

SECTION 15200

SPECIALTY PIPING SYSTEMS

PART 1 –GENERAL

1.1 INTRODUCTION

- A. This section provides guidelines for the development of special piping systems. Specialty piping systems are designed to serve specific program requirements independent of general building mechanical systems. This section should be used in conjunction with the Facilities Design Guide sections on plumbing piping and vacuum and compressed air piping. Specialty piping systems may include:
1. Industrial (non-potable) water
 2. Process cooling water
 3. Research water, typically reverse osmosis and deionized water
 4. Process and equipment vacuum systems
 5. Compressed air
 6. Nitrogen, standard and ultra-high purity
 7. Research grade oxygen
 8. Hydrogen, standard and ultra-high purity
 9. Argon
 10. Liquid nitrogen
 11. Laboratory waste and vent

1.2 QUALITY ASSURANCE

- A. Designer Qualifications: All specialty piping design work shall be signed and stamped by a mechanical engineer licensed in the State of California. Requests for exceptions to this requirement shall be evaluated by the Facilities Department Manager of Engineering Services Division.
- B. Installer Qualifications: List of bidders for installation of process piping systems shall be reviewed by the Project Manager to ensure that bidders are qualified.
- C. Testing:
1. Process piping installers shall provide testing services as set forth in the Contract Documents.
 2. All testing shall be performed in the presence of the Project Manager's representative.
 3. Deviations from the cleaning, testing, and certification requirements set forth in the Contract Documents shall be subject to written approval of the Project Manager.

1.3 REFERENCES

- A. American National Standards Institute (ANSI)
- B. American Society of Mechanical Engineers (ASME)
- C. American Society of Plumbing Engineers (ASPE)
- D. American Society for Testing and Materials (ASTM)
- E. American Water Works Associated (AWWA)
- F. National Fire Protection Association (NFPA)
- G. Underwriters Laboratory (UL)
- H. National Committee for Clinical Laboratory Standards (NCCLS)

1.4 SUBMITTALS

A. General:

1. In the absence of specific requirements in the design contract the following submission requirements shall be followed. Confirm the submission requirements with School of Medicine Project Manager.
2. Design drawings, data and calculations at various stages of completion shall be submitted for each phase of the University's plan review process. The specific submission requirements for each phase are outlined below.
3. Refer also to Section 01330: Submission Requirements.

B. 100% Schematic Design Submissions:

1. Selection of types of specialty piping systems.
2. Preliminary system cost estimate in terms of unit cost (dollars per square foot gross building floor space, dollars per system or component, or similar).
3. Location of major specialty piping equipment
4. Schematic diagrams of major specialty piping systems.

C. 100% Design Development Submissions:

1. Location of all specialty piping equipment.
2. Routing plans for all piping mains.
3. Major riser diagrams.
4. Preliminary design calculations, including selection of major equipment, and preliminary cost estimate for all systems.
5. Life Cycle Cost Analysis on optional systems (as applicable).
6. Outline specifications.

D. 50% Construction Documents Submissions:

1. 50% complete specialty piping plans, sections, and details.
2. Final selection of equipment and systems options considered under Design Development Phase.
3. Design calculations.
4. Revised system cost estimate based on 50% design documents.
5. 50% complete specifications.

E. 95% Construction Documents Submissions:

1. 95% complete design drawings.
2. 00% design calculations.
3. Revised system cost estimate based on 90% design documents.
4. 95% complete specifications.

F. 100% Construction Documents Submissions:

1. Final contract drawings and specifications.
2. Final cost estimate.

G. Contract Closeout:

1. As-Built Drawings: All changes to Contract Drawings and Specifications, including schedules, control diagrams, etc., shall be incorporated into As-Built Drawings in accordance with Section 01330: Submission Requirements.
2. Operations and Maintenance Manuals shall include complete specialty piping systems operating and service descriptions written by the Consulting Engineer. The descriptions shall supplement any operating instructions provided as part of vendor-furnished equipment. Refer to Section 01330: Submission Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Pre-purchased Equipment: The Consultant responsible for the pre-purchase specification of equipment or materials shall consult the Project Manager regarding delivery, inspection and acceptance, storage, and handling of the products.

B. Equipment Furnished by the Contractor: Specific provisions for delivery and storage locations as well as handling, protection, and security measures shall be included in the Contract Documents.

