.1 Piping
 - 2.6.3.2 Motor Operated Multiport Rotary Valve
 - 2.6.4 Supernatant Removal
 - 2.6.5 Controls
 - 2.6.5.1 Compressor Controls
 - 2.6.5.2 Automatic Programming
 - 2.6.6 Compressor Housing

PART 3 EXECUTION

- 3.1 EXAMINATION
- 3.2 WELDING
- 3.3 PAINTING
- 3.4 EQUIPMENT INSTALLATION
- 3.5 FRAMED INSTRUCTIONS
- 3.6 FIELD QUALITY CONTROL
 - 3.6.1 Testing
 - 3.6.1.1 Gas Piping Test
 - 3.6.1.2 Piping System and Heat Exchanger Test
 - 3.6.1.3 Operational Test
 - 3.6.1.4 Boiler and Heat Exchanger Test
 - 3.6.2 Manufacturer's Services
- 3.7 FIELD TRAINING

3.8 MAINTENANCE

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-46 73 00.35 (February 2011)

Preparing Activity: USACE Superseding
UFGS-44 46 19 (October 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2013

SECTION 46 73 00.35

SLUDGE-DIGESTER GAS, HEATING, AND MIXING SYSTEM 02/11

NOTE: This guide specification covers the requirements for sludge-digester gas, heating, and mixing system for sewage treatment plants.

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 items(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 \(CCR\)](#).

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 RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1 (2009; Addenda A 2012) Manually Operated
Gas Valves for Appliances, Appliance
Connector Valves and Hose End Valves

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D (2008; Errata 1 2008; Errata 2 2008;
Errata 3 2009; Addendum 1 2009; Errata 4
2010; Errata 5 2010; Errata 6 2011;
Addendum 2 2011; Addendum 3 2012)
Specification for Pipeline Valves

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings
for Water

AWWA C115/A21.15 (2011) Flanged Ductile-Iron Pipe With
Ductile-Iron or Gray-Iron Threaded Flanges

ASME INTERNATIONAL (ASME)

ASME B16.1 (2010) Gray Iron Pipe Flanges and Flanged
Fittings Classes 25, 125, and 250

ASME B16.3 (2011) Malleable Iron Threaded Fittings,
Classes 150 and 300

ASME B16.5 (2009) Pipe Flanges and Flanged Fittings:
NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B31.1 (2012; INT 2-6, 8-10, 13, 15, 17-25, 27-31
and 42-46) Power Piping

ASME BPVC SEC IV (2010) BPVC Section IV-Rules for
Construction of Heating Boilers

ASME BPVC SEC IX (2010) BPVC Section IX-Welding and Brazing
Qualifications

ASME BPVC SEC VIII D1 (2010) BPVC Section VIII-Rules for
Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A307 (2012) Standard Specification for Carbon

Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM A36/A36M

(2008) Standard Specification for Carbon Structural Steel

ASTM A53/A53M

(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds

(2008) EJMA Standards

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58

(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-69

(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MSS SP-70

(2011) Gray Iron Gate Valves, Flanged and Threaded Ends

MSS SP-78

(2011) Cast Iron Plug Valves, Flanged and Threaded Ends

MSS SP-80

(2008; Errata 2012) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250

(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 1

(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2

(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 3

(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC

NEMA ICS 4

(2010) Terminal Blocks

NEMA ICS 6

(1993; R 2011) Enclosures

NEMA MG 1

(2011; Errata 2012) Motors and Generators

NEMA SG 6

(2000) Standard for Power Switching Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 58 (2011; TIA 10-1; Errata 10-1; TIA 11-2;
TIA 11-3; Errata 11-2; Errata 12-3)
Liquefied Petroleum Gas Code

NFPA 70 (2011; Errata 2 2012) National Electrical
Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2012) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 508 (1999; Reprint Apr 2010) Industrial
Control Equipment

UL 845 (2005; Reprint Jul 2011) Motor Control
Centers

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit
the following list to reflect only the submittals
required for the project.

The Guide Specification technical editors have
designated 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 submittals requiring Government approval on Army
projects, a code of up to three characters within
the submittal tags may be used following the "G"
designation to indicate the approving authority.
Codes for Army projects using the Resident
Management System (RMS) are: "AE" for
Architect-Engineer; "DO" for District Office
(Engineering Division or other organization in the
District Office); "AO" for Area Office; "RO" for
Resident Office; and "PO" for Project Office. Codes
following the "G" typically are not used for Navy,
Air Force, and NASA projects.

