**SECTION 22 60 00**

**GAS AND VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES**

**BASED ON DFD MASTER SPECIFICATION DATED 02/04/2020**

***This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.***

**P A R T 1 - G E N E R A L**

**SCOPE**

This section contains specifications for plumbing pipe and pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL

 Scope

 Reference

 Reference Standards

 Shop Drawings

 Operation and Maintenance Data

 Quality Assurance

 Delivery, Storage, and Handling

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PART 2 - PRODUCTS

 Natural and LP Gas

 Vacuum

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PART 3 - EXECUTION

 General

 Preparation

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**RELATED WORK**

Section 01 91 01 or 01 91 02 – Commissioning Process

Section 22 08 00 – Commissioning of Plumbing

22 05 29 - Hangers and Supports for Plumbing Piping and Equipment

22 05 14 - Plumbing Specialties

22 05 23 – General Duty Valves for Plumbing Piping

**REFERENCE**

Applicable provisions of Division 1 govern work under this section.

**REFERENCE STANDARDS**

ANSI A21.4

ANSI A21.11

ANSI A21.51

ANSI B16.3 Malleable Iron Threaded Fittings

ANSI B16.5 Pipe Flanges and Flanged Fittings

ANSI B16.22 Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings

ANSI B16.29 Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV

ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless

ASTM A105 Forgings, Carbon Steel, for Piping Components

ASTM A126 Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated

 Temperatures

ASTM A861 High Silicon Iron Pipe and Fittings

ASTM B32 Solder Metal

ASTM B88 Seamless Copper Water Tube

ASTM B280 Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

ASTM B306 Copper Drainage Tube (DWV)

ASTM B813 Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube

ASTM B819 Seamless Copper Tube for Medical Gas Systems

ASTM D1785 Poly Vinyl Chloride (PVC) Plastic Pipe

ASTM D2241 Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)

ASTM D2464 Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80

ASTM D2466 Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40

ASTM D2513 Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

ASTM D2564 Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings

ASTM D2657 Heat Fusion Joining of Polyolefin Pipe and Fittings

ASTM D2774 Recommended Practice for Underground Installation of Thermoplastic Pressure Piping

ASTM D2855 Making Solvent Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings

ASTM D3222 Unmodified Poly Vinylidene Fluoride (PVDF) Molding Extrusion and Coating Materials

ASTM D4101 Propylene Plastic Injection and Extrusion Materials

ASTM F405 Corrugated Polyethylene (PE) Tubing and Fittings

ASTM F437 Threaded Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 80

ASTM F438 Socket Type Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 40

ASTM F441 Chlorinated Poly Vinyl Chloride (CPVC Plastic Pipe, Schedules 40 and 80

ASTM F493 Solvent Cements for Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe and Fittings

ASTM F656 Primers for Use in Solvent Cement Joints of Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings

AWS A5.8 Brazing Filler Metal

NFPA 54 National Fuel Gas Code

NFPA 50 Bulk Oxygen Systems at Consumers Sites

NFPA 99 Health Care Facilities

CGA G-4.1 Equipment Cleaned for Oxygen Service

CGA G-4.4 Industrial Practices for Gaseous Oxygen Transmission and Distribution

 Piping Systems

CGA G-6.1 Standard for Low Pressure Carbon Dioxide Systems at Consumer Sites

CGA G-8.1 Standard for Nitrous Oxide Systems at Consumer Sites

CGA P-2.1 Standards for Medical-Surgical Vacuum Systems in Health Care Facilities

**SHOP DRAWINGS**

Schedule from the contractor indicating the ASTM, AWWA or CISPI specification number of the pipe being proposed along with its type and grade if known at the time of submittal, and sufficient information to indicate the type and rating of fittings for each service.

Statement from manufacturer on his letterhead that pipe furnished meets the ASTM, AWWA or CISPI specification contained in this section.

***Manufacturer's statement is appropriate on large or specialized projects and may be deleted on small projects.***

# OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

***Delete the following if there are no additional requirements.***

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. ***[A/E and commissioning provider to define detailed operation and maintenance data requirements for equipment specifications added to this section.]***

**QUALITY ASSURANCE**

Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

Order all copper, cast iron, steel, PVC and polyethylene pipe with each length marked with the name or trademark of the manufacturer and type of pipe; with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size, and name of supplier.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the State.