1.6 GENERAL DESIGN CONSIDERATIONS

A. General:

1. Design shall be in accordance with applicable ASHRAE and ASPE handbooks.
2. Maintenance shall be an important design consideration for all systems. Sectional valving is required. Shutdown of parts of systems should not unnecessarily disrupt operation of entire building systems.
3. Energy conservation shall be an important design consideration for all systems.

B. Coordination: The University expects careful design coordination between plumbing, specialty piping, HVAC, and fire protection disciplines.

PART 2 -SPECIALTY PIPING SYSTEM REQUIREMENTS

2.1 INDUSTRIAL WATER

- A. Industrial water shall be provided from the building domestic water system. Industrial water shall be isolated from the domestic water system with backflow devices.
- B. Industrial water shall be installed to the same criteria as domestic water systems. Industrial water piping shall be clearly labeled as such.

2.2 PROCESS COOLING WATER

- A. Process cooling water shall be installed to the same criteria as small diameter chilled water systems. Process cooling water shall be clearly labeled as such.
- B. Valves:
1. Back pressure valve, Jordan stainless steel type MARK-63, 20-70 PSIG spring range.
 2. Hand valve: GF or GSR, PVC true union ball valve, type 1, grade 1, Teflon ball seal, EPDM "O" ring seals, solvent weld socket ends.
 3. Check valve: stainless steel spring check.

2.3 RESEARCH GRADE WATER SYSTEM DESIGN:

- A. The Architect, in association with the School of Medicine Project Manager, shall meet with the laboratory user to determine which type/grade of National Committee for Clinical Laboratory Standards (NCCLS) water is to be used.
- B. The Stanford Project Manager shall provide the definition of the NCCLS Type I, II, III grade water for wet chemistry and biology laboratories. Electronics

laboratory research grade water requirements shall be defined differently. All research grade water systems shall be tied into the EMCS to alarm on low tank water level condition, low water quality, and on "no flow" condition.

C. NCCLS Types I, II, and III water design requirements :

1. Type II: The makeup pre treatment shall consist of: prefilter, water softener, activated carbon absorption and a five (5) micron filter. Treatment shall consist of a Reverse Osmosis (RO) unit, deionized mixed bed units, ultraviolet light and a 0.2 micron final filter.
2. Type III: The makeup pretreatment shall consist of prefilter, water softener, activated carbon absorption, and a five (5) micron filter. Treatment shall consist of a Reverse Osmosis (RO) unit, provisions for installing deionized mixed bed units for future requirements, ultraviolet light and a 0.2 micron final filter.
3. Type I: The makeup pretreatment shall consist of prefilter, water softeners, activated carbon absorption and a five (5) micron filter. Treatment shall consist of a Reverse Osmosis (RO) unit, deionized mixed bed units, ultraviolet light and a 0.2 micron filter. Final treatment of Type I water will be done at point of use by means of a polishing system selected by the Project Engineer for the specific use in the laboratory.

D. Piping shall be socket fused polypropylene. Valves shall be diaphragm type. Pumps shall be stainless steel where pump materials contact water.

E. The makeup system shall feed into a holding tank. The distribution system shall feed from the holding tank(s) and distribute and return water throughout the building. Modularity in design is encouraged for system isolation. System shall be designed so as to provide valving, venting, and drains for cleaning. There shall be no dead legs greater than five (5) pipe diameters in length. Velocity through the pipe shall be five to seven feet per second (5-7 FPS).

F. A mixed bed deionized unit, ultraviolet light and a 0.2 micron filter shall be in the distribution loop.

G. System Capacity

1. Makeup system

- a. The pretreatment and purification systems are also known as the makeup system. The system shall be sized so as to run as continuously as possible to prevent bacteria buildup. This also allows the system to be downsized, thereby reducing first time cost. Expandability for future requirements shall be considered.
- b. The makeup system capacity shall be sized according to the following:

$$C=RD/24$$

- c. Where "C" is capacity in gallons per hour. "R" is building daily water requirement, usually consisting of a small percentage (approximately 20%) for laboratory use. Any special equipment requiring research grade water would, of course, be added to this requirement. "D" is diversity and is based on empirical knowledge of existing buildings.
- 2. Storage Tank: The storage tank shall be sized to allow for peak system usage. While the makeup system may be producing water over a twentyfour (24) hour day, the actual usage generally will be over a ten (10) hour period.
 - a. The equation below is for sizing storage tanks.
$$S=C(24-T)$$
 - b. Where: S is tank size in gallons; C is makeup system capacity in gallons per hour; T is hours per day system is being used.
- H. Testing: The quality of the water shall be tested for compliance with design criteria as part of the installation contract by an approved testing agency. System shall be tested upon start-up, at one month, and four times at three (3) month intervals thereafter.

2.4 RESEARCH GRADE WATER PIPING

- A. Supply and return piping shall be in piping appropriate for the water quality.
- B. Standard piping shall be unpigmented schedule 80 polypropylene with fusion welded joints.
- C. Ultra-high purity water piping shall use SYGEF virgin PVDF pipe with socket fusion joints and fittings. Systems requiring the highest purity water shall use bead and crevice free (BCF) joints.
- D. Valves: All valves must be pre-cleaned and non-lubricated. The use of Teflon paste, Permatex, Vaseline and other lubricants are expressly forbidden.
 - 1. Shut-off valves: true union ball valves for sizes ½" thru 2". Butterfly valve for 2½" and larger. Material same as piping.
 - 2. Check valve: stainless steel spring check
 - 3. Back pressure: Jordan stainless steel type MARK-50, 2-20 psig spring range

2.5 PROCESS AND EQUIPMENT VACUUM:

- A. Refer to Facilities Design Guide section for Compressed Air and Vacuum Systems.

2.6 NITROGEN

- A. Nitrogen piping shall be piped in ACR Type L copper with brazed fittings and to the requirements in Facilities Design Guide section on Compressed Air and Vacuum Systems.

2.7 OXYGEN, ARGON, ULTRA HIGH PURITY NITROGEN AND HYDROGEN:

- A. Piping: ASTM SA312 Type 316L seamless stainless steel with butt-welded fittings and joints. With the approval of Stanford Facilities and the Stanford Project Manager flared metal gasket face seal fittings (VCR) may be used. Order pipe, tubing and fittings from manufacturer as pre-cleaned and factory sealed for oxygen use. Up to one inch use tubing, 1-1/4 inch and above use schedule 10 pipes, on exterior H2 use schedule 40 pipes, on all other exterior use schedule 10 pipes.
- B. Valves:
 - 1. 1/2" point of use valves: Nupro series stainless steel UW bellows valve with tube extensions for butt-welding.
 - 2. 1/2" and 3/4" line valves: "Carten Systems" stainless steel diaphragm valve with tube extension and purge ports for butt-welding.
 - 3. 1" and larger: Copper stainless steel ball valves with tube extension for butt-welding.

2.8 LIQUID NITROGEN:

- A. MVE or CVI vacuum jacketed cryogenic pipe with Bayonet type fittings. Inner pipe to be constructed out of Invar or 304SS. Jacket shall be 304 stainless steel. Vacuum jacket shall be 304 stainless steel. Vacuum jacket must have provisions for re-evaluation and shall be included as in integral part of the system. Rigid and flexible sections of the system shall be designed for easy adaptation for the dislocation and stresses caused by temperature differentials. Piping shall be designed to withstand a maximum working pressure of 100 PSIG.

2.9 LABORATORY WASTE AND VENT

- A. Laboratory waste and vent piping should be schedule 40 polypropylene pipe with schedule 40 DMV fusion weld fittings. Mechanical joints are acceptable for piping above lab floor and for vent lines.
 - 1. Manufacturers: Fuseal, Enfield, Harvel
- B. Special applications may require the use of chemical waste drain lines. Glass waste piping may be used for these applications if appropriate. Installation and design should comply with the manufacturer's requirements, joints should be mechanical joints.

1. Manufacturers: Schott, Kimax, or equal.

2.10 GAS MANIFOLD SYSTEMS

- A. Gas Manifold: Consist of wall mounted controls cabinet and necessary header connection and pigtailed for multiple cylinders. Arrange controls to have half of cylinders in service and half in reserve.
- B. Manifold Delivery: Provide automatic changeover from primary to secondary bank and allow replacing depleted cylinders with no change in line pressure. Provide bank regulators to reduce cylinder pressure for line regulator with adjustable set point. Provide manifold relief valve with and adjustable set point.
- C. By-pass System: Between regulators to service regulator or switch over system without interrupting supply of gas. Bleed valves allow adjustment of pressure reducing regulators.
- D. Cabinet: House components in lockable cabinet with baked enamel finish.
 1. Three front mounted gages indicate bank and hospital line pressures.
 2. Green indicator light indicates service bank in use.
 3. Red indicator light indicates reserve bank in use.
 4. Provide terminal block connections for remote alarm.