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

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for [Contractor Quality Control
approval.] [information only. When used, a designation following the "G"

designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Equipment Installation[; G][; G, [_____]]

SD-03 Product Data

Materials and Equipment
Spare Parts
Framed Instructions

SD-06 Test Reports

Testing

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals[; G][; G, [_____]]

[Six] [_____] copies of operation and [six] [_____] copies of maintenance manuals for the equipment furnished. One complete set, prior to performance testing and the remainder upon acceptance.

1.3 QUALIFICATIONS

Qualify procedures and welders in accordance with the code under which the welding is specified to be accomplished.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment, delivered and placed in storage, from the weather, excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants.

1.5 SPARE PARTS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than [_____] months prior to the date of beneficial occupancy. Include with the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete gas, heating, and mixing system for sludge digesters shown. The system shall consist of a digester gas handling system, digester heating system, auxiliary fuel system, sludge mixing system and appurtenances as required for a complete and operating system. Coordinate the system with the digester cover specified in Section 46 73 10 FLOATING COVER FOR SLUDGE-DIGESTION TANKS.

2.2 MATERIALS AND EQUIPMENT

Materials and equipment shall conform to the following respective publications and other specified requirements.

2.2.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2.2 Nameplates

Provide each major item of equipment with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.2.3 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.2.4 Steel Shapes, Plates and Bars

Steel shapes, plates, and bars shall conform to ASTM A36/A36M.

2.2.5 Digester Gas Pipe and Fittings

2.2.5.1 Digester Gas Pipe Smaller Than 100 mm 4 Inch Diameter

Pipe shall be screwed joints galvanized steel in accordance with ASTM A53/A53M. Fittings shall be galvanized malleable iron in accordance with ASME B16.3. Couplings shall be in accordance with ASTM A53/A53M.

2.2.5.2 Digester Gas Pipe 100 mm 4 Inch Diameter and Larger

Pipe shall be ductile iron in accordance with AWWA C115/A21.15. Joints shall be ASME B16.1, Class 125 flanged joints. Fittings shall be ductile iron in accordance with AWWA C110/A21.10. Bolts and nuts shall be in accordance with ASTM A307, Grade B.

2.2.6 Sludge Piping

Pipe shall be flanged ductile iron pipe in accordance with AWWA C115/A21.15. Pipe 100 mm 4 inch diameter and smaller shall be thickness Class 51. Pipe 150 mm 6 inch through 600 mm 24 inch diameter shall be thickness Class 50. [Pipe 750 mm 30 inch diameter and larger shall be thickness Class 51]. Fittings shall be ductile iron in accordance with AWWA C110/A21.10. Joints shall be ASME B16.1 Class 125 flanged joints. Bolts and nuts shall be in accordance with ASTM A307, Grade B.

2.2.7 All Other Piping

Pipe shall be standard weight black steel pipe in accordance with ASTM A53/A53M. Pipe smaller than 100 mm 4 inch diameter shall have screwed joints and malleable iron fittings in accordance with ASME B16.3. Pipe 100

mm 4 inch diameter and larger shall have class 150 flanged joints and fittings in accordance with ASME B16.5.

2.2.8 Valves

2.2.8.1 Angle, Check and Globe Valves

Valves shall conform to MSS SP-80, Type 3, globe and angle.

2.2.8.2 Gate Valves

Valves shall conform to MSS SP-80, Type 1, Class 150 or MSS SP-70, Type I, Class 150 bronze trim.

2.2.8.3 Plug Valves

Bronze plug valves shall comply with MSS SP-78. Iron plug valves shall comply with API Spec 6D.

2.2.8.4 Gas Valves

Shut-off valves on gas lines shall be of the cast brass plug-cock type for sizes up to and including 50 mm 2 inch diameter and of the cast iron brass mounted or wholly brass plug-cock type for sizes 65 mm 2-1/2 inch diameter and larger. All gas line valves shall be in accordance with the applicable requirements of ANSI Z21.15/CSA 9.1. Gas valves shall be tested with air at 861.8 kPa 125 psi without developing leakage.

2.2.9 Expansion Joints

Expansion joints shall conform to EJMA Stds.

2.2.10 Pipe Hangers and Supports

Pipe hangers and supports shall conform to MSS SP-58 and MSS SP-69.

2.2.11 Electric Motors

Motors shall conform to NEMA MG 1.

2.2.12 Motor Controls and Motor Control Centers

Controls and motor control centers shall conform to NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, NEMA ICS 4, NEMA ICS 6, UL 508, and UL 845.

2.3 DIGESTER GAS HANDLING SYSTEM

NOTE: Coordinate with Section 46 73 10 FLOATING
COVER FOR SLUDGE-DIGESTION TANKS. Coordinate with
paragraph COMPRESSED GAS SLUDGE MIXING SYSTEM.

