HIGH PURITY

High Purity System Design

A pure water system comprised of PVDF or polypropylene is similar to most chemical feed systems. The critical factor in a pure system is to design it in a continuous moving loop without dead-legs to avoid the possibility of microorganism growth.

Systems should also be sized to have turbulent flow as part of the method of inhibiting bacteria growth. PVDF and PP systems are ideally suited for pure water as they have extremely smooth inner surfaces that reduce particle generation and inhibit sites for bacteria to adhere to and proliferate. In addition, PVDF and PP systems have low extractables; therefore, the water being transported is not contaminated.

In designing a thermoplastic high purity water system, the following items need to be considered:

- Materials of construction
- Operating parameters
- System sizing
- Thermal expansion
- Minimizing dead-legs
- System monitoring
- Hanging
- Welding methods
- Other considerations

Materials of Construction

PVDF is the premier material for high purity water systems. PVDF has been used in ultrapure water systems for over 25 years because it is superior to materials such as stainless steel or PVC. PVDF combines excellent surface finish with low extractables to provide the highest quality piping material for the application. In addition to its purity attributes, PVDF is also available in a variety of components and welding methods that are well-suited for UPW applications. PVDF is a crystalline material that can withstand high pressures. However, the nature of PVDF requires special planning and handling during the installation. These types of requirements are now commonplace on the market and are accepted as standard operating methods. PVDF is recommended for the service of the strictest applications that require low bacteria counts and virtually undetectable levels of metal ions.

For applications less stringent in water quality level, polypropylene is an excellent alternative. PP offers excellent surface smoothness, as well as low extractable levels as compared to stainless steel. Polypropylene systems are thermally fused together, eliminating the use of glues, which will continue to leach into a water system for extended periods of time. PP is an extremely weldable material, making fusion joints simple and reliable. For more information on PP, consult Section B.

The third alternative is E-CTFE. This material, also known as Halar®, provides superior surface even compared to PVDF. Its extraction levels are also similar to those of PVDF. Halar® is a very ductile material, making its use and welding methods extremely reliable. E-CTFE is normally only available in certain sizes and does have some pressure limitations at higher temperature. Halar® has become the preferred material for tank lining applications.

Operating Parameters

Because thermoplastic systems have varying ratings at different temperatures, it is important to design a system around all of the parameters to which it will be subjected. As a first pass, verify the following operating parameters:

- Continuous operating temperature
- Continuous operating pressure
- Media and concentration

By knowing the above parameters, thermoplastic pipe systems can be selected. Compare the actual conditions to the allowable ratings of the material being selected for the job. It is important to predict elevated temperatures, as thermoplastics have reduced pressure ratings at higher temperatures. Valves should be verified separately from a piping system in terms of temperature and pressure, as certain styles and brands of valves have lower ratings than the pipe system. Finally, if the media is not water, a chemical compatibility check should be conducted with the manufacturer.

After verifying the standard operating conditions, it is necessary to examine other operations that might affect the piping. The following is a sample of items to investigate prior to specifying a material.

- Will there be spikes in temperature or pressure?
- Is there a cleaning operation that the piping will be exposed to?

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- If yes, what is the cleaning agent? What temperature will the cleaning be conducted at?
- Will the system be exposed to sunlight or other sources of UV?

Each of the above questions should be answered, and the desired material should be checked for suitability based on the above factors, as well as any others that might be unique to the system in question.

System Sizing

It is well-known that high purity water systems are designed to operate in a continuously flowing loop to prevent stagnant water in the system. Stagnant water can proliferate the growth of bacteria and bio-film. The pattern and design of the loop will vary depending on the facility requirements.

The flow rate in the system is important for determining the pipe diameter size. In a pure water system, elevating flow velocities is recommended to reduce the possibility of bioadhesion to the pipe wall or welded surfaces.

Many specifications will state that the flow should be set at a minimum of five feet per second, which will always be a turbulent flow at this velocity. However, a more sensible approach may be to review the Reynolds Number of the system to ensure that the flow is turbulent. Use of the Reynolds Number may reduce waste caused by the oversizing of pumps to overcome excessive pressure drops due to unnecessarily high velocities.

Because many HP systems are now produced from high-quality Purad® PVDF, high velocities in a continuously flowing system may not be as necessary. High velocities are generally accomplished by undersizing the pipe diameter, which is directly proportional to increased pressure drops. In fact, high minimum velocities are detrimental to the ability of a system to deliver adequate point-of-use pressure during peak demand conditions. Therefore, using cleaner, smoother material such as PVDF is desirable for design and operation.

Sizing Laterals

A pure water system and an ultra pure water system will be made of main loop branches known as laterals. It is important in design to not dead-end laterals and ensure there is always flow movement in the main and in the lateral. Systems are designed with different loop configurations to accommodate the needs of production. However, all laterals must be designed for continuous flow and should feed unused water back into the return line.

For supply laterals feeding multiple tools, the lateral needs to be sized based on an acceptable pressure drop. A general rule of thumb is two psig per 100 feet. Consideration of point-of-use water consumption, length, and frequency of demand must be factored into the sizing process of the lateral.

Sizing Mains

Main trunk lines are sized using the demand for water by the tools plus the tool and return lateral minimum flows. Tool demand can be calculated by taking the average flow demand and multiplying it by 1.2 to 1.8 to accommodate for peak demand. This should be based on the tool manufacturer's parameters.

The return lines should be sized for minimal pressure drop when the tool demand is at a minimum, which will correspond to maximum bypass at the end of a main pressure control station.

Thermal Expansion

Typically, Purad® and PolyPure® systems are designed for ambient or cold DI water. In these cases, because the systems operate continuously and are normally inside a fairly constant temperature building, the need to compensate for thermal expansion is not required. Although, it is an important factor that should be reviewed on each and every installation design.

Hot DI systems that normally operate at temperatures of 150°F to 248°F (65°C to 120°C), depending on the water usage, require a more complex design. PVDF systems can be used in hot water applications and applications where the temperature is cyclical. These systems require analysis of the thermal expansion effects. In most cases, the use of expansions, offsets, and proper hanging techniques is all that is required to ensure a proper design.

Hot DI systems also reduce the rigidity of thermoplastic piping systems, which, in turn, decreases the support spacing between pipe hangers. In smaller dimensions, it is recommended to use continuous support made of some type of channel or split plastic pipe.

Finally, the use of hangers as guides and anchors becomes important. Certain hangers should be used as guides to allow the pipe to move back and forth in-line, while other hangers should be anchoring locations used to direct the expansion into the compensating device. The anchors and hangers should be designed to withstand the end load generated by the thermal expansion.

Minimize Dead-Legs

The term dead-leg refers to a stagnant zone of water in the system. Dead-legs are normally formed in the branch of a tee that is closed off with a valve. See Figure F-1.

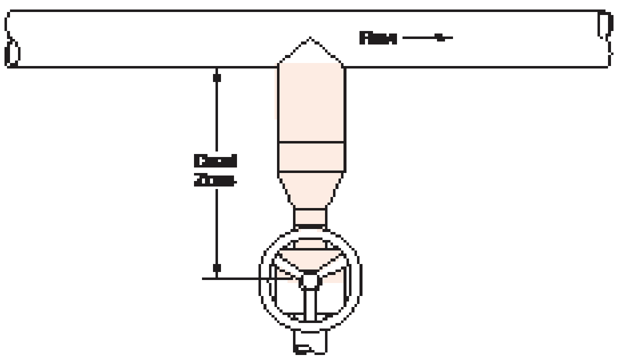

Figure F-1. Dead-legs due to poor design

A rule of thumb in designing a system is to keep all dead-legs to a maximum of six internal pipe diameters in length. The turbulent flow in the main trunk line will create a significant amount of movement to keep the leg moving and prevent bacteria from adhering to the pipe wall. However, the Purad® system allows designers to avoid dead-legs altogether with the advent of T-diaphragm valves and zero dead-leg fittings.

T-valves (see Figure F-2) take the place of a tee, reducer, and diaphragm valve by combining all three into one component. T-valves reduce the quantity of welds in a system as well. By using a T-valve, branch lines can be shut off at any time without creating a dead leg and turned back on without an extensive flush procedure.

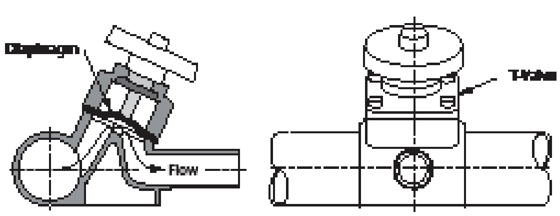

Figure F-2. T-valve eliminates dead-leg

Dead legs in a system can be found in more than just branch lines. Often, the introduction of a gauge, measurement device, and/or sampling valve can create a dead leg. Because it is not recommended to tap into the side of a PVDF pipe for safety reasons, gauges are installed using tees and caps, as shown in Figure F-3.

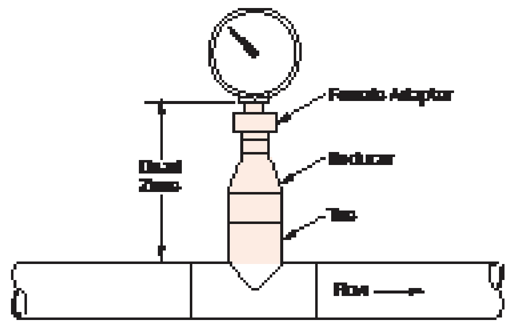

Figure F-3. Dead-leg due to improper instrument installation

Because these tee configurations are narrow in diameter, they create a dead-leg in the branch where microorganism growth can be initiated. The use of instrumentation fittings eliminates dead legs while acting as a safe adapter for gauges or sample valves. See Figure F-4.

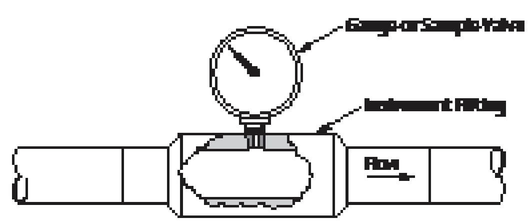

Figure F-4. Proper use of instrument fitting to avoid dead space. Can be used with gauge guard.

The insertion of a resistivity probe can also be a possible source for dead legs. Because most probe manufacturers recommend that fluid flows directly at the probe, they are often situated in the leg of a tee, and the tee acts as a 90° elbow. Because most probes are supplied as a 3/4” NPT fitting or sanitary adapter, there is the necessity to weld reducers onto the tee leg to accommodate the sensor, which will create a dead zone. A simple fitting, the probe adapter conveniently eliminates the need for reducers and shortens the leg of the tee. See Figure D-5. Probe adapters are available in

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all sizes and pressure ratings.

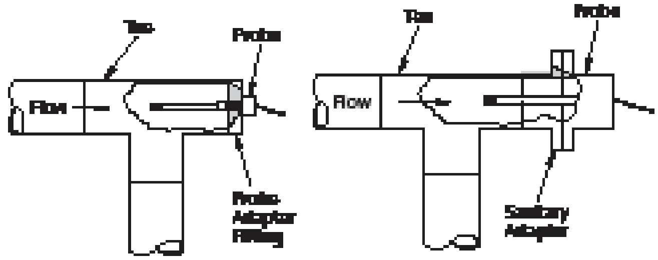

Figure F-5. Proper adapter setups

High Purity Installation

Installing a high purity system properly requires preplanning. The installation is more than the welding of components. It requires the proper environment, material inventory, welding equipment, tools, and thorough training.

General rules on installation

- The quality level of the materials should be maintained from delivery to the finished project.
- No smoking or eating is allowed during working time.
- There should be incoming control of material and marking of quality level according to the user's standards of marking and labeling.
- Do not touch the inner surface of any kind of pipe component, not even in gloves.

Welding environment

Asahi/America does not set requirements for proper welding environments. As the installer, it is necessary to choose the environment based on the installation type, timing, or quality goal. In all cases, the environment for welding should be monitored to ensure that the temperature is in the range of 41°F to 105°F (5°C to 40°C). The humidity should not exceed 70 percent. If using IR fusion, wind must be avoided.

All Purad® , PP-Pure® , and PolyPure® components are manufactured and packaged in a clean room environment. Great care is taken to ensure that they arrive on the project site in protective packaging to maintain their purity. To be consistent, it is ideal to conduct welds in a clean or clean room environment. Particles, dust, or dirt in the air will adhere to the pipe during the welding process. To reduce contamination in the system, as many welds as possible should be conducted in a clean environment. A class ISO 5 or ISO 6 room is perfectly suitable. Portable style clean rooms make for an efficient set-up when conducting all of the welds on site.

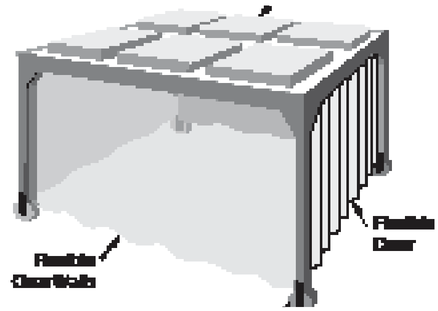

Figure F-6. Portable cleanroom

Within the clean zone, it is recommended to build spool pieces. The size and configuration is dependent on the ability to safely transport it to its final destination. The ends of the spool pieces should be prepared for final connection once in the pipe rack. In smaller dimensions, OD 20mm to OD 63mm (1/2"–2"), the ends should be fitted with unions or sanitary fittings to reduce welds in the pipe rack, as they are more difficult.

In sizes larger than OD 63mm (2"), it is recommended to build spool pieces with flange connections. Doing this avoids having to conduct difficult fusion welds in tight locations. Flanged spool pieces also offer the benefit of being able to make changes later.

If welding in a clean room or clean environment, remove the outer bag in a staging area, and store the fitting inside the clean room in the single bag until ready for use. It is recommended to store the fittings in plastic bins within the clean room instead of using a cardboard box within a clean environment. Label bins by size and fitting style.

PolyPure® fittings should be left in their bag and brought into the clean zone as is. If for some reason the outside of the bag is contaminated, it should be wiped down with IPA prior to entering the clean zone. Valves should be handled in the same manner.

When ready to transport the pipe into the clean zone, open the outer cap on the HDPE protection tube of the PVDF UHP pipes. Place the tube next to the clean zone entry, and slide the pipe directly from the tube into the clean room. This will eliminate the need to wipe down the bag prior to entry. In the clean room, remove the single bag if ready for immediate usage. If stored in the clean environment, it is preferred to leave the pipe in its original packaging.

Place the double bagged PP-Pure® pipe next to the clean zone entry. Open the second bag, and slide the single bagged pipe into the clean room. Remove the single bag if ready for immediate usage.

PolyPure® pipes can remain in their shipping packaging until ready for use or transported into the fabrication clean room.

When ready for welding, remove all packaging and caps. Remember to save the caps for sealing the ends of prefabricated spool pieces.

Training

An ultra pure water or chemical system is a critical utility within a plant's operation. An unplanned shutdown can prove to be more costly than the water piping construction itself. One bad weld can cause hours of repair and frustration, as well as significant loss of revenue. For these reasons, it is critical to receive training at the time of job start-up and to use certified personnel throughout the course of a project. Tool operation is only one of several factors in a thorough training course. Operators, inspectors, and managers need to understand the physical nature of the material: how to properly handle it, how to inspect welds, how to identify potential problems, how to properly maintain equipment, and finally, how best to tie into a line and test it.

All of the above topics are discussed during AGRU's certified training sessions. For the installation of a high-purity system, the following training sessions are available:

- Tool operator training and certification
- Quality control inspection

INDUSTRIAL

Single Wall Chemical Pipe System Design

When properly designing a single wall pipe system for the transport of chemicals, several factors need to be reviewed.

A properly designed thermoplastic system will provide years of reliable service without the headaches of corrosion problems.

At the time of design, consider and plan for the following items:
- Materials of construction
- Thermal expansion
- System sizing
- UV considerations
- Insulation
- Hanging
- Welding methods

Materials of Construction

The first and foremost item in any system design (metal or thermoplastic) is the media that will be running through the pipes and parameters of operation. Using accurate data for the system design will transfer to years of reliable operation. When considering the system design, answer the following questions:

- What is/are the chemical(s) to be in contact with the system?
- What are the chemical concentrations?
- What temperature will the system operate at?
- What pressure will the system operate at?
- What is the flow of the media in the system?

By answering these questions, the proper material of construction can be selected for the project. To assist in the material selection, refer to the chemical resistance tables on our web site. A thermoplastic system's ratings for temperature and pressure are based on water. The addition of certain chemicals will add stress to the system and may reduce the recommended operating parameters. For less aggressive chemicals, the resistance tables on our web site are perfectly suitable. For more aggressive chemicals or mixtures of chemicals, the manufacturer of the pipe system should be consulted.

After verifying the standard operating conditions, it is necessary to examine other operations that might affect the piping. The following is a sample of items to investigate prior to specifying a material.

- Will there be spikes in temperature or pressure?
- Is there a cleaning operation that the piping will be exposed to?
- If yes, what is the cleaning agent? What temperature will the cleaning be conducted at?
- Will the system be exposed to sunlight or other

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