PART 3 –EXECUTION

3.1 PIPING INSTALLATION

- A. General:
 1. Piping shall be protected from damage and contamination during transport and construction. Exposed ends of piping shall be kept sealed prior to and during erection and at the end of each working day.
 2. Specialty gas and copper tubing and piping shall be cut with dedicated wheel cutter. Cut ends shall be square to form proper seating in socket fittings. All cut ends shall be reamed and deburred.
 3. Tools used for copper pipe cutting and installation may only be used on copper piping systems. Copper fragments may contaminate other systems if the tools are used on other piping systems.
- B. Plastic Piping: All plastic piping systems shall be installed in strict accordance with pipe manufacturer's recommendations, including preparation of pipe fittings for joining, selection of solvent and primer, curing, and installation.
- C. Piping Supports:
 1. Spring vibration isolation pipe hangers shall be installed in mechanical rooms and areas sensitive to vibration. The drawings shall indicate

specific areas where this requirement applies.

2. Polypropylene piping shall be supported on continuous trough supports, with hanger spacing and rod sizes same as specified for metallic piping. Troughs shall be galvanized steel V or U shape, or semi-circular shape. V or U shape troughs shall have blocking at hangers to prevent rotation. Troughs shall be sized for a maximum deflection of 1/360th of span under actual loads, with "S" equal to 25,000 psi, and "E" equal to 29,000 psi.

3.2 WELDING AND BRAZING

A. Welder Qualification: All welders must be qualified to pass ASME, Section IX Code, pipe weld in 6-G position, where the root pass will be evaluated for cleanliness (the root pass must be free of oxides), uniformity, and structural reliability. A test weld made by each welder shall be witnessed by the Project Manager's representative.

B. Specialty Piping Welding (Steel Piping):

1. Base Metal: This procedure outlines the method of joining Austenitic stainless steel to Austenitic stainless steel.
 - a. Grade: The materials used in production shall meet the requirement of the applicable ASTM specification, depending on its form (i.e., pipe, tubing, etc.).
 - b. Alternate materials: Changes in alloy must be made within the ASME P-number alloy group. When substitutions are made within this alloy group, care shall be taken to also change the filler metal alloy within the filler metal composition group.
 - c. Weld on VCR metal gasket face seal fittings may be used on piping for non-toxic, non-flammable gases and liquids.
2. Filler Material: Filler wire shall conform to ASME SFA-5 or ASTM A371. It shall be stored and handled in such a manner that it remains clean and dry. Wire that has been contaminated with oil or grease, or has lost its identity shall be discarded.
3. Preparation of Base Metal: Edges or surfaces of the parts to be welded shall be prepared by machining, cutting, or a combination of these methods. All piping material shall be cleaned as previously described. All surfaces shall be thoroughly dry (moisture free) before welding commences. Purge weld shall be gassed back for three to five (3 to 5) minutes at appropriate flow rate.
4. Electrical Characteristics: Welding shall be done with direct current, straight polarity (electrode negative, work positive). High frequency arc starting shall be used.
5. Welding Techniques:
 - a. Welding shall be from outside only on pipe configurations.
 - b. Tack welds shall be of the same quality as required in the completed weld and shall be visually examined for defects before

applying any complete passes. The ends (starts and stops) of the tacks shall blend in smoothly with the base metal so that subsequent passes can be applied without interruption.

- c. All excessive oxidation remaining on any weld bead shall be removed by stainless steel wire brushing only before depositing subsequent beads. Iridescent discoloration is not considered "excessive oxidation" and does not need removal. Wire brushes shall have stainless steel bristles only, and shall not have been used previously on carbon steel or oily surfaces.
 - d. Backup shielding (Argon) shall be provided to the backside of the material in the local area of the weld. The area shall be purged to replace atmospheric gases with argon. A flow rate of five to fifteen (5 to 15) CFH shall be maintained to ensure a slight positive pressure.
 - e. Inspection: Visual inspection shall be done by the welder and the Project Manager's representative after each pass.
 - f. Inspection Criteria: Cracks, cold laps, open porosity and tungsten inclusions shall not be allowed. If the above occurs, the weldment shall be removed and rewelded per this specification. Weld beads shall be applied in such a manner that they are smooth into adjacent beads and the base metal with no areas, such as crevices, undercuts, or overlaps, that would weaken the structure or prevent adequate penetration of subsequent weld passes. Undercut of the final pass which reduces the initial material thickness shall be repaired by additional welding.
- 6. Repair: All materials welded using this procedure or which fall within the requirements of this procedure may also be repair welded using this procedure.
 - 7. Interpass Temperature: Interpass temperature shall not exceed 350°F, which shall be checked with temp stick or surface pyrometer. The temp stick shall not be applied in such a manner that the melted wax could flow or spread into the weld.

C. Specialty Piping Brazing:

- 1. All brazing operators shall be qualified in accordance with the tests described below. The Contractor shall be responsible for qualifying the brazing operation as follows:
 - a. Test samples of each operator's work shall be made according to the procedure set forth below.
 - b. These samples shall be sawed in half and torn apart to reveal the soundness of the joint.
 - c. These samples shall also be examined for cleanliness, oxides, and other contaminants. Test samples will be inspected for weld penetration. Minimum penetration shall be eighty-five percent (85%), and maximum penetration shall be one-hundred-ten

- percent (110%).
 - d. These tests to qualify brazing operators shall be witnessed by the Project Manager's representative.
 - e. The Contractor shall notify the operators whose work is judged to be below standard and they shall not be permitted to continue this type of work.
2. Copper lines shall be brazed using an oxygen-acetylene system with the torch slightly on the carbonizing side.
 3. Braze Alloy: For all copper lines, all joints shall be brazed with a fluxless brazing alloy such as copper-phos or sil-floss (15% silver).
 4. During brazing, all gas lines shall be continuously purged with nitrogen gas, which shall be allowed to escape into the atmosphere through a purge restrictor. No brazed joint shall be less than twelve inches (12") away from the end of the purge, which will require in many instances that an extension be used. For each purge restrictor used, a minimum flow of ten to fifteen (10 to 15) SCFH of nitrogen purge gas shall be used, but in all cases sufficient purge gas shall be used to prevent oxidation. This shall be checked by welder and the Project Manager's representative prior to welding.
 5. All joints that show evidence of overheating, cracking, poor penetration, or other defects of fit-up or workmanship shall be replaced as directed by the Project Manager at Contractor's expense.
 6. If the system becomes contaminated prior to acceptance, the Contractor must replace the entire system at no expense to the University if so required by the University.

3.3 FIELD QUALITY CONTROL

A. General:

1. Any deviation from the cleaning, installation testing, and certification requirements herein shall be approved in writing by the Project Manager.
2. All materials and workmanship shall be subject to inspection and examination by the Project Manager's representative at any place where fabrication or erection is carried on.
3. The Owner reserves the right to reject all or any part of the system that does not conform to the requirements herein. Rejected materials or equipment shall be returned at the Contractor's expense.
4. The University reserves the right to remove random samples of the installed work sufficient to establish the quality of materials and workmanship. If such samples indicate materials or workmanship do not meet the contract specification, the Contractor shall be required to replace or reclean the installed work at no expense to the University. The University shall reimburse the Contractor on a time and materials basis for such work if the system proves to be installed to specification.

5. All testing shall be done in the presence of the Project Manager's representative.
6. Only high-purity cryogenic nitrogen and argon shall be used for purging and leak pressure testing of high purity piping systems.
7. The purity of the gases shall be maintained throughout the entire installation of gas delivery systems. A certified gas analysis will be required by the Owner to guarantee that the final purity of the gases at points of use is the same as that of the cryogenic purging supply at the completion of construction. Analytical purity testing shall be performed at one-hundred percent (100%) completion of construction. The Project Manager's representative shall approve the sampling procedure, analytical test methods, and analytical laboratory used.
8. Upon completion of this work, all systems shall be adjusted for use. Should any piece of apparatus or any material or work fail in any of these tests, it shall be immediately removed and replaced by new materials. The defective portion of the work shall be replaced by the Contractor in the presence of the Project Manager's representative at no expense to the University.
9. Test gauges shall be installed and test medium source connections shall be made to convenient specialty connections. After completion of testing, the gauges and source connection shall be removed and the specified specialty attachments replaced.
10. Only gauges cleaned for O₂ service shall be used.
11. After each system is accepted by the University, Contractor shall leave system with a "block purge" of forty to fifty (40-50) PSIG.
12. Any leaks found shall be repaired in the following manner:
 - a. Welded joint - Reweld
 - b. Brazed joint - Rebrazed
 - c. Plastic joint - Remove/Reweld
 - d. Screw joint - Tighten (do not use compound) or replace as directed by the Project Manager's representative.

B. Pipe Testing:

1. All piping shall be tested as noted below. Test pressures shall be maintained until all leaks have been identified.
2. Defective piping shall be repaired or replaced until tests are accomplished successfully.
3. The use of oil-pumped air or nitrogen is expressly forbidden. All air and nitrogen used for testing and purging operations must be from a cryogenic source.

| SYSTEM | TESTING PRESSURE | TESTING MEDIA | DURATION |
|---|------------------|---------------|----------|
| Industrial Water | 150 PSIG | Water | 4-hours |
| Research Grade Water | 150 PSIG | DI Water * | 4-hours |
| Nitrogen Compressed Air | 150 PSIG | Nitrogen | 24-hours |
| Vacuum | 50 PSIG | Water | 4-hours |
| Hydrogen, Argon and other ultra pure gases | 200 PSIG | Nitrogen | 24-hours |
| Liquid Nitrogen | 150 PSIG | Nitrogen | 24-hours |

*Domestic water may be used for preliminary testing before cleaning of research grade water systems.

- C. Welding Tests: Pressure testing shall be at 1-1/2 times the operation pressure (not to exceed any design pressure), or as specified above, for a period of twenty-four (24) hours without any variations of pressure that cannot be accounted for other than a change in temperature.
1. The pressure shall be reduced to operation pressure and held at that pressure for a period of twenty-four (24) hours without any loss.
 2. Visual inspection shall be made for undercutting, porosity, inclusions, and cracking.
 3. Helium leak testing shall be required for all high purity systems.

3.4 CLEANING

- A. General Cleaning Requirements: All pipe, fittings, valves, and system-related materials shall be cleaned before use.
- B. Cleaning Area for Specialty Piping Construction: There shall be separate cleaning and clean storage areas.
- C. Location: Area shall be clean, dry and dust free. It shall be well lighted and with adequate ventilation to eliminate any hazards from cleaning solutions.
- D. Storage: There shall be three storage areas: uncleaned approved material, work in process, and clean, work-ready material.
- E. Division: All work-ready material shall be stored separately and shall not be allowed to be in contact with the floor, ground, or unclean resting sites.
- F. Dating: All work ready material shall be dated and initialed by the cleaning technician.

- G. Supplies: All chemicals and supplies shall be stored in a safe, ventilated area and protected from contamination.
- H. Used Chemicals: All used chemicals shall be stored in closed drums, held for disposal. Fresh chemicals shall be used daily. No recycled chemicals shall be used.
- I. Industrial Water System:
 - 1. After completing domestic water supply systems, these systems shall be disinfected in accordance with requirements of U.S. Public Health Department. Fifty (50) parts per million (PPM) of chlorine with eight (8) hour retention shall be used and flushed to leave a residual no greater than supply source. Written certification of disinfection completion shall be submitted to the Project Manager.
 - 2. Test piping as described above before disinfecting.

3.5 POLYPROPYLENE PIPING INSTALLATION, TESTING AND START-UP

- A. General:
 - 1. This article establishes requirements for the installation of polypropylene piping for research grade water systems per ASTM D1785, ASTM D2146 or ASTM D2837-85, SDR-11, Thermoplastic Piping Specification.
 - 2. All installation fitters who fabricate and install polypropylene piping systems shall be requalified by making at least three typical pipe joints into a test spool piece that withstands a test pressure that conforms to the manufacturer's design test recommendations. This will include at least one gasketed joint and is intended to meet the Code qualification of nonmetallic pipe joiners. The Contractor shall arrange the qualifying test with the representative present.
 - 3. All materials and workmanship of this system shall be subject to inspection and examination by the Project Manager's representative at any place where fabrication and/or erection are carried on.
 - 4. All research grade piping distribution systems shall be pressure and leak tested by the Contractor and approved by the Project Manager's representative prior to the final analytical test. See also paragraph 3.03.B., Pipe Testing, above.
 - 5. All research grade piping test medium shall be research grade water.
 - 6. Polypropylene piping shall be supported on continuous trough supports, with hanger spacing and rod sizes same as specified for metallic piping. Troughs shall be galvanized steel V or U shape, or semi-circular shape. V or U shape troughs shall have blocking at hangers to prevent rotation. Troughs shall be sized for a maximum deflection of 1/360th of span under actual loads, with "S" equal to 25,000 psi, and "E" equal to 29,000 psi.