**DELIVERY, STORAGE, AND HANDLING**

Promptly inspect shipments to insure that the material is undamaged and complies with specifications.

Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

**DESIGN CRITERIA**

Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM

specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system.

Non-metallic piping will be acceptable only for the services indicated. It will not be acceptable in ventilation plenum spaces, including plenum ceilings.

Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM B88, type L H (drawn) temper copper tubing is specified, ASTM B88, type K H (drawn) temper copper tubing may be substituted at Contractor's option.

**WELDER QUALIFICATIONS**

Welding procedures, welders, and welding operators for all building service piping to be in accordance with certified welding procedures of the National Certified Pipe Welding Bureau and Section 927.5 of ASME B31.9 Building Services Piping or AWS 10.9 Qualification of Welding Procedures and Welders for Piping and Tubing. Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section 927.6 of ASME B31.9 Building Services Piping.

***Welder certifications are required to be renewed every three years. If qualification papers are needed on a project, verify that they are current.***

Before any polyethylene fusion welding is performed, Contractor to submit certification that the welders to be used on this project have successfully demonstrated proper welding procedures in accordance with the Code of Federal Regulations, Title 49, Part 192, Section 192.285.

The Architect or Engineer reserves the right to test the work of any welder employed on the project, at the State's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project and all defective welds replaced.

**P A R T 2 - P R O D U C T S**

**NATURAL AND LP GAS**

Above Ground 2" and Smaller:

ASTM A53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A197/ANSI B16.3 class 150, black malleable iron threaded fittings or ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

Above Ground 2-1/2" and Larger:

ASTM A53, type E or S, standard weight black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

Below Ground:

Thermoplastic polyethylene gas pressure pipe, tubing and fittings, PE 2406/3406/3408, SDR 11.5 maximum, ASTM D2513; with butt-weld ASTM D3261 or socket-type polyethylene heat fusion fittings.

Exterior LP Only - Type K copper water tube, O (annealed) temper, ASTM B88; with cast copper pressure fittings, ANSI B16.18; wrought copper pressure fittings, ANSI B16.22; copper phosphorous or copper-phosphorous-silver brazing alloy, AWS A5.8 BCuP; or cast copper flared pressure fittings, ANSI B16.26.

Below Ground at Service Entrance:

Same as above ground covered with a flexible polymer film with a coal tar and synthetic elastomeric coating of 36 mil thickness or extruded high density polyethylene factory applied coating of 30 mil thickness. Wrap fittings with 10 mil polyethylene tape, ANSI A21.5, double layer, half-lapped. Minimum dielectric strength exceeding 12 KV. Use a compatible primer below polymer film or polyethylene tape.

***Coordinate responsibility of gas service and building piping with HVAC.***

**VACUUM**

Type L seamless copper water tube, H (drawn) temper, ASTM B88, Type L seamless copper tube for air conditioning, H (drawn) temper, ASTM B280 or Type L seamless copper medical gas tube, H (drawn) temper, ASTM B819; with wrought copper pressure fittings, ANSI B16.22; lead free (<.2%) solder, ASTM B32; flux, ASTM B813 or copper phosphorous or copper-phosphorous-silver brazing alloy for copper-to-copper joints, AWS A5.8 BCuP; flux and silver brazing alloy AWS A5.8 BAg for copper-to-brass/bronze joints. Mechanically formed brazed tee connections may be used in lieu of specified tee fittings for branch takeoffs up to one-half (1/2) the diameter of the main. Where vacuum piping and medical or laboratory gases are installed on the same project, the vacuum piping must either meet the medical or laboratory gas piping specification or it must be field labeled every 5’ prior to installation to prevent use for those gases.

***Vacuum systems that are likely to carry oxygen or flammable gases must be silver brazed and soft solder is not allowed.***

**MEDICAL GAS**

Type L seamless copper medical gas tube, H (drawn) temper, ASTM B819; with wrought copper pressure fittings, ANSI B16.22; copper phosphorous or copper-phosphorous-silver brazing alloy for copper-to-copper joints, AWS A5.8 BCuP; flux and silver brazing alloy AWS A5.8 BAg for copper-to-brass/bronze joints. Medically clean piping and fittings at factory in accordance with ASTM B819 and CGA G-4.1. Cap, plug or seal piping to prevent contamination prior to assembly.