A complete system shall be provided for distribution and disposal of gas produced in the digesters. The system shall include all necessary gas safety equipment to insure maximum protection against fire, explosion, and fume hazard at all times. Gas equipment shall be designed for digester gas having a calorific value of 22.3 MJ per cubic meter (600 Btu per cubic foot) 600 Btu per cubic foot, a specific gravity of 0.8, and a maximum pressure

of [_____] Pa inch water column. The system shall provide distribution to the [compressed gas sludge mixing system,] and [gas storage tank,] sludge heating system and waste gas burner.

2.3.1 Waste Gas Burner

Waste gas burners, having a capacity for burning [_____] cubic meters cubic feet of gas per hour at a pressure loss not to exceed 127 Pa 1/2 inch of water column, shall be provided to dispose of excess digester gas. The burner shall be provided with a [_____] mm inch screwed inlet and a pilot-line connection not less than 19 mm 3/4 inch in diameter. The burner shall be provided with a readily adjustable pilot light, properly designed air inlet and mixing chamber, a burner bowl supported by a cast iron or steel pipe pedestal filled with insulating material, and a flanged base with anchor bolts for installation on a concrete foundation or concrete curb. The pilot light and burner shall be arranged to prevent the pilot light from being blown out by gas ignition, wind, or other accidental means. A shut-off valve shall be provided in the pilot gas line. The waste gas burner shall be located a minimum of 15 m 50 feet from the [gas storage tank] [and] [digester].

2.3.2 Flame Checks

Flame checks shall be provided in the pilot line to the waste gas burner. Flame checks shall block flame return and shall have threaded end connections of the same size as the pilot line.

2.3.3 Flame Traps

Flame traps shall be provided in the gas piping system between each source of ignition and the digesters. Flame traps shall be located as close as possible to the source of ignition, the distance not to exceed 7.5 m 25 feet. Each flame trap shall have a capacity to pass at least [_____] cubic meters cubic feet of gas per hour at a pressure loss not to exceed [_____] 127 Pa 1/2 inch of water column. The flame trap element shall prevent the passage of flame and shall permit convenient replacement of the entire element. The unit shall also include a spring actuated thermal shut-off valve, held open by a fusible element, to automatically close in the presence of burning mixtures.

2.3.4 Sediment Traps

Sediment traps shall be provided in the gas piping system prior to all other equipment. Traps shall be baffled and provided with a sealed, safe means of determining the liquid level without closing the gas supply line. Sediment traps shall be of cast iron, ductile iron, or galvanized steel construction with a minimum capacity of 38 L 10 gallons of accumulated sediment and condensate. Supply line connections shall be equal to the supply line size. A manual drip trap shall be provided to drain accumulated condensate from the sediment trap.

2.3.5 Drip Traps

Drip traps shall be provided in the gas piping network at the low points and on the upstream side of each gas meter. Drip traps shall be manually operated, shall be constructed of cast iron, ductile iron, or galvanized steel, and shall have a minimum capacity of 2 L two quarts. Trap construction shall effectively prevent leakage of gas from the system when the trap is being drained.

2.3.6 Gas Meters

Gas meters shall be provided to measure the gas production of each digester and the volume of gas delivered to the waste gas burner and the sludge heating system. Gas meters shall be rated at [_____] cubic meters/second cfm at [_____] Pa inch water column pressure drop with a capacity of 200 percent rated flow. Meters shall be constructed of materials resistant to the corrosive effects of digester gas. A valved bypass shall be provided around each gas meter.

2.3.7 Pressure Indicating Gauges

Pressure indicating gauges shall be provided in the gas piping system to enable monitoring of digester pressure and to enable the pressure balancing at the waste gas burner and the digester heating system. Gauges shall be direct reading in Pa inch of water and shall be [assembled as one unit, wall mounted,] [individually mounted on the pipe,] with shut-off cocks. Shut-off cocks shall be pinned and sealed to prevent gas leakage.

2.3.8 Pressure Relief Valves

A pressure relief valve shall be provided in the gas line to the waste gas burner and connected to the upstream side of the flame trap. Pressure relief valves shall maintain a predetermined back pressure throughout the system at settings from 1.25 to 2.49 kPa 5 to 10 inch of water column and shall release surplus gas to the waste gas burner. The relief valve shall be actuated by a protected diaphragm. The diaphragm shall be a readily adjustable weighted type or compression spring type of ample area to allow sensitive control of the gas pressure. The valve shall be capable of passing [_____] cubic meters cubic feet of gas at a pressure loss not to exceed [_____] Pa inch water column.