B. Pipe Installation Procedures:

1. Polypropylene piping systems shall be installed in strict accordance with pipe manufacturer's recommendations, including preparation of pipe and fittings, selection of latest approved tooling and equipment.
2. All provisions of this specification shall be followed. No substitutions of items or alterations in the procedures are allowed unless authorized in writing by the Project Manager's representative. A thorough visual inspection of the completed pipe system by the Contractor and Project Manager's representative is required.
3. The pipe and fittings shall be carefully unloaded by hand, or using slings made of nonmetallic (e.g., nylon) material. Pipe shall be stored indoors on sleepers. Fittings shall be stored indoors in sealed containers. A qualified fitter shall supervise unloading and visually inspect the piping for evidence of abuse or damage such as cracks or gouges. Damaged pipe shall be rejected and not used.
4. All capped pipe and boxed fittings and prefabricated spools shall be carefully handled to avoid damage.
5. Pipe shall be cut with pipe cutter, beveled and deburred. Joining surfaces of fitting socket and pipe shall be thoroughly cleaned using absorbent clean room cotton cloth wipes and semiconductor grade anhydrous isopropyl alcohol. New clean room cotton wipe shall be used each time.
6. Pipe shall be cut accurately to job measurements and installed per manufacturer's recommendations without springing or forcing, true to line and grade per design specifications.
7. All joints shall be made up in a dry, clean environment according to the manufacturer's instructions.
8. Piping shall be joined by a heat fusion method. Fittings shall be socket type. The pipe end and fitting socket shall be heated to fusion joint temperature per Manufacturer's specifications.
9. The depth of penetration of the pipe into the socket is to be as defined in manufacturer's instructions. The pipe system selected will determine the size of outside bead.
10. Valves shall be located with stems above horizontal plane of pipe and in accessible locations with adequate clearance around hand wheels or levers for easy operation.
11. All valved stubs for future connections shall be piped within six (6) pipe diameters on main run.
12. Special care shall be taken during installation to keep piping system clean. All open ends shall be capped with teflon tape.

C. Piping Distribution Cleaning:

1. Cleaning procedure will require the following materials and equipment:
 - a. Alconox detergent and thirty percent (30%) hydrogen peroxide cleaning agents.
 - b. Circulating pump.

- c. Acid resistant tanks of sufficient size to fill all lines.
 - d. One percent (1%) potassium permanganate testing solution.
 - e. Balsbough resistivity meter.
2. Procedure:
- a. Flush piping system with research grade Type III water to remove all foreign substances.
 - b. Connect piping systems to be cleaned to the pump and tank. Fill the tank with research grade Type III water and add Alconox twenty-five (25) grams/gallon.
 - c. Circulate solution through all research grade piping for six (6) hours, bleeding 0.5 gallons from each valve at two (2) hour intervals.
 - d. Drain system and refill with research grade Type III water and test resistivity. Repeat procedure until the return side of each loop conforms to the NCCLS Type III water specifications.
 - e. Add hydrogen peroxide (1 gallon per 5 gallons of system volume) and repeat Procedures 2.c and 2.d above.
 - f. Flush system with fresh research grade Type III water and test all discharge points with potassium permanganate. Continue flushing until test shows negative. (A positive test will show color change from violet to brown.)
 - g. Drain and fill system including filter housings, pumps, and storage tanks with fresh research grade water and proceed to operate entire system.
 - h. Check water quality and continue flushing with fresh research grade water until the return side of each loop conforms to the NCCLS water type of this piping system.
3. System Start-up:
- a. Prior to start-up, all subsystems shall be checked to ensure they are ready, including but not limited to the following: proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting controls, all filters installed and properly set relief and safety valves.
 - b. All systems shall be started and operated. The services of factory trained technicians shall be provided for start-up of major equipment and systems, including but not limited to temperature controls and pump sets. All balancing valves, flow and pressure regulators, and any other adjustable equipment shall be adjusted for optimum performance and to suit job conditions.

END OF SECTION