***Specify Type K for systems operating at 200-300 psig.***

**LAB GAS**

Type L seamless copper tube for air conditioning, H (drawn) temper, ASTM B280 or Type L seamless copper medical gas tube, H (drawn) temper, ASTM B819; with wrought copper pressure fittings, ANSI B16.22; copper phosphorous or copper-phosphorous-silver brazing alloy for copper-to-copper joints, AWS A5.8 BCuP; flux and silver brazing alloy AWS A5.8 BAg for copper-to-brass/bronze joints. Clean piping and fittings at factory in accordance with CGA G-4.1. Cap, plug or seal piping to prevent contamination prior to assembly.

***Specify Type K for systems operating at 200-300 psig.***

**P A R T 3 - E X E C U T I O N**

**GENERAL**

Install pipe and fittings in accordance with reference standards, manufacturers recommendations and recognized industry practices.

**PREPARATION**

Cut pipe ends square. Ream ends of piping to remove burrs. Clean scale and dirt from interior and exterior of each section of pipe and fitting prior to assembly.

**ERECTION**

Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Where copper or steel piping is embedded in masonry or concrete, provide protective sleeve covering of elastomeric pipe insulation.

Install underground warning tape 6"-12" below finished grade above all exterior below ground piping. Where existing underground warning tape is encountered, repair and replace.

Maintain piping in clean condition internally during construction.

Provide clearance for installation of insulation, access to valves and piping specialties.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

***This requirement is based on NFPA 70, 384-4 and 450-47.***

Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to all equipment, fixtures and systems installed by others where same requires the piping services indicated in this section.

**COPPER PIPE JOINTS**

Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joint. Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

**WELDED PIPE JOINTS**

Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable. "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main.

**THREADED PIPE JOINTS**

Use a thread lubricant or teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

**SOLVENT WELDED PIPE JOINTS**

Install in accordance with ASTM D2855 "Making Solvent Cemented Joints With PVC Pipe and Fittings". Saw cut piping square and smooth. Tube cutters may be used if they are fitted with wheels designed for use with PVC/CPVC pipe that do not leave a raised bead on pipe exterior. Support and restrain pipe during cutting to prevent nicks and scratches. Bevel ends 10-15 degrees and deburr interior. Remove dust, drips, moisture, grease and other superfluous materials from pipe interior and exterior. Check dry fit of pipe and fittings. Reject materials which are out of round or do not fit within close tolerance. Use heavy body solvent cement for large diameter fittings.

Maintain pipe, fittings, primer and cement between 40 and 100 degrees during application and curing. Apply primer and solvent using separate daubers (3" and smaller piping only) or clean natural bristle brushes about 1/2 the size of the pipe diameter. Apply primer to the fitting socket and pipe surface with a scrubbing motion. Check for penetration and reapply as needed to dissolve surface to a depth of 4-5 thousandths. Apply solvent cement to the fitting socket and pipe in an amount greater than needed to fill any gap. While both surfaces are wet, insert pipe into socket fitting with a quarter turn to the bottom of the socket. Solvent cement application and insertion must be completed in less than 1 minute. Minimum of 2 installers is required on piping 4" and larger. Hold joint for 30 seconds or until set. Reference manufacturers recommendations for initial set time before handling and for full curing time before pressure testing. Cold weather solvent/cement may be utilized only under unusual circumstances and when specifically approved by the **DFD** Project Representative.

**MECHANICAL GROOVED PIPE CONNECTIONS**

Use pipe factory grooved in accordance with the coupling manufacturer's specifications or field grooved pipe in accordance with the same specifications using specially designed tools specially designed for the application. Lubricate pipe and coupling gasket, align pipe, and secure joint in accordance with the coupling manufacturer's specifications.

**MECHANICALLY FORMED TEE FITTINGS**

Form mechanically extracted collars in a continuous operation, consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the tube wall. Use an adjustable collaring device. Notch and dimple the branch tube. Braze the joint with neutral flame oxy-acetylene torch, applying heat properly so that pipe and tee do not distort; remove distorted connections.

**NATURAL AND LP GAS**

Install in accordance with NFPA 54 and 58. Pitch horizontal piping down 1" in 60 feet in the direction of flow. Install a 4" minimum depth dirt leg at the bottom of each vertical run and at each appliance. When installing mains and branches, cap gas tight each tee or pipe end which will not be immediately extended. All branch connections to the main shall be from the top or side of the main.

Do not install gas pipe below a building or its foundation or in a ventilation air plenum.