2.3.9 Pressure Controls

Pressure controls shall be provided to maintain proper distribution of gas flow on a priority basis to the [compressed gas sludge mixing system,] [gas storage tank,] digester heater, and the waste gas burners, respectively.

2.3.10 Digester Gas Piping

NOTE: If removal of hydrogen sulfide gas, present
in some anaerobic sludges, is desired, then iron
oxide impregnated wood chip filters should be added
to the gas piping system.

Pipe shall be installed with a minimum slope of 20 mm/meter 1/4 inch/foot toward drip traps and sediment traps.

2.3.11 Digester Gas Storage

A digester gas storage tank, gas compressor, controls, and appurtenances shall be provided as required for the storage of digester gas.

2.3.11.1 Storage Tank

NOTE: Design of supports should be according to UFC 3-301-01 for windload and snowload design. Specific site information on wind and snow loadings must be included in the design. Provide seismic details, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase, in the penultimate sentence, if seismic details are not provided. Pertinent portions of UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT or 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL, properly edited, must be included in the contract documents. Other types of storage, other than the expensive relatively high pressure spherical gas storage tank and supports, should be considered. Digesters with gas holder covers or cylindrical steel tanks with adjusting covers, which supply gas at constant pressure at variable volume, generally supply digester gas at low pressures but at pressure sufficient to operate many boiler burners. A small auxiliary compressor may be added, if required, to boost gas pressure.

The gas storage tank shall be capable of storing [_____] cubic meters cubic feet of gas operating between [_____] kPa maximum and [_____] kPa minimum [_____] psig maximum and [_____] psig minimum pressure. The tank shall be cylindrical above ground tank with supports designed to withstand dead shell load plus a [_____] km/hour mph wind load and a [_____] kPa psi snowload. Seismic details shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and [13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT] [22 05 48.00 20 MECHANICAL SOUND VIBRATION, AND SEISMIC CONTROL] [as shown on the drawings]. The tank shall be air tested in accordance with ASME BPVC SEC VIII D1 to 125 percent of the design maximum pressure.

2.3.11.2 Compressor

A reciprocating type electric motor driven gas compressor, capable of compressing [_____] cubic meters cubic feet of digester gas per minute at [_____] kPa psig to a maximum operating pressure of [_____] kPa psig, shall be provided. Compressor components shall be stainless steel or equally noncorrosive materials. Motor shall conform to NEMA MG 1. Controls shall conform to NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, NEMA ICS 4, NEMA ICS 6, UL 845, and UL 508. Electric controls shall be provided as required for automatic operation of the compressor. Control panel shall include circuit breaker, magnetic starter, and manual-off-automatic selector switch. Power supply to the control panel shall be [_____] volts ac, [_____] phase, 60 Hz and shall be equipped with thermal overload protector with manual reset. All electrical wiring and motors shall be explosion-proof and be installed according to NFPA 70. Panel shall be NEMA 250, Type 7.

2.3.11.3 Pressure Relief Valve

A pressure relief valve shall be provided on the gas storage tank. A stop valve, locked open except for maintenance shall be provided between the gas storage tank and the pressure relief valve. Sediment traps and drip traps

shall be provided in gas lines at the base of the tank. Pressure controls for gas distribution shall be provided. A remote pressure indicator shall be provided in the compressor building to indicate tank pressure [in kPa psi gauge].

2.4 DIGESTER HEATING SYSTEM

NOTE: Boilers providing building radiation and digester heating operate at 71 to 82 degrees C (160 to 180 degrees F). Hot water to heat exchanger is mixed to maximum 66 degrees C (150 degrees F) to prevent caking on sludge tubes.

2.4.1 System Performance Requirements

A complete system shall be provided for automatic control of the digester operating temperature at 35 degrees C 95 degrees F, within plus or minus 0.3 degrees C 0.5 degrees F, by means of an external sludge heating system. The digester heating system shall have a minimum sludge heating capacity of [_____] kW Btu/hr based on heating [_____] L/second gpm of sludge from digesters operating at 35 degrees C 95 degrees F. Boiler shall be fire tube hot water boiler with maximum operating pressure of 207 kPa 30 psig, with boiler, burners, draft fans, combustion safety controls and equipment, breeching and stacks, fuel system, and fittings and accessories in accordance with Section 23 70 02.00 10 CENTRAL STEAM GENERATING SYSTEM-COMBINATION GAS AND OIL FIRED. Draft fan shall be designed for corrosive application.

2.4.2 Heat Exchanger

The heat exchanger shall be of the water bath or concentric tube type and shall be provided with an integral factory-fabricated insulation jacket. Heat exchanger insulated jacket shall be insulated with a minimum of 40 mm 1-1/2 inch of fiberglass having a density of 12.0 kg/cubic meter 0.75 pcf and a K-factor of 2.15 at 38 degrees C 0.38 at 100 degrees F. The jacket shall have minimum 16 gauge sides and 5 mm 3/16 inch plate top and bottom.

2.4.2.1 Sludge Tubes

Sludge tubes shall be standard weight ductile iron pipe with cast iron return bends with flanged, gasketed connections. Return bends shall be readily removable for inspection, cleaning, or replacement. Sludge tubes and return bends shall be large enough to pass a [_____] mm inch diameter sphere. Sludge tube connections shall be arranged to prevent sludge contamination of the heating water due to a gasket or connection failure.

2.4.2.2 Pressure Relief Valve

A pressure relief valve, constructed and installed in accordance with ASME BPVC SEC IV shall be provided. The valve discharge shall be piped to within 150 mm 6 inch of the floor in full line size.

2.4.3 Burning Equipment

NOTE: Delete type of burner and fuel train for inapplicable fuels.

The burning equipment shall be of the capacity to develop the specified boiler capacity and shall have dual fuel, combination or separate, burners. The burning equipment shall include equipment for burning either digester gas, with heat content of approximately 22.3 MJ per cubic meter 600 Btu per cubic foot and a specific gravity of 0.8, or [No. 2 fuel oil, with heat content of 39,000 MJ per cubic meter 140,000 Btu per gallon] [natural gas, with heat content of 37.3 MJ per cubic meter 1,000 Btu per cubic foot or a mixture of the two gases] [LP gas with heat content of [_____] MJ per cubic meter Btu per cubic foot]. Gas piping and equipment for LP gas shall conform to NFPA 58.

2.4.4 Electric Control Panel

A single electric control panel, containing the digester temperature controller, the burner controller, and the branch circuit breakers and magnetic starters for the sludge circulating pump, induced or forced draft fan motor, and heat exchanger water circulating pump shall be provided. Induced or forced draft fans, motor, and associated boiler and burner controls shall be in accordance with Section 23 70 02.00 10 CENTRAL STEAM GENERATING SYSTEM COMBINATION GAS AND OIL FIRED. Controllers shall be in accordance with NEMA ICS 1, circuit breakers shall be in accordance with NEMA SG 6, and motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, NEMA ICS 4, NEMA ICS 6, UL 508, and UL 845. [The control panel shall include provision for integrating the control function of the building radiation hot water circulating pump into the control package.] The control panel shall be NEMA 250, Type 12 construction and shall have [dual swing-out doors.] [a single swing out door.] All equipment shall be mounted and wired with rigid steel conduit and flexible water-tight connectors, all in accordance with NFPA 70. Main power to the control panel shall be [480] [_____] volts ac, [3] [_____] phase, 60 Hz, and control power at 120 volts ac, single phase, 60 Hz. Interlocks shall be provided as required for sludge heater operation with raw sludge pumps. The following selector switches and indicating lamps, clearly labeled, shall be provided on the control panel doors:

- a. Digester heater switch (manual/automatic/off).
- b. Fuel selection switch (digester gas/[oil] [natural gas] [LP gas]/automatic).
- c. Constant water bath switch (on/off).
- d. Induced draft fan (automatic/continuous).
- e. Sludge recirculation pump (continuous/intermittent).
- f. Low boiler water lamp with alarm horn and silencer.
- g. Induced draft [or forced draft] fan failure lamp with alarm horn and silencer.
- h. Flame failure lamp with alarm horn and silencer.
- i. Boiler high temperature lamp with alarm horn and silencer.

2.4.5 Digester Temperature Control

Digester temperature control shall be permitted by the manual/automatic off switch mounted on the control panel. Automatic control of the digester temperature shall be by means of a thermostat located at the inlet to the sludge tubes of the heat exchanger. The water circulation pump for sludge heating and the burner equipment shall be automatically controlled by the temperature of the sludge passing the thermostat. A repeating cycle time switch shall be provided for periodic starting of the digester recirculation pump, with controls arranged such that the recirculation pump will continue to operate until the digester heating requirements are satisfied or shall stop after a short cycle if heat is not required by the digester. Indicating thermometers, with a range from **minus 18 to 66 degrees C 0 to 150 degrees F**, shall be provided in the sludge inlet and outlet of the heat exchanger. Each thermometer shall be provided with a mounting socket that will enable the removal of the thermometers without draining the sludge tubes.

2.4.6 Sludge Circulating Pump

Pump shall be as specified in Section **22 13 29** SANITARY SEWERAGE PUMPS.

2.4.7 Sludge Piping

Sludge piping shall be arranged to permit heating of the digester contents by pumping the digester sludge through the heat exchanger and back to the digester. The piping arrangement shall also include provision for heating of raw sludge before it enters the digester or for heating a mixture of raw sludge and recirculating sludge.

2.4.8 Water Circulation Pumps

Water circulation pumps shall be single stage, centrifugal, enclosed impeller, electrically driven, non-overloading type with integrally mounted motor. The pump shall be connected to the motor with a flexible coupling. Motor shall conform to **NEMA MG 1** for operation on [_____] volts ac, [_____] phase, 60 Hz and shall be equipped with thermal overload protector with manual reset. Motor frame shall be [open] [dripproof] [totally enclosed] [explosion-proof] type.

2.4.8.1 Heat Exchanger Water Circulation Pump

The heat exchanger water circulation pump shall be mounted in line with the heat exchanger package. Pump rating shall be determined by the heat exchanger manufacturer as required to provide turbulent flow across the sludge tubes.

2.4.8.2 Building Heat Water Circulation

**NOTE: Delete paragraph Building Heat Water
Circulation if system is not used for building
heat. Coordinate criteria with building heating
system specification.**

The building heat water circulation pump shall be rated at [_____] **L/second**
gpm and [_____] **mm feet** TDH.

2.5 MECHANICAL SLUDGE MIXING SYSTEM

NOTE: For projects with single-stage
sludge-digestion, delete "primary" and include
reference to bottom 1/10 of contents. For projects
with two-stage sludge digestion, include "primary"
and delete reference to bottom 1/10 of contents.

Electric motor driven mechanical mixers shall be provided in each [primary]
[_____] digester, each capable of producing a flow of [_____] L/second gpm
of sludge. The combined action of all the mixers shall effectively
circulate all [except the bottom 1/10] of the digester contents. Mixers
shall be suitable for mixing sludge on a continuous basis.

2.5.1 Motor

The electric drive motor shall be mounted on the outside of the digester on
the [gear reduction unit] [or] [mixer bearing support.] Motors shall be in
accordance with NEMA MG 1 and shall be of explosion-proof design for
operation near digester gas. Motor shall be sized for and shall not
overload under the intended conditions. Motor shall operate on [_____]
volts ac, [3] [_____] phase, 60 Hz and shall be provided with thermal
overload protection.

2.5.2 Speed Reducer

A unit shall be provided for the mechanical reduction of speed while
transmitting power from the motor to the mixer shaft. The reducer shall be
either V-belt drive or gear drive type. Reduction ratio shall be as
required for proper mixer operation.

2.5.2.1 V-Belt Speed Reducer

The unit shall consist of sheaves and V-belts, properly sized for the
required horsepower transmission. Belts shall be of the static-conducting
type for operation near digester gas. A means of adjusting belt tension
shall be provided. An enclosure shall be provided to protect the unit from
weather and to protect personnel from injury.

2.5.2.2 Gear Reducer

The unit shall consist of gears, shafts, and bearings, mounted in a cast
metal housing. Unit shall be sized to transmit the intended horsepower.
Lubrication shall be by oil bath and the unit shall have provision for
filling, draining, and checking the oil level. Seals shall be provided on
all shaft penetrations to prevent the escape of oil and the entry of
contaminants. A vent shall be provided to allow the entry and escape of
air. The vent shall be designed to minimize contaminant entry.

2.5.3 Shaft

A cold-rolled steel shaft, [_____] mm feet long, shall be provided for
support and rotation of the [impeller] [or] [propeller]. The shaft shall
be designed to prevent excessive deflection under normal load conditions.
The shaft shall extend from the speed reducer unit through the bearing and
support assembly to the [impeller] [or] [propeller].

2.5.4 Bearing and Support Assembly

A cast metal unit, complete with bearings, shall be provided for the support of all other mixer components. The assembly shall mount directly on the digester [cover] [wall] and shall provide a gas tight seal. The unit shall contain two bearings, mounted sufficiently apart from each other to give stable support to the shaft. Bearings shall be self-aligning roller or ball bearings designed for axial loading and sized to support the shaft and [impeller] [or] [propeller] under all load conditions. The assembly shall have grease fittings, passages, and relief ports as required for proper bearing lubrication.

2.5.5 Seals

NOTE: Coordinate with Section 46 73 10 FLOATING
COVER FOR SLUDGE-DIGESTION TANKS. Coordinate with
paragraph COMPRESSED GAS SLUDGE MIXING SYSTEM.

Shaft seals shall be provided at the top and bottom of the bearing and support assembly. The upper seal shall both retain grease and prevent the entrance of contaminants. The lower seal shall be designed to retain grease and to prevent the passage of digester gas under [_____] kPa psi pressure.

2.5.6 Impeller or Propeller

An [impeller] [or] [propeller] shall be provided on the end of the shaft to impart motion to the sludge. The unit shall effectively transmit the mixer's mechanical energy to the sludge without producing unbalanced forces on the shaft. The unit shall be constructed of a material capable of withstanding rapid motion through sludge without undue wear or corrosion. [The unit may operate unenclosed or enclosed in a draft tube. The draft tube shall be flared at the bottom and shall be constructed of at least 6 mm 1/4 inch thick steel plate.] [The propeller shall be designed to avoid fouling and also to pump sludge in either direction.]

2.5.7 Controls

Each mixer shall be provided with a magnetic starter; forward, stop, and reverse pushbuttons; and a circuit breaker with manual reset. Controls shall be [120] [_____] volts ac, single phase, 60 Hz, and shall be housed in explosion-proof NEMA 250, Type 7 enclosure Reverse operation shall be provided for periodic dislodging of sludge from the [impeller] [or] [propeller].

2.6 COMPRESSED GAS SLUDGE MIXING SYSTEM

NOTE: Include only the applicable system. Consult
with various manufacturers to determine correct
system for the project and to obtain criteria to be
specified.

For projects with single-stage sludge-digestion,
delete "primary" and include reference to bottom
1/10 of contents. For projects with two-stage
sludge digestion, include "primary" and delete

reference to bottom 1/10 of contents.

A system shall be provided for mixing [all except the bottom 1/10] of the [primary] [_____] digester contents by the circulation of digester gas. The system shall be designed for safe handling of digester gas. [The system for each digester shall consist of a compressor, piping system, and [_____] diffusers located within each digester as indicated. The system shall provide [_____] cubic meters/second cfm of digester gas at [_____] kPa psi sequentially to each of the diffusers to provide thorough mixing of the digester contents.] [The system for each digester shall consist of a compressor, piping system, and [_____] diffusers within a centrally mounted draft tube, forming a confined gas lift for circulation and mixing of the digester contents. The system shall provide a total of [_____] cubic meters/second cfm of digester gas at [_____] kPa psi to the diffusers.] [The system for each digester shall consist of a compressor, piping system, and [_____] diffusers located [on] [near] the bottom at the center of each digester as indicated, forming an unconfined gas lift for circulation and mixing of the digester contents. The system shall provide a total of [_____] cubic meters/second cfm of digester gas at [_____] kPa psi to the diffusers.]

2.6.1 Compressor

NOTE: For gas recirculation and low pressure gas handling, rotary displacement, sliding vane, or liquid ring compressors may be used.

A positive displacement, electric motor driven, air cooled compressor shall be provided for circulating the digester gas. The compressor shall be capable of providing [_____] cubic meters/second cfm of gas at [_____] kPa psi and shall be driven by a [_____] kW horsepower explosion-proof electric motor. The motor shall operate on [_____] volts ac, [3] [_____] phase, 60 Hz. Motor shall conform to NEMA MG 1. Controls shall conform to NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, NEMA ICS 4, NEMA ICS 6, UL 845, and UL 508. Panel shall be NEMA 250, Type 7. Motor power shall be transmitted to the compressor through a static-conducting V-belt drive.

2.6.2 Diffusers

Diffusers capable of diffusing the specified quantity of gas into the sludge shall be provided. The diffusers shall be constructed of a material resistant to corrosion caused by digester sludge and shall be of a nonclogging design which prevents the backflow of sludge into the gas piping upon loss of gas pressure. [Draft tubes shall be constructed of at least 6 mm 1/4 inch thick steel plate and shall have flared bottoms.]

2.6.3 Piping System

NOTE: Certain gas recirculation piping systems provide discharge wells which allow removal of the discharge tubes within the wells for inspection or change of depth of discharge without interrupting digester operation and provide sealing in of gas during removal and replacement of discharge tubes.

2.6.3.1 Piping

Piping shall comply with paragraph DIGESTER GAS HANDLING SYSTEM.

2.6.3.2 Motor Operated Multiport Rotary Valve

NOTE: Include this paragraph only if paragraph
COMPRESSED GAS SLUDGE MIXING SYSTEM is specified.

A single motor operated multiport rotary valve or multiple motor operated valves shall be provided for control of gas supply to the individual diffusers.

2.6.4 Supernatant Removal

NOTE: Include this paragraph if supernatant removal
is included in project.

[Overflow box with weir or supernatant piping] [Rotatable draw-off supernatant pipe to pull supernatant at varying levels] shall be provided. Digester sight glass or depth indicator shall be provided.

2.6.5 Controls

2.6.5.1 Compressor Controls

A magnetic starter, start-stop pushbuttons, and a circuit breaker with manual reset shall be provided for the compressor. Circuit breaker shall be in accordance with NEMA SG 6 and motor controls shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, NEMA ICS 4, NEMA ICS 6, UL 508, and UL 845. A relief regulator system consistent with the system operational pressures shall be provided. A flame arrestor, moisture separator, and sediment trap shall be provided on the suction piping to the compressor. All controls shall be 120 volts ac, single phase, 60 Hz, and shall be housed in an explosion-proof NEMA 250, Type 7 enclosure.

2.6.5.2 Automatic Programming

NOTE: Include this paragraph only if paragraph
COMPRESSED GAS SLUDGE MIXING SYSTEM is specified.

Equipment shall be provided to automatically program a predetermined discharge period through the diffusers in sequence. The time period shall be adjustable. A selector switch shall be provided to allow discharge to any desired diffuser.

2.6.6 Compressor Housing

A weatherproof enclosure shall be provided for the compressor and motor assembly. The enclosure shall have lockable access doors and shall be louvered for ventilation. [The enclosure shall be insulated and equipped with a thermostatically controlled electric heater.] The enclosure shall

be mounted on the digester cover.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 WELDING

NOTE: If the need exists for more stringent pipe welding requirements, delete the sentences in the first set of brackets.

[Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING STRUCTURAL.] [Welding and nondestructive testing procedures for piping shall be as specified in Section 40 05 13.96 or 40 17 26.00 20 WELDING PROCESS PIPING.]

3.3 PAINTING

All ferrous metal equipment shall be cleaned, primed, and given two coats of machinery enamel at the factory. Fiberglass, stainless steel, and galvanized components need not be painted. Field painting shall be in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.4 EQUIPMENT INSTALLATION

NOTE: Coordinate with Section 46 73 10 FLOATING COVER FOR SLUDGE-DIGESTION TANKS.

Install equipment where indicated and in accordance with the manufacturer's written instructions and under the supervision of the manufacturer's representative. Provide sufficient clearances around all equipment to allow for proper operation and maintenance. Connections with or protrusions through the digester cover or walls shall be gastight. Special attention shall be given to the proper installation of gas and fuel systems to insure safe operation. [Equipment installed on floating digester covers shall be counterbalanced to insure proper operation of the cover.]

Submit drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

3.5 FRAMED INSTRUCTIONS

Post framed instructions, containing wiring and control diagrams under glass or in laminated plastic, where directed. Submit a copy of the instructions proposed to be framed and posted. The framed instructions shall be posted before acceptance testing of the system. Show with the instructions wiring and control diagrams and complete layout of the entire system. The instructions shall also include, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system.

3.6 FIELD QUALITY CONTROL

3.6.1 Testing

Provide performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls. Include in the boiler and heat exchanger test reports manometer readings at the main gas regulator, pilot gas regulator, burner inlet, burner and the furnace; amperes drawn by all motors; voltage of main flame and pilot controller signal; and flue gas readings including percent oxygen, percent carbon dioxide, temperature, efficiency, and smoke test results.

3.6.1.1 Gas Piping Test

Test gas piping by subjecting it to pneumatic pressure of not less than 105 kPa 15 psi for 6 hours. During the test the system shall be disconnected from the source of pressure and, with corrections made for barometric and temperature changes, the pressure shall remain constant for the test period, as indicated by a test gauge.

3.6.1.2 Piping System and Heat Exchanger Test

The piping system and heat exchanger shall be isolated and shall be tested for a period of at least 6 hours at a hydrostatic pressure of 310 kPa 45 psi.

3.6.1.3 Operational Test

Subject the entire gas, heating, and mixing system to an operational test to demonstrate satisfactory functional efficiency.

3.6.1.4 Boiler and Heat Exchanger Test

Test boiler and heat exchanger as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING.

3.6.2 Manufacturer's Services

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installation, adjustment, and testing of the equipment.

3.7 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Training shall be provided for a total period of [_____] hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance manuals.

3.8 MAINTENANCE

Provide operation manuals that detail the step-by-step procedures required for system startup, operation, and shutdown. Operation manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

Provide maintenance manuals that list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout and simplified wiring and control diagrams of the system as installed. Manuals shall be approved prior to the field training course.

-- End of Section --