Bury exterior underground piping a minimum of 24" below grade.

If an above ground vent terminates in an area subject to snow accumulation, terminate the line at least five feet above grade.

All joints in underground polyethylene gas pipe must be made by qualified personnel proficient in the joining methods of ASTM D2513 thermoplastic gas pressure pipe and polyethylene fittings. Do not install polyethylene gas pipe inside buildings.

Install a shut off valve at each appliance. Provide a valved connection at the main for equipment and appliances furnished by others.

Piping through a roof shall be run through an approved roof penetration with flashing and counter flashing.

Each gas pressure reducing valve vent and relief valve vent shall be run separately to a point outside of the building, terminated with a screened vent cap, and located according to gas utility regulations.

# MEDICAL GAS, LAB GAS AND VACUUM

Comply with requirements of NFPA 99.

Examine piping and fittings internally for contamination prior to assembly. Do not install contaminated material. On-site cleaning may be performed only at joints contaminated prior to brazing by scrubbing in hot alkaline cleaner and water solution (sodium carbonate or trisodium phosphate, one pound to 3 gallons of water) and rinsing with clean hot water.

Purge piping system with dry nitrogen during brazing operations. Use flux only where copper to brass/bronze joints are required and on soldered vacuum systems. Apply flux sparingly avoiding contamination of piping system. Wash exterior of finished joints with water and stainless steel brush. Use hot water on fluxed joints. Inspect joints for flux residue, oxidation, unmelted filler metal, failure to fully penetrate or surround joint with filler metal, cracks in fittings or filler metal or potential leaks. Replace defective fittings or pipe and repair defective joints. Replace defective joints requiring more than two repairs. Assemble threaded joints with teflon tape. Unions are not allowed in distribution pipeline system for gas systems and only on vacuum distribution piping where exposed and readily accessible.

Do not run piping where subject to physical damage, excessive heat, corrosion or contact with oil. Do not interconnect piping serving patients with piping serving laboratories.

INSTALLER PERFORMANCE TESTING: Blowout piping systems prior to connection of outlets, inlets or gauges with dry nitrogen to remove particulate contamination. Fill piping systems with dry nitrogen and perform initial pressure test. Complete installation of pressure sensitive components and perform final pressure test. Perform heavy, intermittent purging of pipeline with dry nitrogen until no discoloration is evident in white cloth held over outlets and inlets. Cross connect test one system at a time testing all inlets and outlets to verify that test gas is being dispensed only from the outlets or inlets of the system being tested.

MEDICAL GAS AND MEDICAL VACUUM SYSTEM VERIFICATION: Provide systems verification by factory trained technician employed by the medical gas equipment manufacturer. Submit certification report describing testing procedures, results and indicating the system and all components and equipment were tested in accordance with and meet the requirements of NFPA 99.

**PIPING SYSTEM LEAK TESTS**

Isolate or remove components from system which are not rated for test pressure. Perform final testing for medical and lab gas with all system components in place. Test piping in sections or entire system as required by sequence of construction. Do not insulate or conceal pipe until it has been successfully tested.

If required for the additional pressure load under test, provide temporary restraints at fittings or expansion joints. Backfill underground water mains prior to testing with the exception of thrust restrained valves which may be exposed to isolate potential leaks.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

For air or nitrogen tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.

Inspect system for leaks. Where leaks occur, repair the area with new materials and repeat the test; caulking will not be acceptable.

Entire test must be witnessed by the Division's representative. All pressure tests are to be documented on Division of Facilities Development forms to be provided to the contractor.

 Test Initial Test Final Test

## System Medium Pressure Duration Pressure Duration

Natural and LP Gas Air N/A 100 psig 24 hr

Compressed Air Air N/A 150 psig 24 hr

Oxygen Nitrogen 150 psig 2 hr 65 psig 24 hr

Vacuum Nitrogen 150 psig 2 hr 65 psig 24 hr

Nitrous Oxide Nitrogen 150 psig 2 hr 65 psig 24 hr

Medical/Lab Compressed Air Nitrogen 150 psig 2 hr 65 psig 24 hr

Nitrogen Nitrogen 200 psig 2 hr 200 psig 24 hr

Helium Nitrogen 150 psig 2 hr 65 psig 24 hr

Carbon Dioxide Nitrogen 150 psig 2 hr 65 psig 24 hr

# CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 2208 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

# AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION