# Solar Decathlon Plumbing Subsystem
# Final Design Report


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# Executive Summary

The U.S. Department of Energy announced it will be hosting an international public competition called the Solar Decathlon in Irvine, CA during October 2015 to showcase high-efficiency houses. Cal Poly students created a team – Solar Cal Poly – to participate. Three mechanical engineering students joined the team to work on the plumbing section of the competition. The team completed multiple iterations and designs of the plumbing system within the Solar Cal Poly house as the house was designed and redesigned. The construction and final design of the plumbing system will be decided by the construction crew and architecture team within Solar Cal Poly. The mechanical engineering design was selected with the intent to satisfy architecture design needs. There are cold and hot water PEX supply systems, a code-compliant sprinkler system, and black and grey ABS waste systems designed for easy hookup after transport to Irvine, CA.

In addition to architectural design needs, structural integrity, ease of assembly, safety, durability, head loss, building code, and integration with other systems were all considered in the design of the system. Of particular importance was integration with the Solar Cal Poly water systems team. This team dictated use of the grey water captured by the plumbing system, and directly coordinated supply conditions and requirements with our team. A black-grey connection valve was designed for the plumbing system to easily divert water away from water systems as necessary. Sewage pumps were designed into the system to allow flow into grey water and septic tanks above grade.

The entire system was designed for easy on-site hook up. To prevent need to travel underneath the house during competition, all hook-ups were designed along the edge of the house, to connect to pre-laid plumbing connections. Tanks were placed for easy access on-site. Plumbing supply lines and sprinkler lines were analyzed to ensure they will supply adequate pressure and volume.

The following report details the design, build, test, and report process that the plumbing team underwent to design the Solar Cal Poly plumbing system.

# Chapter 1: Introduction

## Sponsor Needs and Background

The U.S. Department of Energy, one of the leading national organizations in energy conservation, wants to increase public interest in high-efficiency building technologies. The D.O.E. has announced it will be hosting an international public competition in Irvine, CA in October 2015 to showcase high-efficiency houses. This competition is called the Solar Decathlon competition. Cal Poly students have created a team – Solar Cal Poly – to participate. Solar Cal Poly will design, build, and operate a small zero-energy house at competition. The house will be open to the public, and Solar Cal Poly will be responsible for showcasing and maintaining the house for duration of the week of competition. After the competition, the house will be stored on Cal Poly's campus until it is sold to a homeowner for residential use.

## Problem Definition

The purpose of this project is to design and produce a working plumbing system for the Solar Cal Poly house within the limits of Department of Energy competition rules and restrictions. The plumbing system must supply comfortable and reliable amounts of cold and hot water for the competition and future buyer of the house post-competition. The system will also dispose of liquid waste, differentiating between gray and black waste for reuse and disposal, respectively. Complete design and construction documentation of the system will be completed and provided to Solar Cal Poly for submittal to the D.O.E. Testing and system analysis and simulation will help ensure functionality and efficiency of the design.

## Objective and Specifications

The overall goal of this project is to create a functional, reliable, and efficient plumbing system that can easily integrate into the Solar Cal Poly house design. The QFD (Quality Function Deployment) lists customer requirements, as well as engineering requirements that will be tested upon construction of our final design. The QFD can be found in Appendix A.

First, customer requirements were assigned weighted values in reference to importance to Solar Cal Poly, the Department of Energy, and potential post-competition buyers. Then, values were assigned based on the strength of the relationship of the customer requirements to the engineering requirements. These values were used to determine important tests needed upon construction of our system design. Other existing plumbing materials and systems were also considered with reference to engineering requirements within the QFD. These existing products assisted in creating a baseline for system performance. Finally, the Decision Matrix in Appendix A shows correlation of each engineering requirement to other requirements.

This allowed us to determine related requirements and consider removing requirements with conditions fulfilled with other requirements. Table 1 lists specifications and targets for this project determined based on the results of the QFD.

**Table 1.** Solar Cal Poly Plumbing Formal Engineering Specifications

| Spec. # | Parameter Description | Requirements or Target | Tolerance | Risk | Compliance |
|---|---|---|---|---|---|
| 1 | Pipe Head Loss | 20% | Max. | L | A |
| 2 | Pipe Flexibility | Hand bending w/o kinking | Min. | M | A,T,S |
| 3 | Centralized | Main controls in core room | Min. | M | A,S,I |
| 4 | Years Life | 80 | Min. | L | S |
| 5 | Durability/ Strength | Code requirements | Min. | M | A,S |
| 6 | Seal Quality | No Leaks | Min. | H | T,I |
| 7 | Corrosion Resistance | No serious degradation after 20 years | Min. | L | S |
| 8 | Temperature Effects | No system degradation/ other concerns | Min. | M | S |
| 9 | Common Usage | 80% of plumbers familiar with system | Min. | L | T,S |
| 10 | Power Economy | No sharp bends in supply | Min. | M | A,T |
| 11 | Earthquake Safety | No catastrophic failure after magnitude 6.0 earthquake | Min. | M | A,I |
| 12 | Weight | reasonable human carrying load | Max | L | A,T |
| 13 | Number of Parts | minimum number of parts | Max | M | A |

Each specification is associated with a target goal, a minimum or maximum tolerance, a risk level, and a compliance. The target goal is the intended quantitative or qualitative limit of the design. The tolerance states whether the target goal is a minimum or maximum limit. The risk level assesses the importance of each specification to the design. The compliance lists possible types of tests to ensure each specification has been appropriately met.

Some additional details of the projects specifications are as follows:

- Controls of system should be centralized and accessible in the core mechanical room to allow for easy access, organization, and display to the public.
- System should appeal to many different house owners and markets to relate to the public and any potential buyers.
- Economic feasibility should be considered to provide a realistic system that Solar Cal Poly will be able to afford and that the D.O.E. will be able to market to the public.
- Documentation should be standardized to match previous D.O.E. competition documentation, allowing competition judges, public, etc… to comprehend the plumbing system easily and quickly.

- High efficiency plumbing is more difficult to implement in plumbing systems compared to other building technologies, but should be considered as a significant concept within a zero-energy house
- High reliability plumbing is important in any house. Plumbing is an essential system for house functionality, and failure is non-optional.
- Plumbing system will comply with three different building code/regulation standards: D.O.E., International Residential, and state of California building code law.
- System should be easy to assemble and maintain. Students associated with Solar Cal Poly will be building the majority of the system, and will not have knowledge of complex soldering techniques.
- Pipe and pump noise should be at or below audible levels if possible, as to not interfere with living conditions or public opinion of the house
- System should incorporate elements of environmental sustainability. Sustainability is an important consideration in the theme of Solar Cal Poly's house design. The plumbing system should also reflect this design whenever possible.

## Project Management Plan

We will continue to collaborate closely with other mechanical engineering, architectural engineering, and architectural teams to effectively design, document, and build the plumbing systems. We will fully assist and help them as necessary to understand the plumbing system we have designed.

Our team meets many times each week in order to manage and foster teamwork. We currently meet Tuesdays and Thursdays 8:00 a.m. - 11:00 a.m. for mechanical engineering team meetings. Additionally, all Solar Cal Poly teams (mechanical engineering, architecture, architectural engineering, etc...) meet Sundays. Other meetings occur throughout the quarter as necessary, such as a recent meeting between our plumbing team and architectural engineering structural team.

Our plumbing team has worked hard in order to create a passionate, supportive, fun, and helpful environment. In most cases, each individual is free to follow their passion as work items arise. In the case that there an individual is not completing adequate work, the other remaining plumbing members will discuss their concerns, and ask for more commitment from the individual. We have yet to encounter this issue. A detailed timeline can be found in the Gantt chart in Appendix F.

The following (Table 2) is a summary of individual team member responsibilities.

**Table 2.** Team Member Responsibilities

| Team Member | Task |
|---|---|
| General | Allow individuals to complete tasks they are passionate about<br>Advise and ask for further commitment if needed |
| Chris | **Meeting Coordinator** |
| | send out group texts to inform and for meeting time confirmation |
| | **Piping and Instrumentation Diagrams Lead** |
| | work to put together piping and instrumentation diagrams similar to those published by Czech Technical University and University of Vienna |
| Rob | **Documentation Management** |
| | Store, scan, print, and distribute paperwork as necessary |
| | **Plumbing Code Lead** |
| | research code, specifications of piping/parts, design plumbing systems to meet code |
| Tyler | **Treasurer** |
| | complete financial documentation as necessary |
| | **Revit Lead** |
| | build 3-D models of the plumbing system designs<br>carry out simulations, simulation analysis, and verification |

# Chapter 2: Background

Our first consideration when conducting research for Solar Decathlon plumbing design was to note systems that were previously designed by other teams. Each previous team that has participated in the Solar Decathlon has designed, built, and tested their own plumbing system. There are three teams that we chose to research. These teams competed in 2013 under the names Czech Technical University, Team Austria (Vienna University of Technology), and Team Las Vegas (University of Nevada, Las Vegas). All three of the teams placed highly in the Department of Energy Solar Decathlon engineering contest. Additionally, the house design of Team Las Vegas shares similarities to the Solar Cal Poly house design.

First, we considered the Czech Technical University plumbing design. They provided many detailed schematics, including fire detection and alarm, fire suppression plan, plumbing symbols and notes, domestic water supply plan, domestic waste plan, domestic water supply diagram, and domestic waste diagram. The domestic water supply diagram and domestic waste diagram are both piping and instrumentation diagrams, while the other schematics (other than plumbing symbols and notes) are drawn relative to the floor plan. Czech Technical University decided to use a whole-house manifold system (further detailed under Background > Pipe Layout), with ¾" PEX for both hot and cold supply lines, each running into a separate manifold. There are individual ½" PEX sub-lines that then run to each appliance as necessary. Waste is carried separately from gray water and black water appliances through two separate plastic piping (high temperature resistant) lines to a gray water and septic tank, respectively. There is a connection point underneath the house to divert gray water into the septic tank as needed. Fire protection systems are integrated into the house using an independent water tank and pump, separate from the potable water supply line. Sprinkler heads are designed to trigger automatically, and cover most of the living area other than toilet and exterior porch. CPVC piping lines are used to supply water to the fire sprinklers.

Next, we reviewed the Team Austria plumbing design. Team Austria provided schematics of domestic supply, domestic return (waste), plumbing sections, fire detection and alarm, sprinkler coverage plan, and fire protection piping. However, both the schematics and the project manual provided by Team Austria are vague. While the supply diagrams seem to indicate a straight, trunk and branch type piping system design (further detailed under Background > Pipe Layout), Team Austria only identifies piping as "domestic water piping" or "sanitary waste and vent piping". The septic, gray water, and potable water tanks are all located underneath the deck. Team Austria uses a waste pipe running from the gray water tank to the septic tank to divert gray water as needed. Fire protection uses water from the potable water tanks, and eight sprinklers located throughout the house provide coverage to the majority of the floor space. Unfortunately, Team Austria does not provide more detailed plumbing design.

Finally, we analyzed the Team Las Vegas plumbing design. The design included the same detailed schematics as Czech Technical University. Additionally, Team Las Vegas included piping elevations for the mechanical room. Team Las Vegas used a trunk and branch layout (further detailed under Background > Pipe Layout) for their house with 1" PEX piping main lines and ½" PEX piping appliance lines for both the hot water and cold water supply. The return lines alternate between 3" and 2" PVC depending on the connected appliance. All the vents are 2" and the common gray water line for the bathroom area is 3" running into the gray water storage tanks. There was no noticeable way to divert

gray water to the septic tank. The fire protection system has 1" lines and sprinklers dispersed throughout the house to effectively suppress fires.

Overall, each team had their own separate design, with some similar elements between all three. All teams had relatively similar waste systems, using plastic piping such as PVC or ABS. PEX was commonly used in supply lines, with larger main lines, and smaller individual appliance lines. Schematics were also relatively similar, with supply, waste, fire detection and alarm, sprinkler coverage plan, and fire protection piping provided by all teams. Team schematics for Team Austria, Czech Technical University, and Team Las Vegas, respectively, can be found in Appendix G.

## Pipe Layout

There are four different systems used in piping layout[1] (Figure 1). These layouts are called the trunk and branch system, the core system, the whole-house manifold system, and the demand-initiated recirculation system. Each has advantages and disadvantages. The trunk and branch system has one long, large pipe that runs from the water heater to the farthest fixture in the house, with smaller, individual fixture pipes that run from the trunk to appliances. This system is very common and usually is most efficient in smaller homes. The core system is similar to the trunk and branch system, but requires plumbing areas to be placed near the hot water heater, as a core unit. This improves the efficiency of the trunk and branch system, but is very dependent on the house layout. A whole-house manifold system runs appliance piping from a central core splitter, or manifold, to many different appliances. This can decrease efficiency and is most useful on larger homes. However, because each appliance has a less water will need to be moved through the line. These manifold systems often utilize PEX piping, taking advantage of its flexibility, thus reducing the amount of fittings required in the system. Finally, demand-initiated recirculation systems circulate water as needed in order to provide hot water faster. This can reduce water waste and save time. However it also decreases efficiency, as the energy used to heat the water is constantly being lost to the local environment.

[1] Us Environmental Protection Agency Watersense Program. "Guide for Efficient Hot Water Delivery Systems." *WaterSense® New Home Specification Guide for Efficient Hot Water Delivery Systems, Version 1.2* (n.d.): n. pag. *Http://www.epa.gov/watersense/*. WaterSense®. Web. <http://www.epa.gov/watersense/docs/hw_distribution_guide.pdf>.

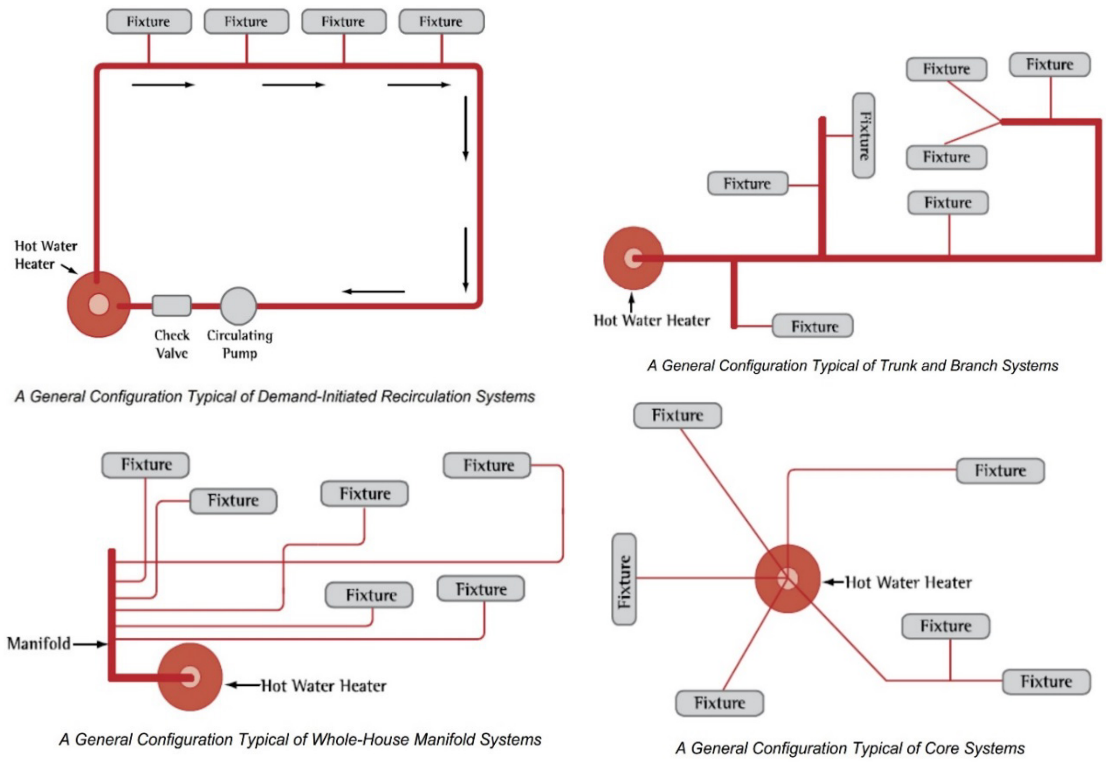



**Figure 1.** Common Piping Layout Designs

A trunk and branch system uses less pipe than a manifold system but because the trunk line size is larger, more water will need to be moved for hot water to reach an appliance. This larger pipe size also requires a more powerful pump to pressurize the water column, which in turn raises the cost of the system.

## Pipe Material Selection

One of the defining aspects of a plumbing design is the selection of piping material. There are several different types to choose from, each with their own distinct pros and cons. The team devoted time to carefully select the most effective materials for the correct design specifications. The materials researched are listed in Appendix A and in Table 3.

**Table 3.** Pipe Material Pros and Cons

| Material | Pros | Cons |
|---|---|---|
| PVC (Polyvinyl Chloride Pipe) | • Used to transport high pressure water<br>• Size ranges from ½ inch to 4 inch diameter<br>• Low cost<br>• Glue connections<br>• Corrosion resistant<br>• Strong | • Can only transport cold water (< 140 °F[1]) |
| CPVC (Chlorinated Polyvinyl Chloride Pipe) | • More flexible and thinner than PVC<br>• Moderate cost<br>• Handles both hot and cold water<br>• Small outer diameter (equal to copper pipe)<br>• Glue connections<br>• Corrosion resistant<br>• Strong | • More expensive than PEX |
| PEX (Polyethylene Pipe) | • Higher heat resistance than most other plumbing pipe<br>• Flexible and easy to assemble<br>• Often used in water based heating systems<br>• Moderate cost<br>• White, blue and red colors available<br>• Higher flexibility leads to less required fixtures<br>   ○ Lower minor head loss | • More expensive than PVC |
| Copper | • Most common type of piping used in residential homes<br>• High resistance to corrosion and high temperature<br>• Long life<br>• Come in rigid and flexible subtypes | • More expensive than plastic piping (PEX, PVC, CPVC)<br>• Most difficult assembly, requiring soldered fittings |
| Stainless Steel | • Long life (50 years)<br>• Highly resistant to corrosion, temperature and salt water | • Most expensive material |
| ABS (Acrylonitrile butadiene styrene) | • Used in drain-waste-vent pipe systems and sewer systems<br>• Highly durable with high impact strength<br>• Higher impact strength than PVC | • Can deform under direct sunlight |

## Line Sizing

The website[2] by plumbing basics was used as a general resource in the design and sizing of our plumbing lines. Especially that of the return system and the main trunk of the trunk and branch system. There were two useful tables which provided useful information for the sizing of the return piping. The tables

[2] "Plumbing." . *Learn How to Do the Plumbing Yourself and save Money*. N.p., n.d. Web. 13 Nov. 2014. <http://www.plumbing-basics.com/>.

converted plumbing fixtures into units of discharge and table showed the minimum size for the discharge pipe with different unit loads.

## Residential Sprinkler System

The team found that the system had to adhere to the standards and protocols outlined by the National Fire Protection Association (NFPA) Standard for Installation of Sprinkler Systems for One and Two-Family Dwellings and Mobile Homes, NFPA 13D. The Cal Poly Fire Protection Engineering department has generously provided our team with academic use of the NFPA 13D standard. Because of its extreme importance, the residential sprinkler system has to be approved and signed off by a professional engineer (PE) to be satisfy the California Building Code and International Residential Code. Some of the codes expressed by the NFPA 13D standard included the following. See Table 4 below.

**Table 4.** Distance Regulations for Sprinkler Systems

| Sprinkler to Heat source | Minimum Distance | Notes |
|---|---|---|
| Surfaces of ranges and wall ovens | 1'-6" | Lateral distance |
| Edges of Fireplaces | 3'-0" | Lateral distance |
| Front of Fireplaces | 5'-0" | Lateral distance |
| Surfaces of hot air flues<br>Un-insulated heating ducts<br>Un-insulated water pipes | 1'-6" | Lateral distance |
| Edges of a ceiling mounted hot air diffuser | 2'-0" | Lateral distance |

The team found that sprinkler system design is dependent on the type of sprinkler head, piping, and design pressure used. Several styles of pendent and horizontal sidewall sprinkler heads were considered, with the team deciding upon the use of the Concealed Pendent style. This design is completely integrated above the drop ceiling so that only the flat cover plate is visible before deployment. This low visibility was considered an appropriate stylistic choice that fit into the plan set by the architects without sacrificing functionality.

The recommendations of the NFPA 13D were used to correctly size the sprinkler lines, properly position the sprinkler heads. When working with the sprinkler the position is based on the data provided by the Viking Corporation for the Concealed Pendent Sprinkler the VK457 for the coverage of each sprinkler head at various pressures and flow rates. The NFPA 13D has a Prescriptive Pipe sizing calculation the can be used to obtain the maximum distance from the supply source for a line size and type.

The team found that there are three different layouts for fire sprinkler systems: branched, looped, and networked. The branched system is the simplest and utilizes the least amount of piping but also has the highest amount of pressure losses. A looped system has a main loop on which sprinkler head are located or shortly branch off from. The looped system provides better system performance because the water has two flow paths to take to get to the triggered sprinkler head(s). Finally, in a networked system all the sprinkler heads are interconnected with each other. This results in the most hydrodynamically efficient system but also uses the most amount of piping.

# Chapter 3: Design Development

## Design Considerations

Plumbing system design is highly dependent upon the environment and requirements in which the plumbing system is installed. This includes house layout, client preferences, building code, and geography. These requirements have limited the scope and freedom of the plumbing design. As a result, we have used thorough ideation and sketches focused directly on exploring the effectiveness and viability of different sub-sections within the plumbing system design. The sub-sections discussed include supply pipe layout, and piping material, heat recovery system, grey and black waste lines, sprinkler system, and hot water tank design.

### Limiting Requirements

There have been several limiting requirements considered during design development. First, we wanted to develop a system that accounts for house layout. The majority of the outer envelope of the Solar Cal Poly house uses SIP (structurally insulated panel) walls. These walls are filled with insulation and thus unable to accommodate plumbing piping. This meant that we will only be able to run piping through internal walls or through specific, un-SIPed external locations.

Second, we wanted to consider client preferences and requirements. Solar Cal Poly is constructing the Solar Decathlon house in San Luis Obispo, then separating the house into sections, transporting the house to Irvine, and reassembling the house in Irvine in several days. This means that the plumbing system must be easily assembled, disassembled, and reassembled. Solar Cal Poly wants to emphasize overall house design. The architecture team wants a specific layout of the house. This has further limited our plumbing design to fit the architecture team's layout. The water systems team wants to utilize gray water. This means that gray water will have a separate waste pipe.

Third, building code has restrictions on system designs. We are following Department of Energy Solar Decathlon code, California State Building Code, and International Residential Code. Waste piping must be certain sizes, with vents located in certain areas. Certain pipes are not allowed to carry hot water. Certain junctions are not allowed at certain locations. In general, building code is as restrictive as possible. This helps prevent injuries and ensure safe practices. We will meet building code regulations, and work within building codes to develop safe, effective, and efficient plumbing design concepts.

Finally, geography imposes some limits. Both supply pipes will be insulated to prevent freezing. However, freezing is not common enough to require a circulation system. Sunlight is abundant, promoting solar heating and limiting hot water heater design.

### Supply Pipe Layout

We considered and compared several different pipe layout design concepts for plumbing supply piping. First, we worked on creating supply layout ideas and solutions. We considered four different layout options, known as trunk and branch systems, core systems, whole-house manifold systems, and demand-initiated recirculation systems (further detailed under Background > Pipe Layout). After generating these ideas, we immediately screened the ideas to make sure they met our limiting requirements. The core system was eliminated, as it was impossible to implement with the floor layout the client desired. Additionally, the demand-initiated recirculation system does not meet client preferences. Therefore, we were able to eliminate two options through customer requirements and

proceeded to idea selection between the trunk and branch system and the whole-house manifold system.  We used sketches of the trunk and branch and whole-house manifold systems as shown in Figure 2 and Figure 3, respectively, to better visualize and thoroughly define the different ideas.

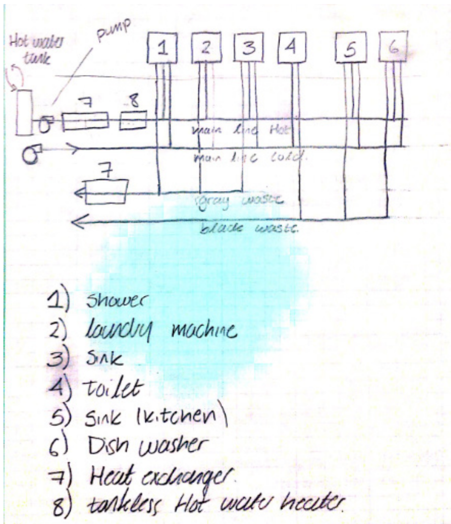



**Figure 2.** Preliminary Trunk and Branch System Design

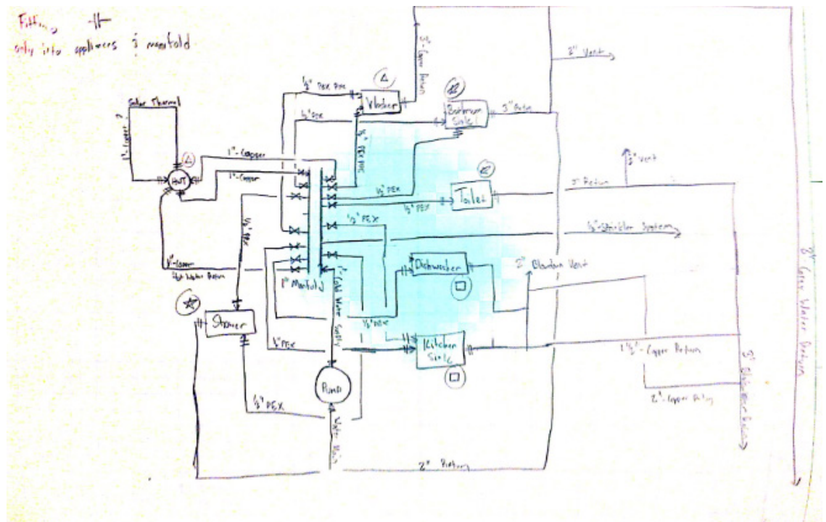



**Figure 3.** Preliminary Whole-House Manifold System Design

The trunk and branch system supplies hot and cold water to appliances through a large, main line.  Smaller hot and cold lines then branch off of this line to respective appliances.  The whole-house manifold system supplies water to a single, main hub (located in the western core in this house) from which smaller hot and cold lines each travel throughout the house to their respective appliances. This design would encompass a double manifold in the mechanical room and then a large network of hot and cold lines to each appliance.

Although research and many examples of similar houses indicate that trunk and branch is a better option for our plumbing design in the Solar Decathlon house, we decided to use additional structured selection techniques with reference to customer requirements and engineering specifications to confirm which system was more appropriate.  Several key customer requirements, as identified in both "Chapter 1: Introduction", sub-section: "Objective and Specifications" and also by the QFD (Appendix A) include cost, ease of assembly (assembly, disassembly, and reassembly), and efficiency.

We compared relative cost of the systems in Table 5[3,4].  Although both systems are relatively cheap, the trunk and branch systems is still cheaper.

[3] "PEX Tubing." *, Plumbing , Aquapex Tubing , PEX Pipe*. N.p., n.d. Web. 18 Nov. 2014. <http://www.supplyhouse.com/PEX-Tubing-516000>.

[4] "Home Improvement Made Easy with New Lower Prices | Improve & Repair." *Home Improvement Made Easy with New Lower Prices | Improve & Repair*. N.p., n.d. Web. 18 Nov. 2014. <http://www.homedepot.com/>.

**Table 5.** Price Comparison between Trunk and Branch and Whole-House Manifold systems

| **System Type** | 1/2" Pex (ft) | ($/ft) [1] | 3/4" Pex (ft) | ($/ft) [2] | 1" Pex (ft) | $/ft [2] | Total ($) |
|---|---|---|---|---|---|---|---|
| Trunk & Branch 3/4" | 49 | 0.36 | 37 | **0.61** | 0 | 1.24 | 40.32 |
| Trunk & Branch 1" | 67 | 0.36 | 0 | **0.61** | 37 | 1.24 | 70.00 |
| Manifold | 384 | 0.36 | 0 | **0.61** | **0.00** | 1.24 | 138.24 |

Additionally, the sketches shown in figure 2 and figure 3 indicate that complexity, number of parts, and overall weight of the trunk and branch system is lower, indicating that the trunk and branch system will be easier to assemble and disassemble. Finally, the amount of piping, length of pipes, and layout of the two designs indicates that the whole-house manifold system would be less efficient than the trunk and branch system in the Solar Cal Poly house. These specifications are quantified into a decision matrix in Table 6.

**Table 6.** Pipe layout decision matrix (high values indicate better fulfillment of requirement)

| Applicable Engineering / Customer Specifications | Trunk and Branch | Whole-House Manifold |
|---|---|---|
| Weight | 3 | 1 |
| Number of Parts | 4 | 2 |
| Complexity | 4 | 1 |
| Cost | 4 | 2 |
| Efficiency | 3 | 4 |
| Total | **18** | 10 |

The trunk and branch system is more effective in several ways. It limits the amount of required supply piping, allowing for easy assembly and increased efficiency. This also makes the system less invasive towards other teams, by organizing and consolidating the system. It lowered the cost of the system that would have been generated by more PEX piping and larger complex manifolds. The cost analysis generated by the team can be seen in Table 5 above.

## Piping Material

Piping material is very important to our plumbing system design. It affects customer requirements (ease of assembly, efficiency), engineering specifications (strength, reliability), and building code (allowable pipe materials for waste, hot water). In order to determine what materials we would use, we first used ideation to list different materials, and the pros and cons of using each one. This process is shown in chart form in Appendix A. We then proceeded use the QFD, as shown in Appendix A as a structured selection technique to select the best piping material, based on the customer requirements and engineering specifications. For greater reference detail, please refer to the QFD in Appendix A.

Using structured QFD selection, PEX piping was selected for use in the hot and cold supply lines. PEX's maneuverability and relative cheapness were superior to other options. In addition, PEX's ability to deal with a range of water temperature and simple installation helps facilitate its use in residential settings.

ABS plastic was selected for use in the waste lines. ABS is very commonly used in waste lines. It was chosen because of its cheapness, reliability, ease of assembly, and ability to deal with temperature. ABS also has a better impact strength than PVC. ABS can deform under direct sunlight; however, because the ABS waste lines are contained below the house, this risk is minimal.

## Heat Recovery System

After research and consideration of various shower, HVAC, and other related heat recovery systems, it was determined that a heat recovery system wasn't practical for the Solar Cal Poly house. The lack of large quantities of gray water that could be used for heat exchange, and the presence of a solar hot water heater, which would already provide nearly all of the house's hot water needs were both major factors in this decision. A heat recovery system will not provide enough benefits to meet client requirements.

## Gray and Black Waste Lines

There are several limiting coding specifications for gray and black waste piping. The slope required for horizontal waste lines depends on its diameter. Horizontal waste lines 3 inches in diameter or less require a slope of ¼ inches per horizontal foot. Waste lines that are 4 inches in diameter or larger only require a slope of ⅛ inch per horizontal foot[5], but are usually avoided and often require approval for use. As clearance below the house was an important factor in the design of the waste lines, we considered the viability of using wider, 4 inch waste piping for the horizontal section of the waste lines. When analyzing the details of the house layout provided by Solar Cal Poly, we determined that the black line will travel a horizontal distance of 34.40 feet. With 3 inch piping requiring ¼ inch per foot grade, this distance produced a minimum vertical drop of 8.60 inches. With 4 inch piping requiring ⅛ inch per foot grade, the distance produced a minimum vertical drop of 4.30 inches.

[5] "CALIFORNIA PLUMBING CODE." *CALIFORNIA PLUMBING CODE* (n.d.): n. pag. *CALIFORNIA PLUMBING CODE*. Sanbruno.ca.gov. Web. <http://sanbruno.ca.gov/comdev_images/california_plumbing_code.pdf>.

The vertical clearance between the bottom of the floor joists and the asphalt grade of the Irvine public competition is limited to 11.5 inches. As seen in Figure 4, the distance between the top of the floor and the pavement is 20 inches. Because the structure of the floor is 8.5 inches thick, it leaves the plumbing a distance of 11.5 inches of space to work with. This means that all pipe specifications in the plumbing gray and black waste designs, including p-traps, junctions, vertical grade requirements, and real diameter would need to fit within 11.5 inches of clearance.  Additionally, after reaching the mechanical room, the waste will still need a minimum of 15 inches of clearance to drain into the septic tank located on the left of the property. Therefore, neither piping diameter will match the problem. A waste pumping system will be needed.

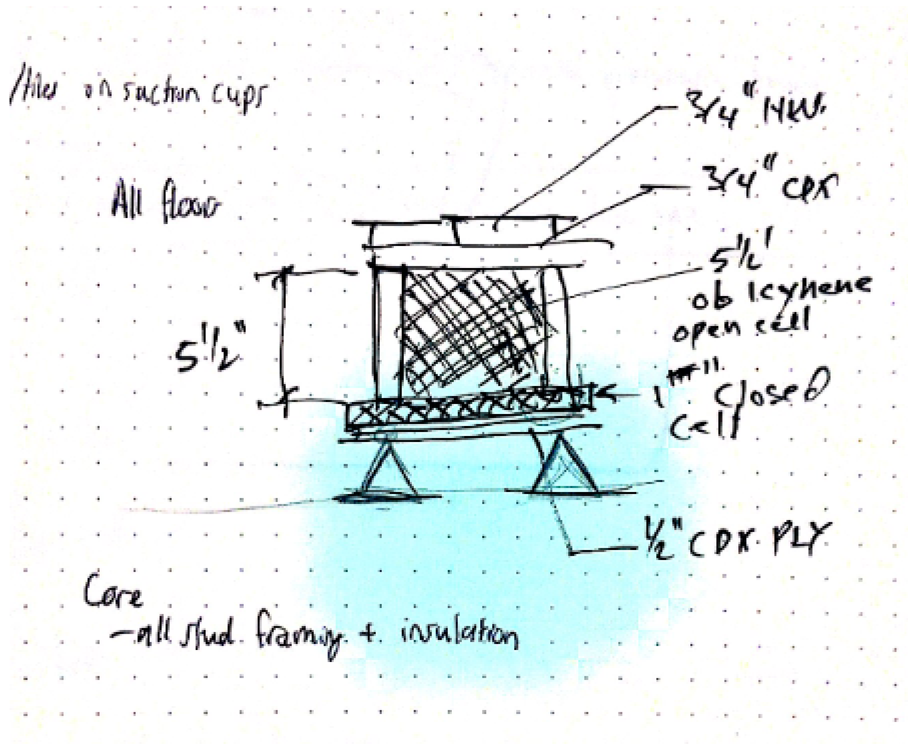



**Figure 4.** Schematic of Floor Structure of House

We decided to use a black and gray waste line of 3 inches, with a drop of ¼ inches per 1 foot. This decision was made to negate risk of special documentation, required approval, or criticism from the Department of Energy for using a non-standard 4 inch waste line.

The required waste pump will be located below the porch. It is a Saniflo brand[6], and Saniswift model type pump.  It will provide increased versatility and freedom during the construction and operation of the Solar Cal Poly house.

The gray line travels a much shorter distance, as it does not begin in the kitchen. Instead it starts in the bathroom, travels a much shorter distance and exits through the southern side of the core and makes its

[6] "Saniflo SaniSWIFT | Gray Water Pump." *Saniflo Depot*. Saniflo, n.d. Web. 5 Nov. 2014. <http://www.saniflodepot.com/products/saniflo-saniswift-gray-water-pump>.

way to the gray water constructed wetlands. The gray line is 3 inches in diameter and made of ABS plastic like the black line.

## Plumbing Design Iterations

Despite the team's approach to the design process, there were three design iterations that occurred over the course of the design process. At first, we spec'd out a simple trunk and branch system. Next, the design improved and detailed as materials, diameters, and preliminary dimensions were specified. This was mostly limited by client requirements and build code limiting requirements.  The second design iteration can be viewed as sketches in Appendix A.

Finally, we transferred our design into Revit.  The most current design iteration is shown in the Revit documents in Appendix B. The hot supply is shown in red, while the cold supply is shown in blue. Both the black and gray waste lines are shown in green. The sprinkler system is shown in black.

The final design selected is a trunk and branch system with smaller manifolds located below the bathroom and kitchen to supply hot and cold water to appliances. The trunk supply lines are ¾" inch diameter PEX, while the individual offshoots / branches are ½ inch diameter PEX pipes. The main black and gray return lines are 3 inch diameter ABS while the vents and most of the returns from most appliances are 2 inch diameter ABS, as required by code.

## Revit Testing Procedure

Most of the technical analysis required to justify the plumbing design can be performed in Revit. Therefore, to ensure sound engineering principles, the team decided to create a quantitative test model and check the accuracy of the pressure loss calculations prior to conducting the tests in Revit. The simple plumbing design shown in Figure 5 was drawn in Revit. The design consists of a hot and cold water supply to a two basin sink. The team used the cold water line as their testing sample. The cold line

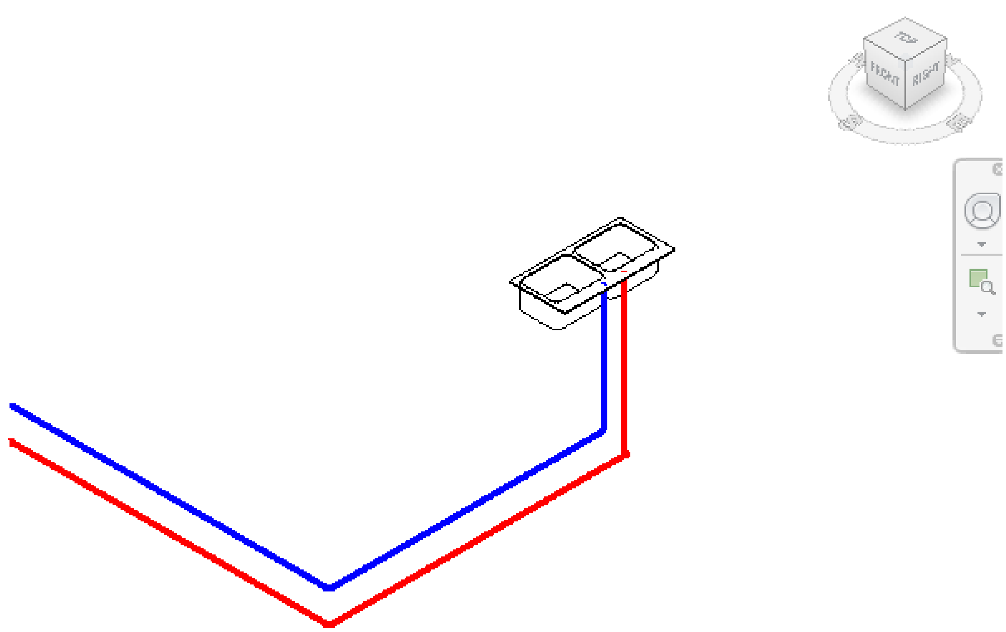


**Figure 5.** Revit test model

started from the origin, extended 10 feet in the x direction, then traveled 10 ft in the y direction, and finally traveled 4 feet vertically in the z direction.

The system was modeled as PEX tubing with the characteristics shown in Table 7. The sink portion of the schematic was ignored, and instead the team used the model to determine the pressure drop from the start of the pipe to the end of the pipe. The simulation utilized a flow-rate of 15 GPM through the tube with a constant relative roughness of 0.00006 at steady state. The flow-rate was converted to a velocity of 6.19 ft per sec through the 1 inch diameter system

**Table 7.** Properties for Revit test model

| Item | Material | Relative Roughness | Inner diameter (inch) |
|---|---|---|---|
| PEX tubing | PEX | .00006 | 1 |
| 90 degree generic elbows (1 in Nominal radius) | PEX | .00006 | 1 |

The pressure loss report generated by Revit is shown below in Figure 6. The team discovered that the pressure drop was relatively small; equal to 3.00 psi from the beginning to the end of the pipe. The majority of the drop was caused by the pipe itself, which was based on the major head loss of the pipe. There was also a substantial drop caused by the two 90 degree elbows.

**Domestic Cold Water 2**

| System Information | |
|---|---|
| System Classification | Domestic Cold Water |
| System Type | Domestic Cold Water |
| System Name | Domestic Cold Water 2 |
| Abbreviation | |
| Fluid Type | Water |
| Fluid Temperature | 60 °F |
| Fluid Dynamic Viscosity | 1.12 cP |
| Fluid Density | 62.3600 lb/ft³ |

**Total Pressure Loss Calculations by Sections**

| Section | Element | Flow | Size | Velocity | Velocity Pressure | Length | K Coefficient | Friction | Total Pressure Loss | Section Pressure Loss |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Fittings | 15 GPM | - | 0 FPS | 3.28 psi | - | 0.37 | - | 1.21 psi | 1.21 psi |
| | Plumbing Fixture | 15 GPM | - | - | - | - | - | - | 0.00 psi | |
| 2 | Pipe | 15 GPM | 1"ø | 6 FPS | - | 3' - 9 7/8" | - | 15.68 FT/100ft | 0.26 psi | 0.36 psi |
| | Fittings | 15 GPM | - | 6 FPS | 0.26 psi | - | 0.37 | - | 0.10 psi | |
| 3 | Fittings | 15 GPM | - | 0 FPS | 0.02 psi | - | 2.583679 | - | 0.04 psi | 0.04 psi |
| 4 | Pipe | 15 GPM | 1"ø | 6 FPS | - | 8' - 4 5/8" | - | 15.68 FT/100ft | 0.57 psi | 0.67 psi |
| | Fittings | 15 GPM | - | 6 FPS | 0.26 psi | - | 0.37 | - | 0.10 psi | |
| 5 | Fittings | 15 GPM | - | 0 FPS | 0.02 psi | - | 2.583679 | - | 0.04 psi | 0.04 psi |
| 6 | Pipe | 15 GPM | 1"ø | 6 FPS | - | 9' - 10 31/32" | - | 15.68 FT/100ft | 0.67 psi | 0.67 psi |
| | Fittings | 15 GPM | - | 6 FPS | 0.26 psi | - | 0 | - | 0.00 psi | |

Critical Path : 6-5-4-3-2-1 ; Total Pressure Loss : 3.00 psi

**Detail Information of Straight Segment by Sections**

| Section | Element ID | Flow | Size | Velocity | Velocity Pressure | Length | Pressure Loss | Total Pressure Loss |
|---|---|---|---|---|---|---|---|---|
| 2 | 953251 | 15 GPM | 1"ø | 6 FPS | 0.26 psi | 3' - 9 7/8" | 0.26 psi | 0.26 psi |
| 4 | 952944 | 15 GPM | 1"ø | 6 FPS | 0.26 psi | 8' - 4 5/8" | 0.57 psi | 0.57 psi |
| 6 | 952932 | 15 GPM | 1"ø | 6 FPS | 0.26 psi | 9' - 10 31/32" | 0.67 psi | 0.67 psi |

**Figure 6.** Revit pressure loss report simulation for test model

The next step in the process was to create a hand calculation to check if the values produced by Revit were accurate. The team created a simple problem that was subjected to the same flow-rate of 15 GPM as the Revit model. The hand calculation used Bernoulli's equation to determine the pressure drop between the start and end of the line. As shown in Figure 6, the program calculated the major and minor head loss and then plugged them into the Bernoulli's equation with other parameters to calculate the pressure drop.

The hand calculation (Appendix E) yielded a pressure drop value of 2.88 psi. This pressure is close to the value produced by Revit, and confirms the feasibility of using Revit to simulate head losses. The percent error between the two calculations was 4 %, which is close enough to the Revit value to continue with Revit as the primary testing apparatus.

Now that Revit has been proven accurate, the next step is to complete the necessary detailed analysis for the entire plumbing system. This will include pressure drop calculations of the hot and cold supply system at critical moments, such as when all taps are engaged. These simulations will both effectively model everyday usage of the plumbing system, and also provide valuable tool and concept evaluation of worst case scenarios. A 3-D Revit model has been created and drawing views can be seen in Appendix B.

### Fire Suppression System

The fire sprinkler system had a few different iterations as the final plan of the house changed. Firstly a branched system with all VK476 flush pendent sprinklers, then a combo of the flush pendent sprinklers and horizontal sidewall sprinklers, then a looped system with all sidewall sprinklers, finally a branched system with all concealed pendent sprinklers, further discussed in the Final Design section of the report.

The fire suppression system went through a few different iterations before settling on our final design. The first design was a branched system of VK476 flush pendent sprinklers. The selected system design flow rate and pressure was 13 gallons per minute (gpm) and 7 psi. This was the lowest design pressure and flow rate for the sprinkler heads and was selected because we elected not to design the fire suppression system with an additional booster pump if possible. As per the technical documentation for the Viking VK476 flush pendent sprinklers, this design flow rate and pressure resulted in sprinkler coverage of 16 x 16 feet per sprinkler head. With this coverage area, 7 sprinkler heads were required to fully protect the interior floor space of the house. These sprinkler heads were arranged as shown in the Appendix A with 2 sprinkler heads in the private and public living spaces, respectively, and 1 sprinkler head in the bathroom, kitchen, and mechanical room, respectively.

To confirm a branched sprinkler system would effectively work for our house. We performed two calculations, referenced in Appendix E. Both calculations were performed with PEX piping and the design requirements of the Viking flush pendent sprinkler. The first calculation was the Prescriptive Pipe Sizing calculation given in NFPA 13D. This method totals up the pressure losses in the system and uses the remaining pressure head in Table 10.4.9.2 to determine the allowable length of pipe from service valve to farthest sprinkler. First we performed the calculation with a ¾” diameter pipe and determined the maximum allowable length of pipe to be 38 feet. The actual distance from the service valve to the furthest sprinkler is 65.5 feet. Thus, by this calculation a ¾” pipe diameter is not sufficient for the sprinkler system. We performed the calculation again with a 1” pipe diameter and determined the maximum allowable length of pipe to be 220 feet. Thus our branched sprinkler system will provide sufficient pressure to the fire sprinklers.

The second calculation utilized the Hazen-Williams Equation to calculate major head loss in the pipes. As per NFPA 13D we chose two sprinklers as our design load. We chose the sprinklers in the living space as they were the furthest from the service valve. By starting at the furthest sprinkler and working back towards the service valve we can determine the pressure loss in the system when two sprinklers are operating. First we ran the calculation with a ¾" diameter pipe and determined that there would have 53 psi of losses for this design case. With a supply pressure of 50 psi this line size is not sufficient. So we performed the calculation again with a 1" pipe diameter in the system and determined we would only have 16 psi of pressure loss. Thus reconfirming what the prescriptive pipe sizing calculation told us.

Hydraulic calculations for fire sprinkler systems are not supported in Revit so we relied on the hand calculations detailed in NFPA 13D.

Because low visibility of the sprinkler system is a major design requirement from the architecture and interior design team the sprinkler lines will branch off the cold water supply line in the mechanical room and go up to ceiling level. Then the lines will reside in the side walls of the core and branch out to the public living space and private living space following the ceiling joints. A cross section of the sprinkler and ceiling joist plan is shown in Figure 7.

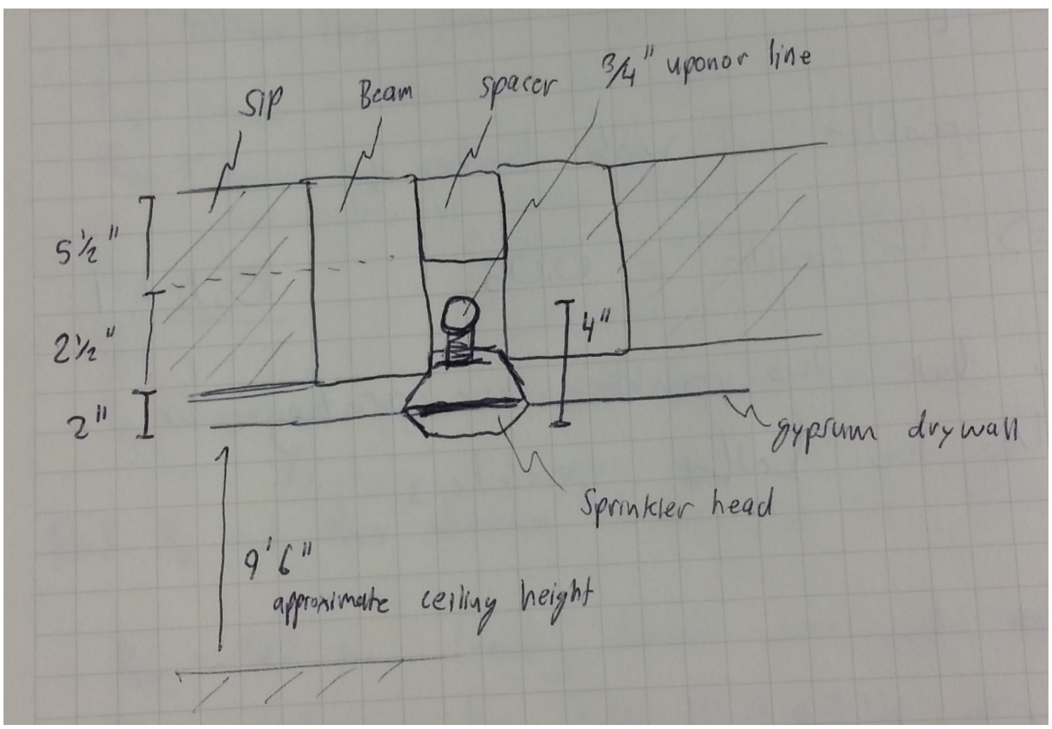



**Figure 7.** Cross sectional view of ceiling joist with spacer and fire sprinkler line.

With a 13 gpm flow rate and 7 psi pressure supplied to the Viking flush pendent sprinklers a coverage of 16 X 16 feet is achieved. The spacing of the ceiling joists in the public and private living spaces as shown in structural drawings in Appendix B allows for proper spacing of our sprinkler heads to provide full coverage to the living areas.

The next system we considered was a system with both pendent and horizontal sidewall sprinkler heads, with Tyco flush horizontal sidewall sprinkler heads. This was due to the added clerestory window at the

top of the north wall of the core and the added ventilation bar in the core. This resulted in a change from the bathroom and kitchen sprinklers to horizontal sidewall sprinklers. The overall layout remained the same as the first design iteration.

Our third design iteration happened after talking with the Fire Engineering Department Head, Fred Mower. He suggested to consider a looped design since the existing system was almost a looped system throughout the core. In order to confirm that the looped system would be effective, the branched system NFPA 13D Prescriptive Pipe Sizing calculation from the previous systems was used. In order to effectively cover the interior of the house, a 20 x 20 foot coverage was required. The layout for this plan can be seen in Appendix A.

The design pressure and flow rate for this was as follows. The calculation for the system can be seen in Appendix E. Due to the higher efficiency of a looped sprinkler system meant that the branched system would work. However, due to the higher required pressure and flow rate through the sprinkler heads to achieve adequate coverage, a change from PEX piping to CPVC Blazemaster piping would be required. Ultimately the architects vetoed this plan because they did not want to use horizontal sidewall sprinklers due to their somewhat greater visibility.

For all designs except for the looped system, the fittings we utilized were SharkBite push fit and barb coupling. Due to the confined nature of the sprinkler system more fittings were necessary than for the supply lines. However efforts were made to minimize the fittings to minimize the pressure losses due to minor head loss. There are three 1” push fit tee fittings, five 1” barb elbows and reducing elbows. The sprinkler heads all had ½” threaded connections so the line size needed to be reduced from 1” to ½”. This was accomplished in two reduction stages. The reduction occurred as close to the sprinkler head as possible so as to reduce major head losses from the increased fluid velocity in the pipes at the smaller line sizes.

## Hot Water Tank

Our water system will utilize a closed-loop solar water heating system as the primary source of hot water. Through ideation of different ways to ensure constant hot water temperature, we decided to select a smaller electrical heater as a supplement to the solar hot water heating system. Originally we planned to include an instant hot water heater after the hot water tank but after discussions with Professor Shollenberger we changed to a Rheemglas Fury 81V-80HE-1 hot water heater with hook-ups for an external closed-loop heating system. As Solar Cal Poly already has the Rheemglas Fury tank[7] on campus, we decided the reduced cost and customer requirements justifies using the Rheemglas Fury hot water tank in the Solar Cal Poly house.

[7] "Fury Rheemglas® Electric Water Heater - Products." *Fury Rheemglas® Electric Water Heater - Products*. N.p., n.d. Web. 18 Nov. 2014. <http://www.rheemmfg.com.sg/our-products/floor-mounted-water-heaters/fury-rheemglasr-electric-water-heater-double>.

# Chapter 4: Final Design

## Overall System Description

The final design of the Solar Cal Poly plumbing system was split into four different subsystems:

- Cold water supply
- Hot water supply
- Return/Waste lines
- Fire Suppression system

## Cold Water Supply

### Description

The cold water supply subsystem (Figure 7) is responsible for transporting clean, cold water from the supply tank and supply pump (designed by water systems Solar Cal Poly team) throughout the house. The cold water supply system consists PEX piping, insulation, PEX clamps, and various fittings.

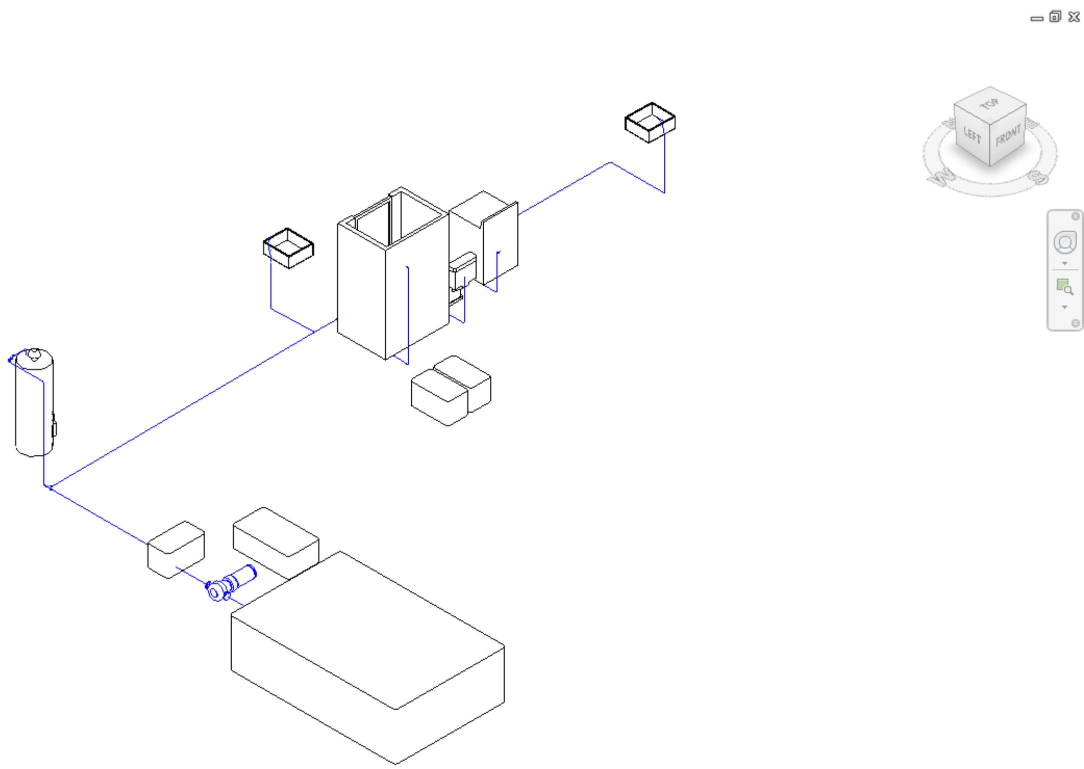


**Figure 8.** Cold water supply subsystem Revit model

### PEX Piping

PEX piping will consist of three sizes of pipe. First, a large 1” pipe will be used from the tank to the utility room. Then, within the utility room, the cold water piping will branch off towards the cold water appliance line, the water heater inlet, and the hose bib. These three branches will consist of ¾” pipe.

Finally, as the ¾" cold water supply line passes appliances, ½" piping will be used to run from the ¾" pipe to individual ½" appliance lines.

## Insulation

Insulation will be used whenever possible in cold water pipes to prevent potential freezing in cold climates, and unnecessary low-level heat draw in hot climates. This is not an important feature of cold water piping, but still has been taken into consideration and implemented.

## PEX Clamps

PEX piping needs special considerations when being connected to fixtures. PEX clamps will allow ease of assembly while still achieving required durability and functionality. All PEX piping will be secured to fixtures using PEX clamps.

## Fittings

Fittings on the cold supply line will be kept to a minimum. PEX can be connected to Plastic Polymer PEX Pipe 90-Degree Bend Supports which can be used to replace normal 90 degree elbow fittings. These bend supports are available in 1", ¾", and ½" diameter increments, which allows the team to utilize them in many different locations along the line. This lack of fittings also decreases the head loss due to fixtures, and creates a more effective and energy efficient system.

Fittings will be used in several places. When there needs to be an offshoot from the main line to supply a specific appliance with cold water, a tee fitting will be utilized. ¾" to ½" Tees will be placed in three locations below the bathroom to supply the shower, bathroom sink and toilet. The toilet tee will actually never be connected and will instead be capped during competition. This is because the toilet doesn't need to be connected during competition.

Because cold water is only required to be supplied to one fixture in the kitchen; the sink, the last tee under the bathroom will connect the ¾" mainline to two ½" offshoots. The second ½ connection will travel from the edge of the bathroom below the kitchen and up through the island to the kitchen sink.

## Pressure Drop Simulation

In order to make sure that there wasn't excess pressure drop throughout the system, a simulation was created in Revit using models of the plumbing system to check maximum pressure drop. Excess pressure drop can limit the volume and velocity of the water as it exits various fixtures. Many fixtures require a certain amount of inlet pressure. The simulation determined the critical path, and its pressure drop. The critical path is shown by the red arrows overlaid on the Revit model in Figure 9. The corresponding pressure loss is documented in Table 8.

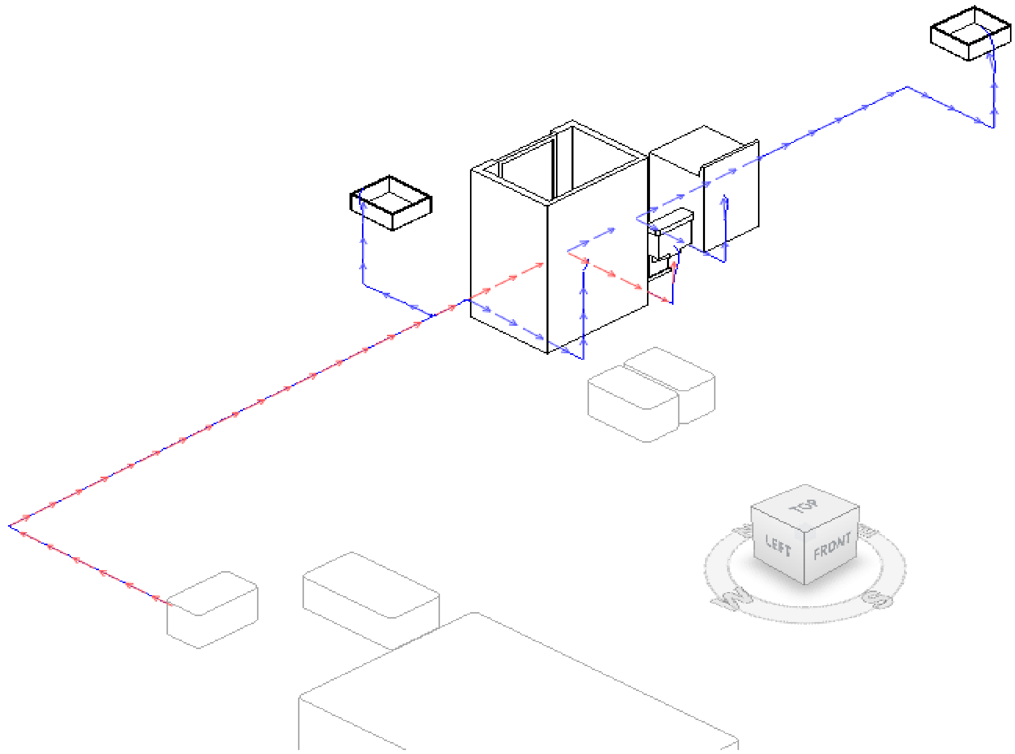


**Figure 9.** Revit simulation of pressure drop along the critical path of the cold water supply line.

The critical path starts at the west end of the core. It travels along the length of the core, and then branches off to the toilet. This critical line produces a pressure drop of 31.12 psi which seems a little high. However, this drop is negligible compared to the 50 psi supply pressure, so it is within range. Another consideration is that the toilet isn't hooked up during the competition.

**Table 8.** Hot Water Supply with Toilet Pipe Pressure Loss Report.

| Total Pressure Loss Calculations by Sections | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | Element | Flow | Size | Velocity | Velocity Pressure | Length | K Coefficient | Friction | Total Pressure Loss | Section Pressure Loss |
| 1 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 6' - 5 7/8" | - | 24.67 FT/100ft | 0.54 psi | 14.14 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.18 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 2 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 1.5 | - | 0.04 psi | 0.04 psi |
| 3 | Pipe | 11 GPM | 3/4"ø | 7 FPS | - | 23' - 2 23/32" | - | 38.42 FT/100ft | 2.41 psi | 2.65 psi |
| | Fittings | 11 GPM | - | 7 FPS | 0.31 psi | - | 0.745349 | - | 0.23 psi | |
| 4 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 8' - 5 25/32" | - | 24.67 FT/100ft | 0.69 psi | 14.28 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.18 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 5 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| 6 | Pipe | 10 GPM | - | 7 FPS | - | 1' - 2 1/2" | - | 30.07 FT/100ft | 0.16 psi | 0.32 psi |
| | Fittings | 10 GPM | - | 7 FPS | 0.33 psi | - | 0.5 | - | 0.17 psi | |
| 7 | Pipe | 5 GPM | 1/2"ø | 9 FPS | - | 6' - 4 29/32" | - | 77.00 FT/100ft | 1.99 psi | 27.70 psi |
| | Fittings | 5 GPM | - | 9 FPS | 0.50 psi | - | 1.09 | - | 0.55 psi | |
| | Plumbing Fixture | 5 GPM | - | - | - | - | - | - | 25.16 psi | |
| 8 | Fittings | 5 GPM | - | 4 FPS | 0.07 psi | - | 1.5 | - | 0.11 psi | 0.11 psi |
| 9 | Pipe | 8 GPM | - | 6 FPS | - | 3' - 8 5/8" | - | 22.09 FT/100ft | 0.26 psi | 0.35 psi |
| | Fittings | 8 GPM | - | 6 FPS | 0.18 psi | - | 0.5 | - | 0.09 psi | |
| 10 | Pipe | 3 GPM | - | 1 FPS | - | 1' - 0 17/32" | - | 0.64 FT/100ft | 0.00 psi | 9.92 psi |
| | Fittings | 3 GPM | - | 1 FPS | 0.01 psi | - | 1.091832 | - | 0.01 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 9.91 psi | |
| 11 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 5' - 1 1/8" | - | 6.27 FT/100ft | 0.26 psi | 0.37 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.10 psi | - | 1.09 | - | 0.11 psi | |
| 12 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 1.5 | - | 0.04 psi | 0.04 psi |
| 13 | Pipe | 5 GPM | - | 4 FPS | - | 2' - 6 23/32" | - | 8.06 FT/100ft | 0.07 psi | 0.10 psi |
| | Fittings | 5 GPM | - | 4 FPS | 0.06 psi | - | 0.5 | - | 0.03 psi | |
| 14 | Pipe | 3 GPM | 1/2"ø | 4 FPS | - | 18' - 1 13/16" | - | 24.67 FT/100ft | 0.95 psi | 14.67 psi |
| | Fittings | 3 GPM | - | 4 FPS | 0.16 psi | - | 1.900078 | - | 0.31 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 15 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 0.5 | - | 0.01 psi | 0.01 psi |
| Critical Path : 3-6-9-8-7 ; Total Pressure Loss : 31.12 psi | | | | | | | | | | |

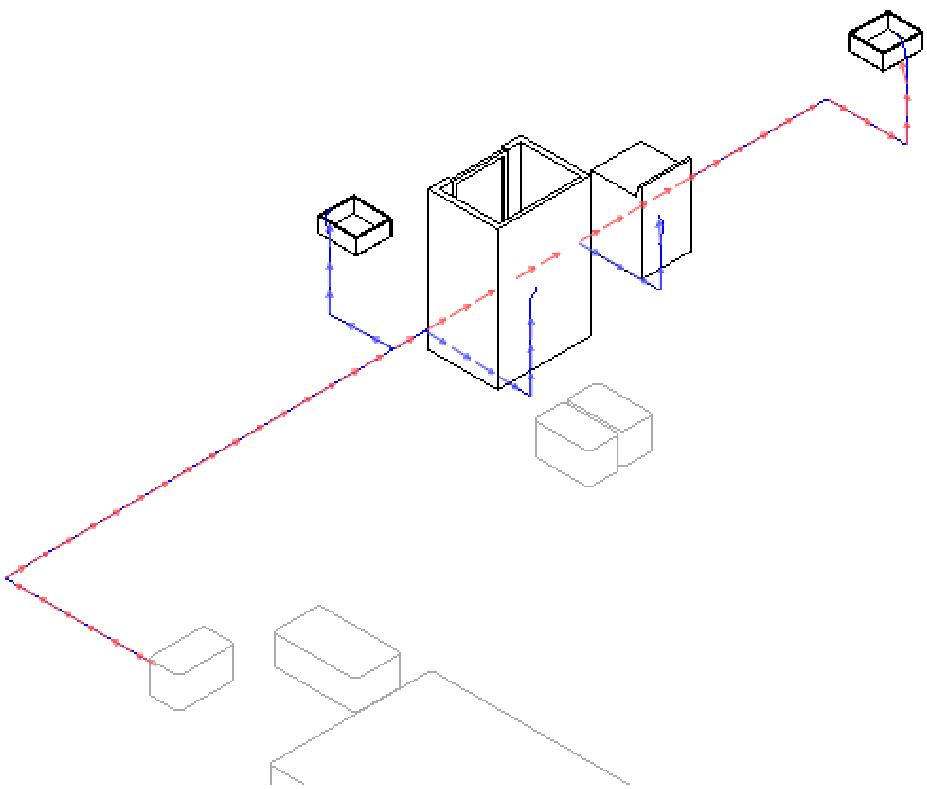


**Figure 10.** Cold water supply Revit simulation denoting pressure drop critical path. No toilet pressure.

To test the critical path without the toilet, another simulation was run, as shown in Figure 10. It can be seen that the critical path is very different when the toilet is removed from the simulation. The critical path now travels all the way down the central core to the kitchen sink on the far end. The corresponding pressure loss report is shown in Table 9. The maximum flow rate decreased from 11 GPM all the way down to 8 GPM which is a more realistic number. As shown in the updated pipe pressure loss report shown below, the new pressure drop is a much more manageable 16.48 psi. This large difference between the two models is caused by the fact that the toilet is modeled with a flush valve, which increases flow rate by a large margin.

**Table 9.** Hot Water Supply without Toilet Pipe Pressure Loss Report

Total Pressure Loss Calculations by Sections

| Section | Element | Flow | Size | Velocity | Velocity Pressure | Length | K Coefficient | Friction | Total Pressure Loss | Section Pressure Loss |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 6' - 5 7/8" | - | 24.67 FT/100ft | 0.54 psi | 14.14 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.18 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 2 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 1.5 | - | 0.04 psi | 0.04 psi |
| 3 | Pipe | 8 GPM | 3/4"ø | 5 FPS | - | 23' - 2 23/32" | - | 20.62 FT/100ft | 1.30 psi | 1.42 psi |
| | Fittings | 8 GPM | - | 5 FPS | 0.17 psi | - | 0.745349 | - | 0.12 psi | |
| 4 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 8' - 5 25/32" | - | 24.67 FT/100ft | 0.69 psi | 14.28 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.18 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 5 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| 6 | Pipe | 7 GPM | - | 5 FPS | - | 1' - 2 1/2" | - | 13.61 FT/100ft | 0.07 psi | 0.15 psi |
| | Fittings | 7 GPM | - | 5 FPS | 0.15 psi | - | 0.5 | - | 0.07 psi | |
| 8 | Fittings | 0 GPM | - | 0 FPS | 0.00 psi | - | 1.5 | - | 0.00 psi | 0.00 psi |
| 9 | Pipe | 5 GPM | - | 4 FPS | - | 3' - 8 5/8" | - | 8.06 FT/100ft | 0.09 psi | 0.13 psi |
| | Fittings | 5 GPM | - | 4 FPS | 0.06 psi | - | 0.5 | - | 0.03 psi | |
| 10 | Pipe | 3 GPM | - | 1 FPS | - | 1' - 0 17/32" | - | 0.64 FT/100ft | 0.00 psi | 9.92 psi |
| | Fittings | 3 GPM | - | 1 FPS | 0.01 psi | - | 1.091832 | - | 0.01 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 9.91 psi | |
| 11 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 5' - 1 1/8" | - | 6.27 FT/100ft | 0.26 psi | 0.37 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.10 psi | - | 1.09 | - | 0.11 psi | |
| 12 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 1.5 | - | 0.04 psi | 0.04 psi |
| 13 | Pipe | 5 GPM | - | 4 FPS | - | 2' - 6 23/32" | - | 8.06 FT/100ft | 0.07 psi | 0.10 psi |
| | Fittings | 5 GPM | - | 4 FPS | 0.06 psi | - | 0.5 | - | 0.03 psi | |
| 14 | Pipe | 3 GPM | 1/2"ø | 4 FPS | - | 18' - 1 13/16" | - | 24.67 FT/100ft | 0.95 psi | 14.67 psi |
| | Fittings | 3 GPM | - | 4 FPS | 0.16 psi | - | 1.900078 | - | 0.31 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 13.42 psi | |
| 15 | Fittings | 3 GPM | - | 2 FPS | 0.02 psi | - | 0.5 | - | 0.01 psi | 0.01 psi |

Critical Path : 3-6-9-13-15-14 ; Total Pressure Loss : 16.48 psi

Flush value toilets, also known as tank-less toilets, rely on pure water pressure from the supply line to flush the contents. This differs from a standard flush tank toilet, where the contents are flushed by slowly pumping a large amount of water into a tank located above the bowl, and then allowing gravity to flush the toilet. The difference in pressure drop between the two systems is understandably large, with the flush value requiring a much larger drop in pressure to operate effectively. For the purposes of the DOE competition the system is designed on the criteria that the toilet isn't hooked up to the system.

## Hot Water Supply

### Description

Similar to the cold water supply subsystem, the hot water supply subsystem is responsible for transporting clean, hot water from the hot water tank throughout the house. The hot water supply system consists PEX piping, insulation, PEX clamps, and various fittings. Figure 11 shows the hot water supply subsection of the Solar Cal Poly final plumbing design

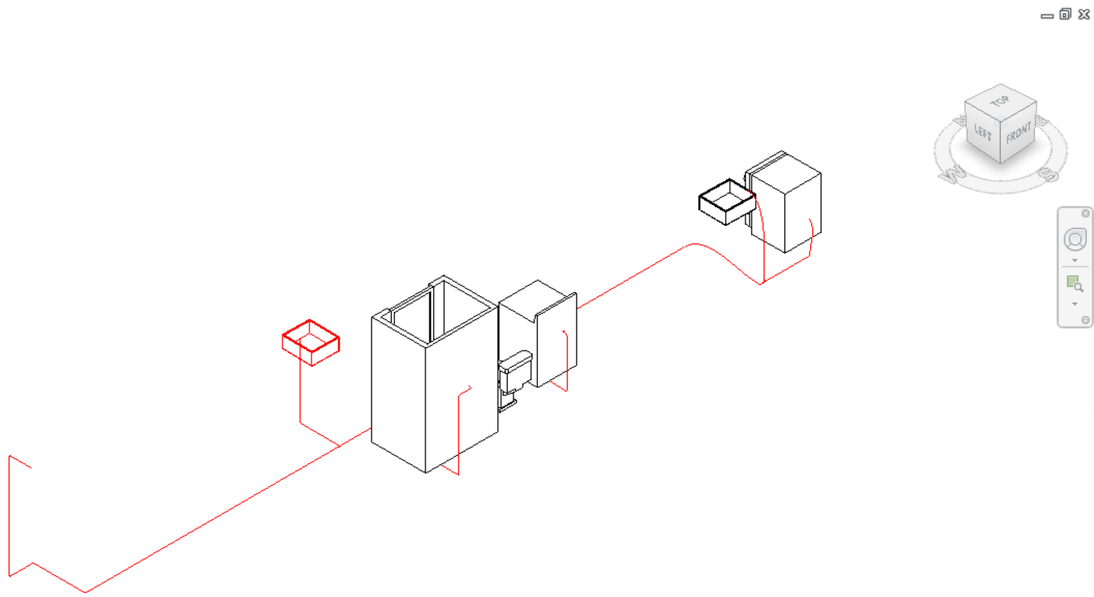


**Figure 11.** Hot water supply subsystem Revit model

## PEX Piping

Hot water PEX piping will consist of two sizes of pipe. First, a ¾” pipe will be used to run hot water from the hot water heater in the utility room through the center of the house. Then, as the ¾” hot water supply line passes appliances, ½” piping will be used to run from the ¾” pipe to individual ½” appliance lines.

## Insulation

Insulation will cover as many hot water pipes as possible. Significant energy losses result from the heat transfer from hot water pipes to the local environment. Insulation is a cheap and effective way to prevent this energy loss. Additionally, insulation will help prevent pipes from freezing when water is stagnant.

## PEX Clamps

PEX piping needs special considerations when being connected to fixtures. PEX clamps will allow ease of assembly while still achieving required durability and functionality. All PEX piping will be secured to fixtures using PEX clamps.

## Fittings

Fittings on the hot supply line will also be kept to a minimum. Fittings will be used in several places. When there needs to be an offshoot from the main line to supply a specific appliance with hot water, a tee fitting will be utilized. ¾” to ½” Tees will be placed in three locations below the bathroom to supply the shower, bathroom sink and washing machine. In order to allow for easier installation, the hot offshoots will be kept close to the cold offshoots. This will allow the team to group the pipes in clusters.

There will also be a single tee located in the island in the kitchen. This tee will split the main supply line into two smaller ½" diameter supply lines to feed the kitchen sink and dishwasher. Because the house layout has a gap of 6 inches between the back of the kitchen counter and the back of the dishwasher, the team will be able to use another 90-Degree Bend Support to feed the inlet of the dishwasher.

### Hot Water Lag Time Calculation

When the hot water lines don't run for an extended period of time, the water past the hot water heater cools down and becomes cold. The team will insulate the hot water lines to try to extend the life of the hot water, but even with the insulation, the liquid will eventually lose its heat and become room temperature. Because of this, a calculation was created to determine the amount of time required for each appliance to receive hot water under worst case scenarios. This worst case scenario is when the appliance in question is the only one running, creating the entire draw along the line. The results are shown in the Table 10 below.

**Table 10.** Time required to provide hot water to each appliance assuming the worst case scenario.

| Appliance | Hot Flowrate | Length of ¾ inch diameter line (ft) | Length of ½ inch diameter line (ft) | Volume of line to Appliance | Time Required for Hot water |
|---|---|---|---|---|---|
| Shower | 1.2 GPM | 28.10 | 6 | 0.706 Gal | 35.3 Sec |
| Bathroom Sink | 1.2 GPM | 25.35 | 5 | 0.633 Gal | 31.7 Sec |
| Washing Machine | 2.5 GPM | 34.47 | 4 | 0.833 Gal | 20.0 Sec |
| Kitchen Sink | 1.2 GPM | 47.85 | 3.5 | 1.136 Gal | 56.8 Sec |
| Dishwasher | 2.5 GPM | 47.85 | 3.5 | 1.136 Gal | 27.3 Sec |

Because the team plans to insulate the hot supply lines, and that the competition takes place in the warmer climate of Irvine, CA during the late summer, these times are within range and are acceptable. If the competition took place in a colder environment, the system would have to be adjusted to be able to provide hot water quickly.

## Pressure Drop Simulation

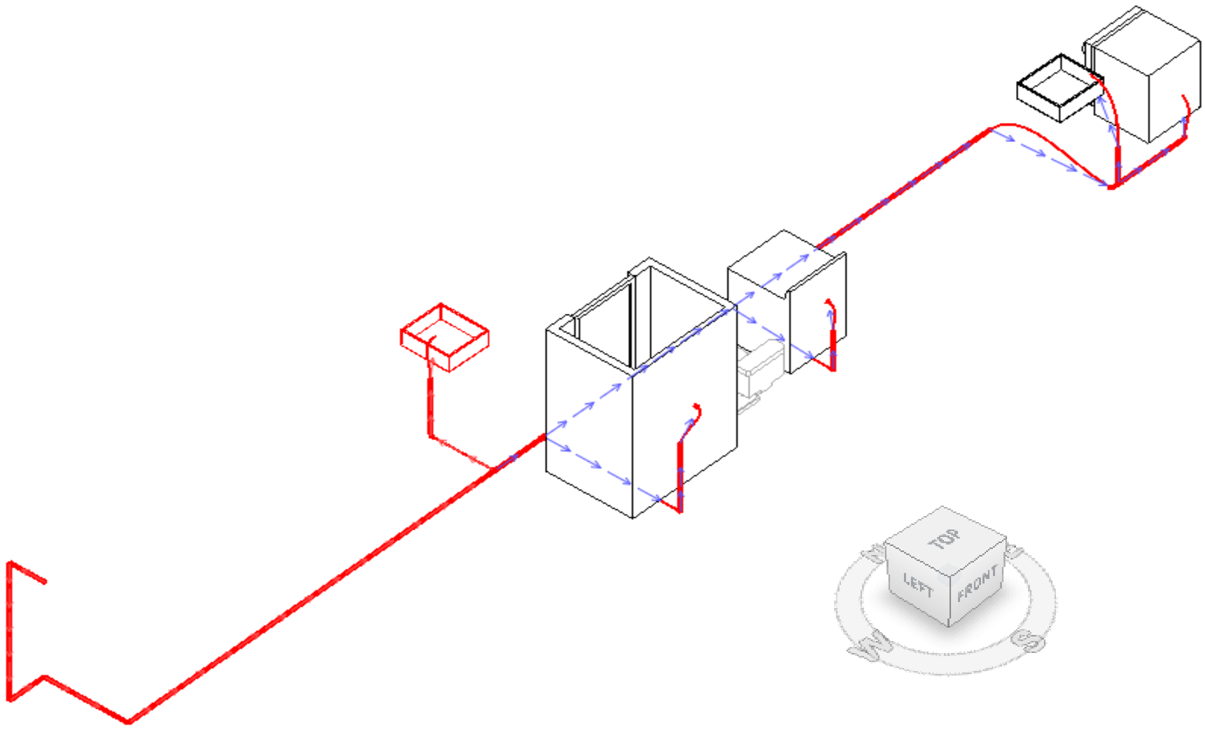



**Figure 12.** Hot water supply Revit simulation denoting pressure drop critical path.

In order to make sure that there wasn't excess pressure drop throughout the system, a simulation was created in Revit using models of the plumbing system to check maximum pressure drop. Excess pressure drop can limit the volume and velocity of the water as it exits various fixtures. Many fixtures require a certain amount of inlet pressure. The simulation determined the critical path, and its pressure drop. The critical path is shown by the blue arrows overlaid on the Revit model in Figure 12. The corresponding pressure loss is documented in Table 11.

**Table 11.** Hot Water Supply Pressure Loss Report.

| Total Pressure Loss Calculations by Sections | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | Element | Flow | Size | Velocity | Velocity Pressure | Length | K Coefficient | Friction | Total Pressure Loss | Section Pressure Loss |
| 1 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 8' - 10 3/8" | - | 15.45 FT/100ft | 0.75 psi | 8.89 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.13 psi | - | 1.09 | - | 0.14 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 8.00 psi | |
| 2 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| 3 | Pipe | 9 GPM | 3/4"ø | 6 FPS | - | 1' - 8 7/8" | - | 19.18 FT/100ft | 0.14 psi | 0.28 psi |
| | Fittings | 9 GPM | - | 6 FPS | 0.26 psi | - | 0.5 | - | 0.13 psi | |
| 4 | Pipe | 10 GPM | 3/4"ø | 7 FPS | - | 24' - 10 15/32" | - | 25.05 FT/100ft | 2.70 psi | 3.76 psi |
| | Fittings | 10 GPM | - | 7 FPS | 0.35 psi | - | 3 | - | 1.06 psi | |
| 5 | Fittings | 3 GPM | - | 1 FPS | 0.01 psi | - | 1.091832 | - | 0.01 psi | 8.01 psi |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 8.00 psi | |
| 6 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 6' - 5 5/8" | - | 26.65 FT/100ft | 0.69 psi | 0.87 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.17 psi | |
| 7 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| 8 | Pipe | 7 GPM | 3/4"ø | 5 FPS | - | 7' - 0 3/4" | - | 13.68 FT/100ft | 0.42 psi | 0.51 psi |
| | Fittings | 7 GPM | - | 5 FPS | 0.18 psi | - | 0.5 | - | 0.09 psi | |
| 9 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 4' - 3 7/8" | - | 15.45 FT/100ft | 0.37 psi | 8.40 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.13 psi | - | 0.28 | - | 0.04 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 8.00 psi | |
| 10 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| 11 | Pipe | 6 GPM | 3/4"ø | 4 FPS | - | 14' - 5 19/32" | - | 8.93 FT/100ft | 0.61 psi | 0.75 psi |
| | Fittings | 6 GPM | - | 4 FPS | 0.11 psi | - | 1.25 | - | 0.14 psi | |
| 12 | Pipe | 4 GPM | 1/2"ø | 6 FPS | - | 4' - 2 7/32" | - | 23.62 FT/100ft | 0.51 psi | 8.74 psi |
| | Fittings | 4 GPM | - | 6 FPS | 0.21 psi | - | 1.09 | - | 0.23 psi | |
| | Plumbing Fixture | 4 GPM | - | - | - | - | - | - | 8.00 psi | |
| 13 | Fittings | 4 GPM | - | 3 FPS | 0.05 psi | - | 0.5 | - | 0.03 psi | 0.03 psi |
| 14 | Pipe | 3 GPM | 1/2"ø | 5 FPS | - | 6' - 3 1/16" | - | 26.65 FT/100ft | 0.64 psi | 10.69 psi |
| | Fittings | 3 GPM | - | 5 FPS | 0.16 psi | - | 1.09 | - | 0.17 psi | |
| | Plumbing Fixture | 3 GPM | - | - | - | - | - | - | 9.87 psi | |
| 15 | Fittings | 3 GPM | - | 2 FPS | 0.03 psi | - | 1.5 | - | 0.05 psi | 0.05 psi |
| Critical Path : 4-15-14 ; Total Pressure Loss : 14.50 psi | | | | | | | | | | |

As shown, the critical path starts on the West end of the core and travels through the central main line, than branches to the North side of the core to the Bathroom sink. This critical path experiences a maximum pressure drop of only 14.50 psi, which when considered to our supply of 50 psi, doesn't cause any problems or concerns.

## Return/Waste Lines

### Description

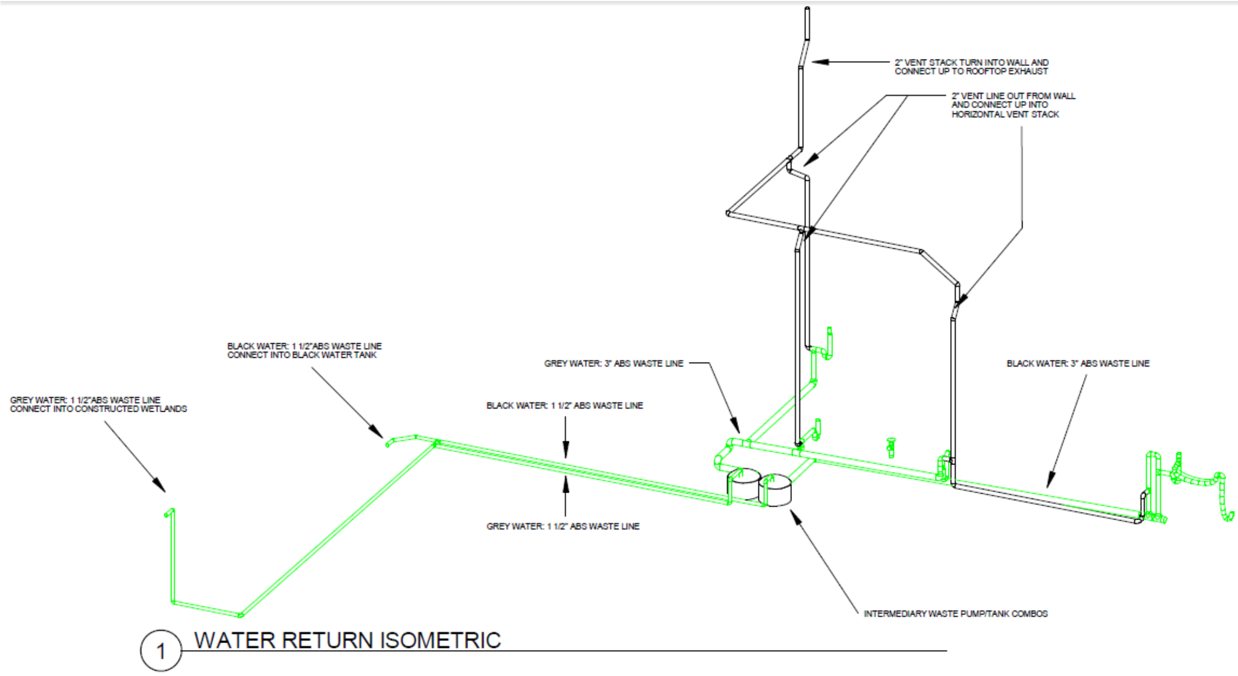



**Figure 13.** Water return isometric diagram

To transport waste from the kitchen and bathroom to the septic tank, black and grey return/waste lines will be constructed.  These lines will run separate, but parallel to one another as shown in Figure 13. As shown, the lines will run parallel to each other in two different places. Firstly below the main core of the house and secondly below the deck located on the south end of the house.  Additionally, septic pumps will be integrated into the design.  There will be a valve connecting the grey waste line to the black waste line to allow diversion of the grey water into the septic tank if necessary.

The plumbing subsystem designed the return systems from the each appliance outlet back to their respective black or grey water pump, and then from the exit of the black water pump back to the septic tank.  Solar Cal Poly water systems team designed the grey water pump and pump outlet piping. Therefore, this report will document the grey water line design prior to the grey water pump.

Overall, the return lines consist of ABS piping, fittings, vents, and the black water septic pump.

### ABS Piping

Two sizes of ABS piping will be used in the return lines.  Within the walls, 2" lines will be used, including vent piping and fixtures.  No functional appliances have 3" waste outlets.  Below the floor, these 2" appliance waste lines will flow into 3" main return lines.  These 3" lines will carry waste to the septic pumps with a downward slope of ¼" drop per foot of travel. After each septic pump, the lines will

convert into 1 ½ inch lines to be able to effectively integrate into the pump outlets. Both grey and black lines will be set up in this fashion.

### Fittings

Many of the functions of the return lines will be achieved through fittings. All appliance waste outlets will be followed by p-traps. These fixtures use water to block septic air from permeating the house. After each p-trap, return lines will be connected to air vents to vent pressure and encourage pipe flow. Most T-fixtures will utilize sanitary tees to better direct return line flow. Cleanouts will be located at the end of both the grey and black lines to help clear pipes as necessary. A valve will be located at the end of the lines connecting the grey waste line to the black waste line to allow diversion of the grey water into the septic tank if necessary.

### Kitchen Island

The kitchen island presented a special challenge for the design. Kitchens have specific requirements based on California plumbing code, and these requirements were incorporated into the design. The team designed a special waste layout as shown below in figures 14 and 15-1. Several important design choices are explained below.

The line that connects the outlet of the dishwasher to the rest of the system is made of flexible PEX piping. It flows out of the bottom of the dishwasher and makes its way over to the drainage of the kitchen sink, connecting with a sanitary tee just above the p-trap. The p=trap is then connected to one of a pair of vertical pipes. This system of parallel vertical pipes allows for no flow to make its way up to the opening of the vent system (shown by the black pipe). It also contains a small vent at the topmost point of the parallel pipes which allows the p trap below the sink to be pressurized on both sides.

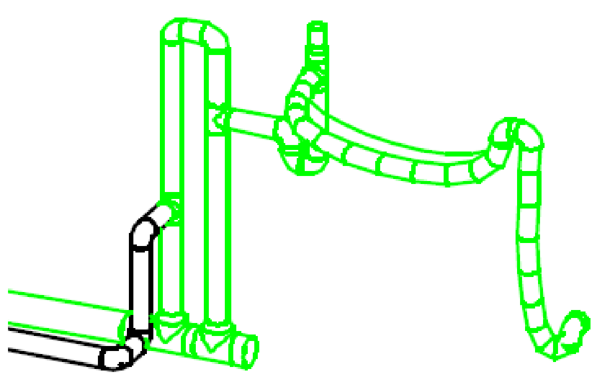


**Figure 14.** Kitchen island return assembly

## Vents

Vents regulate pressure and encourage pipe flow within return lines. There will be three separate vent pipes branching off from appliances. These three will include vents from the bathroom sink, shower and laundry machine. However, vent pipes are fairly intrusive in wall construction. We designed the plumbing system to each vent would be able to merge above in the mechanical chase, as shown in the special plumbing assembly drawing in figure 15 – 1 and figure 15-2. There will only be one vent leading to the outlet on the roof within the return design. Rather than four separate vents, this one single vent will allow for more structural wall strength within the Solar Cal Poly house during transport.

The roof vent was positioned on the northern end of the roof to make sure that its presence wouldn't have a negative effect of the solar panels. As seen above in figure 13, the vent system is also positioned in such a way that it doesn't conflict with the placement of the sprinkler system, HVAC system or any structural members contained in the celling.

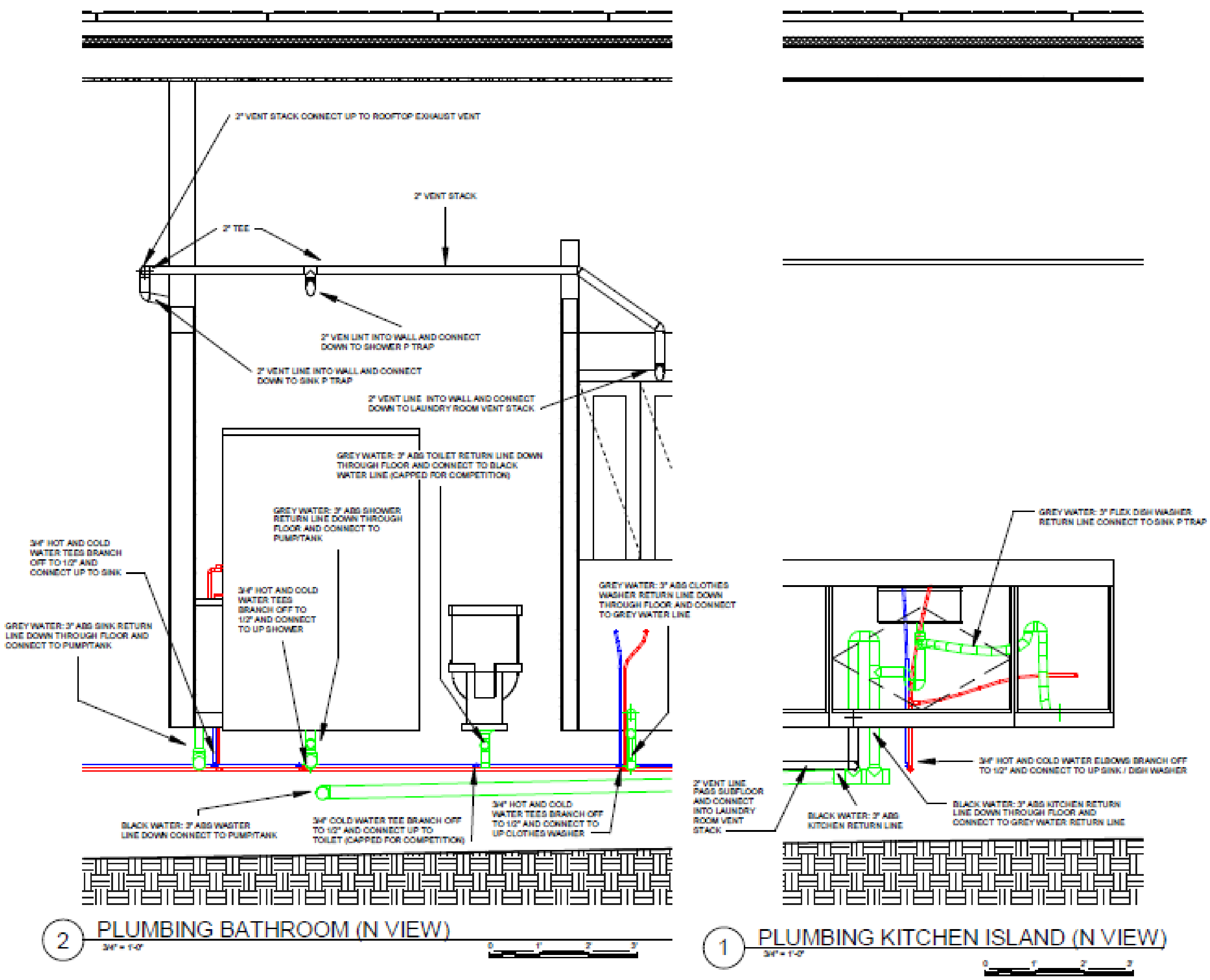



**Figure 15.** Plumbing North view, showing placement of waste lines, kitchen island makeup, and pipe vent placement

## Black Water Line Septic Pump

Return lines require a minimum slope of ¼" drop in elevation for every 1' of travel distance. Unfortunately, Solar Cal Poly did not account for this in their floor layout. As such we cannot meet the slope requirements with gravity alone. A Saniflo: Saniswift septic pump will need to be installed halfway through the black return line, under the deck. This will pump the black return water vertically, than push it horizontally below the deck and finally up and into the septic tank. Since the black water that will need to be pushed into the septic tank only comes from two appliances (kitchen sink and dishwasher) the pump didn't need to be designed to any specific flowrate. It will turn on periodically to push the return into the tank, but because of its limited use, the team designed it to be able to deal with the vertical and horizontal push required.

## Complete Combined Plumbing Layout

The complete combined layout is show in Figure 16. It is designed such that the pipes are contained within the walls and don't conflict with each other or the structural components of the house. The single vent exits the house through the core's ceiling, while the vast majority of the layout is also contained within the core as well. This placement makes the assembly process easier and more streamlined, while also allowing easier disassembly and transport.

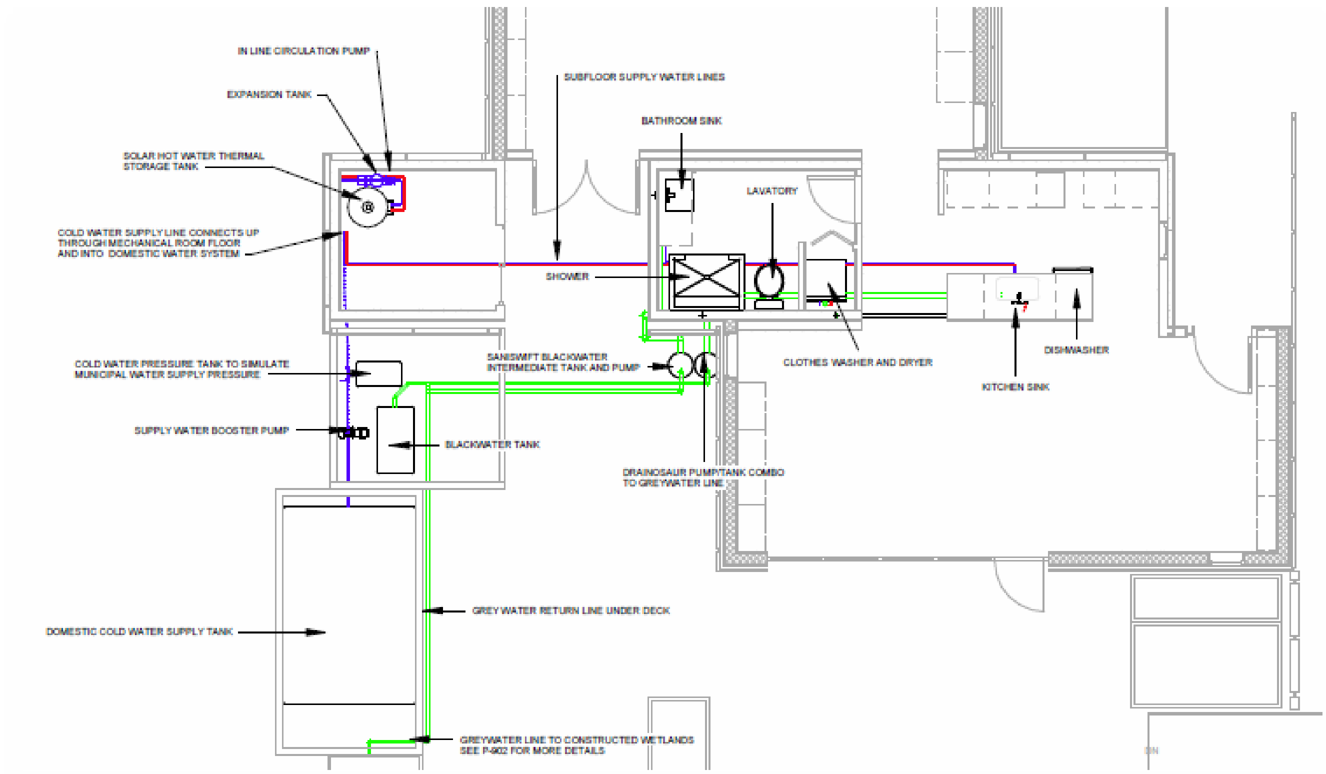



**Figure 16.** Complete combined Solar Cal Poly plumbing layout

## Fire Suppression System

The fire suppression system is designed in accordance with the National Fire Protection Association (NFPA) Standard 13D. "Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes" 2013 Edition. The sprinkler system is a wet pipe branched sprinkler system originating in the mechanical room. Other designs considered were looped, network, and multi-purpose systems.

Because of the small size of the house we determined we could use a branched system instead of a looped of network system. Both of these systems allow for greater water flow to the sprinklers by providing multiple pathways for the water to reach each sprinkler. After consulting with Fire Protection Graduate Student Aric Carracino and reviewing the NFPA 13D Standard we determined a looped or network system was likely unnecessary for the house. A branched system is the simplest of the other sprinkler systems and thus we hoped to utilize it for our house. Additionally, a branched system allowed for greater ease of module assembly. The original proposed loop would be placed above the Core Break, which means that the loop would need to be fully assembled in the upper core and separate connection points to cross the core break into the lower core level and then again into the public and private living space modules.

Protection from freezing was not required for our system because as per NFPA 13D section 9.1.1 a wet pipe system without an antifreeze system is permitted when installed in areas maintained above 40ºF. As the sprinkler system is completely within the footprint of the house the temperature will be maintained above 40ºF for comfortable living conditions. Additionally the system can utilize ordinary temperature residential sprinklers because the ceiling ambient temperature will be less than 100ºF, as specified in NFPA 13D section 7.5.6.1.

From these design constraints we selected a Viking concealed pendent. The concealed pendant sprinklers have a coverage of 16 X 16 feet when supplied with 13 gallons per minute (gpm) and 7 psi. We selected the Viking concealed pendent sprinkler over the Viking flush pendent sprinkler and because for of visibility and aesthetic concerns from the architecture team. The manufacturer data sheets for the Viking sprinkler head can be seen in Appendix D.

As in the design development, to confirm the branched sprinkler system would effectively work for the house the Prescriptive Pipe Sizing calculation given by the NFPA 13D was once again used and can be seen in Appendix E. From this calculation the maximum pipe length for a 1" diameter PEX pipe could be 57 feet while the actual maximum pipe length for the system is 53 feet. However for this calculation for the maximum pipe length included the pressure losses from the water service pipe and water meter which for the design case of the competition are not relevant. Excluding these two pressure losses results in a maximum pipe length of 95 feet. Thus the branched sprinkler system will provide sufficient pressure to the fire sprinklers.

As per the technical documentation for the Viking VK457 concealed pendent sprinklers, at our design flow and pressure the sprinklers have a coverage of 16 x 16 feet. This spacing complies with the code specified in the Viking corporation document for the installation of the VK457 pendent in spaces with a flat roof with a supply pressure equal to at least 7 psi. The sprinklers are fed by a 1 inch supply line that branches off from the main cold water supply. This supply line branches from the house main underneath the planter box located just south of the mechanical room. After the branch, a series of

pressure gages, a backflow preventer valve, a waterflow alarm and drain and test are in the line. The design of this valve block was by NFPA 13D recommendations as seen below in Figure 17.

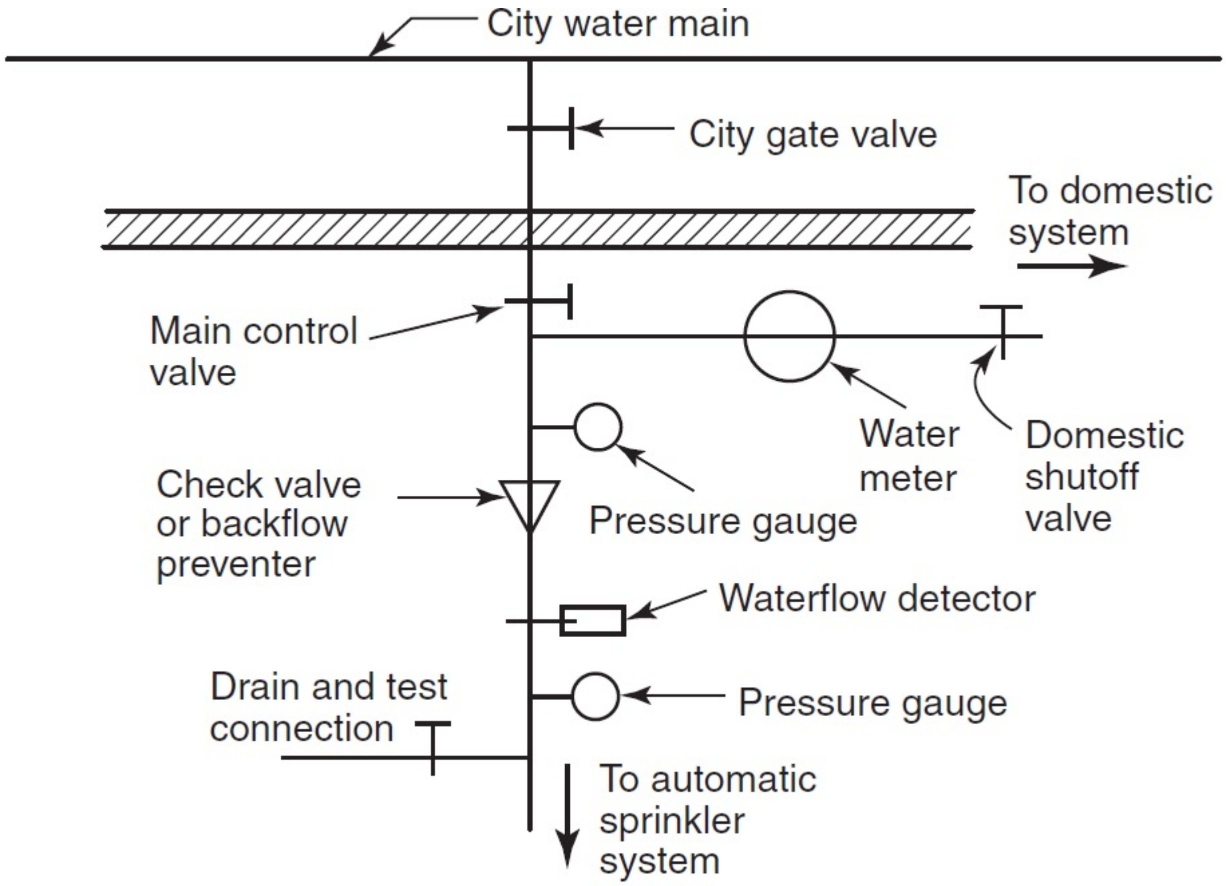



**Figure 17.** Supply line piping and instrumentation diagram as provided by the NFPA 13D. This was used to design the valve block in our plumbing system.

After the valve block, the sprinkler supply line runs under the floor of the core and branches up to two access ports located behind the washing machine and behind the refrigerator. These access ports allow connections to be made between the core module and the private and public living space modules. The attaches to the main line in the mechanical room, runs upwards to the ceiling, and then travels to the 9 sprinkler heads contained in the residence. The architecture team decided to add a drop ceiling to accommodate the lighting so the inter-joist construction discussed in the Chapter 3 and detailed in Figure 7 is not required as the sprinkler lines will be strapped to the SIP panels and not reside in between them.

We found a new fitting that successfully accomplished the 1” to ½” reduction from PEX to Female NPT thread in one fitting. This fitting replaced the three part reduction from 1” to ½” threaded connection. The final fire suppression design can be seen in Appendix B.

## Bill of Materials

The following Bill of Materials (Table 12) notes all equipment we expect to need for the project. This list includes item descriptions, quantities, specification sheet location, manufacturer details, final pricing and delivery information, sources, timing, and vendor contact information. We also included vendor contact information for furture use during delivery if necessary. Specification sheets can be found in Appendix C.

**Table 12.** Bill of Materials

| GENERAL NOTES (Mechanical Plumbing) | | | | | |
|---|---|---|---|---|---|
| | Description | Quantity | Brand | Model | Specification |
| | | | | | |
| 1 | 3000 Gallon Low Profile Water Tank | 1 | Norwesco | 43011 | 1275 gal, low profile |
| 2 | 300 Gallon Low Profile Utility Tank | 1 | Ace / DenHartod | LP0300-RT | 50 gallon, low profile |
| 3 | Pressurized Well Tank | 1 | Water Worker | HT20HB | 20 gallon |
| 4 | Drainosaur Pump/Tank Combo | 1 | Little Giant | WRSC-6-506065 | 1/3 HP, 115 V |
| 5 | Supply Water Booster Pump | 1 | Walrus | TQ800 | 1 HP, 115 V |
| 6 | Black Water Pump (SaniSwift) | 1 | Saniflo | SANISWIFT | 3/10 HP |
| 7 | Fire Detection and Alarm | 5 | Home Depot | 21009992 | 10-Year Battery Operated Ionization Smoke Alarm |
| 8 | Fire Sprinkler (Viking VK468 Flush Pendent) | 1 | Viking | VK468 | 4.9 K-Factor |
| 11 | Fire Sprinkler (Viking VK476 Flush Pendent) | 5 | Viking | VK476 | 4.9 K-Factor |
| 12 | Fire Sprinkler (Tyco Flush Horizontal Sidewall) | 2 | Tyco | TY2384 | 4.9 K-Factor |
| 13 | 1 in. x 6 ft. Tubolit Self-Seal Foam Pipe Insulation | 4 | Armacell | OES11838 | 1" PEX |
| 14 | 1/2 in x 1/2 in PEX Female Thread Adapter Elbows | 7 | SharkBite | U308LFA | 1/2" PEX x 1/2" Female Thread |
| 15 | 3/4 in x 1/2 in Brass PEX Barb Reducer Coupling | 8 | SharkBite | UC058LF | 3/4" x 1/2" PEX |
| 16 | 3/4 in. Brass PEX Barb Tee | 2 | SharkBite | UC370LFA | 3/4" x 3/4" x 3/4" PEX |
| 17 | 1 in x 1 in Brass PEX Barb Elbow | 3 | SharkBite | UC260LFA | 1"x 1" PEX |
| 18 | 1 in x 1 in x 1 in Brass PEX Barb Tee | 7 | SharkBite | UC374LFA | 1" x 1" x 1" PEX |
| 19 | 1 in. x 3/4 in. Brass PEX Barb Reducer Coupling | 8 | SharkBite | UC060LFA | 1" x 3/4" PEX |
| 20 | 1 in. Brass PEX Barb x Male Pipe Thread Adapter | 1 | SharkBite | UC140LFA | 1" PEX x 1" male thread |
| 21 | 1 in. Supply PEX Piping | 120' | SharkBite | U880B100 | 1" PEX |
| 22 | 3/4 in Cold Water PEX Piping | 60' | SharkBite | U870B100 | 3/4" PEX |
| 23 | 1/2" Insulated Cold Water PEX Piping | 20' | SharkBite | U860I100 | 1/2" Insulated PEX |
| 24 | 3/4" Hot Water PEX Piping | 60' | SharkBite | U870R100 | 3/4" PEX |
| 25 | 1/2" Insulated Hot Water PEX Piping | 20' | SharkBite | U860I100 | 1/2" Insulated PEX |
| 26 | 3/4" Pipe Insulation | 120' | Pratt Retail Specialties | 419921 | 3/4" Insulation ONLY |
| 27 | 3/4 in. x 1/2 in 3-Port Open PEX Manifold | 2 | SharkBite | 22784 | 3/4" x 1/2" x 1/2" x 1/2" x 3/4" PEX |
| 28 | 1/2 in. PEX Clamps | 1 | SharkBite | UC953CPA100 | 100-Pack |
| 29 | 3/4 in. PEX Clamps | 1 | SharkBite | UC955CPA100 | 100-Pack |
| 30 | 1 in. PEX Clamps | 5 | SharkBite | UC956A | 10-Pack |
| 31 | 3/4 in. Brass PEX Barb x Female Threaded Adapter | 2 | SharkBite | UC088LFA | 3/4" PEX x 3/4" female thread |
| 32 | 3/4 in. x 1/2 in PEX reducer Tee | 1 | SharkBite | UC454LFA | 3/4" x 1/2" x 1/2" |
| 33 | 1/2 in. Brass PEX Barb x Female Threaded Adapter | 1 | SharkBite | UC072LFA | 1/2" PEX x 1/2" female thread |
| 34 | 3/4 in. Brass MPT x MHT Quarter-Turn Hose Bibb Valve | 1 | Homewerks Worldwide | VHBQTCF4B | 3/4" male thread x hose bib |
| 35 | 16 oz. ABS Cement in Black | 2 | SharkBiteOatey | 308923 | ABS Bonding Agent |
| 36 | 3 in. x 20 ft. ABS Sch. 40 Plain-End Foamcore Pipe | 6 | Nibco | 57737 | 3" straight ABS |
| 37 | 2 in. x 2 ft. Plastic ABS Pipe | 8 | Nibco | 1202 | 2" straight ABS |
| 38 | 2 in. ABS DWV Hub x Hub x Hub Sanitary Tee | 5 | Nibco | 02753H | 2" x 2" x 2" sanitary tee |
| 39 | 2 in. ABS DWV Hub x Hub Coupling | 10 | Nibco | C5801HD2 | 2" coupling |
| 40 | 3 in. Black ABS DWV H x H Coupling | 8 | Nibco | C5801HD3 | 3" coupling |
| 41 | 2 in. ABS P-Trap | 3 | Nibco | C5885HD2 | 2" P-trap |
| 42 | 2 in. ABS DWV 90 Degree Hub x Hub Elbow | 4 | Nibco | C5807HD2 | 2" 90° |
| 43 | 3 in. ABS DWV SPG x FIPT Female Street Adapter | 1 | Nibco | C58032HD3 | 3" x 3" female prep for plug |
| 44 | 3 in. ABS DWV MIPT Cleanout Plug | 1 | Nibco | C5818HD3 | 3" plug |
| 45 | 3 in. x 3 in. x 2 in. ABS DWV Hub x Hub x Hub Sanitary Tee | 4 | Nibco | C5811HD332 | 3" x 2" x 3" sanitary tee |
| 46 | 3 in. ABS DWV 90 Degree Hub x Hub Elbow | 4 | Nibco | C5807HD3 | 3" 90° |
| 47 | 1/2 in. Plastic Polymer PEX Pipe 90-Degree Bend Support with Mounting Bracket | 25 | SharkBite | 23050 | 1/2" PEX bend |
| 48 | 3/4 in. Plastic Polymer PEX Pipe 90-Degree Bend Support with Mounting Bracket | 5 | SharkBite | 23051 | 3/4" PEX bend |

# Chapter 5: Product Realization/Manufacturing Plan

The Solar Decathlon project team has a dedicated Construction Management team that has created a construction plan. We have included this construction plan in Appendix F. We used this construction plan as a basis for our plumbing construction plan. Our updated Gantt Chart can be seen in Appendix F. As we are only one subsystem of the house we must be sure to complete each phase of our construction on time so as not to delay the build.

**Original Plan**

Material Procurement Phase: To comply with the CM construction plan we will be ordering materials for the plumbing system between 2/1/15 and 3/15/15.

Component Testing: Once we receive major components such as the Saniswift black water pump we will perform initial testing to ensure they are functional before installation into the piping system. This will occur as parts arrive between 2/1/15 and before installation beginning on 3/29/15.

Installation Phase: As a part of the sub-floor construction phase the cold water supply, hot water supply, and return lines will be installed between 3/29/15 and 4/12/15. The fire suppression system will be installed during the framing construction phase and the sprinkler lines are planned to be installed between 4/20/15 and 5/11/15.

**Updated Plan**

Procurement was handled by the architecture department and by the contractor Meno, we submitted our bill of materials and construction documents in a final construction plan to Meno on 6/1/15 and they will be handling further procurement. For all our materials we have written short form specification sheets, which can be seen in Appendix H, that specify requirements the contractor must abide by in ordering and installing our parts.

After discussions between Cal Poly faculty and facilities it was determined that the students would not be able to participate with the construction of the plumbing system due to liability. The students would be able to oversee the construction of the system and would work closely with the contractor to ensure the system was correctly built and installed. However due to delays in these discussions between facilities and faculty, the construction plan was delayed from what we planned for in our Gantt Chart and the Construction Management plan. Because of this most of the construction will be taking place over the summer when we will no longer be involved with the project.

No parts will be manufactured specifically for this project.

# Chapter 6: Design Verification

In order to verify our design, a series of tests and procedures will be performed to effectively qualify the system. A summary of these tests are shown in Table 13 below. This figure details the plumbing team's Design Verification plan and report (DVP&R). The DVP&R is used not only to specify the test description, specification reference, and acceptance criteria, but also to detail the results of the test and whether or not the outcome meets the desired specifications.

**Table 13.** Plumbing Design Verification Plan and Report (DVP&R)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ME428 DVP&R Format** | | | | | | | | | | | | | |
| Report | 12/2/2014 | | Sponsor: | Solar CalPoly | | | | | Component/Assembly | | Solar Decathlon Plumbing | REPORTING ENGINEER: | |
| **TEST PLAN** | | | | | | | | | | **TEST REPORT** | | | |
| | | | | | | SAMPLES TESTED | | TIMING | | TEST RESULTS | | | NOTES |
| Item No | Specification or Clause Reference | Test Description | Acceptance Criteria | Test Responsibility | Test Stage | Quantity | Type | Start date | Finish date | Test Result | Quantity Pass | Quantity Fail | |
| 1 | Building Code | Inspect design to ensure IRC, CSBC, and DOEBC legality | Meets IRC, CSBC, and DOEBC rules and requirements | Robert Burtt | | 1 | B | | | | | | |
| 2 | Minimum Supply Pressure | Lowest pressure in piping system | <= 50 psi | Tyler Dunaway | | 1 | B | | | | | | |
| 3 | Supply Pressure | Run supply pump to ensure meets calculated pressure (det. Item 2) | Within ± 10% of calculated source from Item #2 | Robert Burtt | | 1 | C | | | | | | |
| 4 | Fire Safety | Simulate sprinkler coverage in layout | Coverage of 90% of house or as required by fire protection code | Chris Lutze | | 1 | B | | | | | | |
| 5 | Fire Safety | Sprinkler line flow rate test | Sprinkler head flow rate <= line flow rate | Chris Lutze | | 1 | C | | | | | | |
| 6 | Fire Safety | Sprinkler line pressure test | Sprinkler line pressure > 7 psi | Chris Lutze | | 1 | C | | | | | | |
| 7 | Fuctionality | Waste Pump test | Waste can be pumped into, through, and out of horizontal pipe section | Robert Burtt | | 2 | C | | | | | | |
| 8 | | | | | | | | | | | | | |
| 9 | Building Code/Safety | Visual Inspection | Parts meet standards for system, correct parts and sizing installed in correct locations | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 10 | Efficiency/Durability | Leak test | Pressurize full system after assembly to ensure no leaks | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 11 | Fuctionality | Run test | Run appliances to make sure water is working correctly, house is functional | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 12 | Appliances | Appliance flow rate test | Shower supplies 15 gallons over 10 minutes or more. Other appliances run at functional flow rates. | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |

The design verification plan includes 11 individual tests. Some of these focus on the sprinkler system coverage and flow rate, while others are focused on determining the functionality and performance of the hot and cold supply lines. The entire system will also be viewed and signed off by a professional engineer to make sure that it follows all codes and regulations.

The timing of each individual test will be determined by its location in the construction management schedule. Many of the supply and waste tests will take place during and following the subfloor construction period (3/29/15 - 4/12/15). The sprinkler system will be tested during and following the framing construction phase (4/20/15 - 5/11/15). Smaller sub components such as the Saniswift black water return pump will be tested after it arrives on site (2/15/15 - 3/15/15). Because the pump does not require an entire assembly for its testing, the testing phase will be more effective and will occur before the subfloor is finished.

However due to the construction delays, our procurement was shifted back and we did not have any parts to test so we did not perform any tests.

Another useful resource that will be utilized during the Design Verification phase will be the Potential Failure Mode and Effect Analysis (Design FEMA) which is shown in Appendix A. The Design FMEA lists all of the potential failure modes that could potentially occur to the system and the recommended action to counteract the failure. It also lists the potential causes of specific issues. If a failure occurs during the

build and testing phase, the plumbing team will be able to troubleshoot the problem with the help of this document.

For example, if particulates are found in the water supply during testing if could mean a few things are happening. First, there could be corrosion occurring in the pipes or fixtures. Second, there could be corrosion effecting the pumps. Using the FMEA sheet, the team will be able to quickly jump from symptoms to potential causes, to solution. If used properly, this troubleshoot technique could help avoid a catastrophic failure in the case of particulates in the water, an eventual effect could be equipment failure or pipe rupture. The FEMA will also be useful because it measures the occurrence probability and the criticality of potential failure modes. If the failure mode in question is very critical (Equipment failure caused by cavitation) the team will act more quickly to counteract the problem if it begins to occur.

# Chapter 7: Conclusions and Recommendations

## Conclusion

The final product was not completed in the time allotted. After discussions between Cal Poly faculty and facilities it was determined that the students would not be able to participate with the construction of the plumbing system due to liability. The students would be able to oversee the construction of the system and would work closely with the contractor to ensure the system was correctly built and installed. However due to delays in these discussions between facilities and faculty, the construction plan was delayed around a period of ten weeks from what we planned for in our Gantt Chart and the Construction Management plan. The contingency plan is to complete the build portion of the project during the summer before the competition in October 2015.

During this summer period a team of student construction managers and private contractors will build the entire house. This will include the building, integration and testing of the plumbing system as specified by the content and construction documentation provided by this report. Because all three of the plumbing team members will be receiving full time employment away from San Luis Obispo, they will be contacted via phone to specify any design choices or testing protocols that need further explanation and or documentation.

## Recommendations

The project was designed based on the requirement that the house could function during the course of the Department of Energy competition. Therefore we designed the plumbing layout to work while the house was built, broken down into sections, transported by truck, and finally repositioned on a concrete parking lot for competition. This created multiple problems that wouldn't be issues for a normal stationary house built on the ground. The most important effect on the design was the addition of two intermediate pumps in the return system that pushed the waste water from the house to the septic tank and the constructed wetlands.

This added components that are unnecessary for normal houses. When the project is completed and the house is sold to a private buyer, it will be positioned on a private lot and therefore the return plumbing will be either integrated into the city's sewer system, or if the house is positioned far away from the cities plumbing system, a larger stationary septic tank. This would allow both the grey and black return lines to be dug into the ground, allowing for the return to be powered by gravity. This would remove an expensive component (the pumps) while simultaneously removing the added maintenance and operation costs associated with running the pumps.

The grey water pump could still be integrated into the design if the home owner wanted to keep the constructed wetlands component of the home in its existing form. However, depending on the layout of the plot of land, this added use of energy could be removed.

# APPENDIX A – Design Documents

## Pipe Material Pros and Cons

| Material | Pros | Cons |
|---|---|---|
| PVC (Polyvinyl Chloride Pipe) | • Used to transport high pressure water<br>• Size ranges from ½ inch to 4 inch diameter<br>• Low cost<br>• Glue connections<br>• Corrosion resistant<br>• Strong | • Can only transport cold water (< 140 °F[1])[8] |
| CPVC (Chlorinated Polyvinyl Chloride Pipe) | • More flexible and thinner than PVC<br>• Moderate cost<br>• Handles both hot and cold water<br>• Small outer diameter (equal to copper pipe)<br>• Glue connections<br>• Corrosion resistant<br>• Strong | • More expensive than PEX |
| PEX (Polyethylene Pipe) | • Higher heat resistance than most other plumbing pipe<br>• Flexible and easy to assemble<br>• Often used in water based heating systems<br>• Moderate cost<br>• White, blue and red colors available<br>• Higher flexibility leads to less required fixtures<br>    ○ Lower minor head loss | • More expensive than PVC |
| Copper | • Most common type of piping used in residential homes<br>• High resistance to corrosion and high temperature<br>• Long life<br>• Come in rigid and flexible subtypes | • More expensive than plastic piping (PEX, PVC, CPVC)<br>• Most difficult assembly, requiring soldered fittings |
| Stainless Steel | • Long life (50 years)<br>• Highly resistant to corrosion, temperature and salt water | • Most expensive material |
| ABS (Acrylonitrile butadiene styrene) | • Used in drain-waste-vent pipe systems and sewer systems<br>• Highly durable with high impact strength<br>• Higher impact strength than PVC | • Can deform under direct sunlight |

[8] "Temperature Limitations." *Temperature Limitations*. N.p., n.d. Web. 10 Nov. 2014. <http://www.harvel.com/technical-support-center/engineering-design-data/temperature-limitations>.

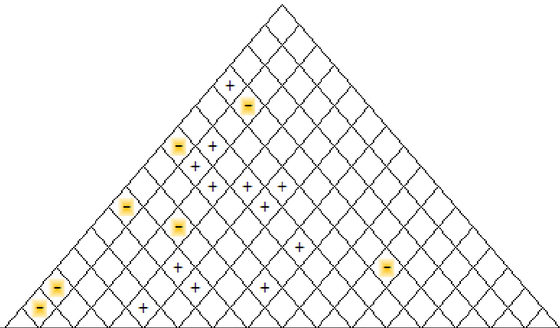
## Quality Function Development

QFD: House of Quality
Project: Plumbing Solar Decathlon
Revision: 1
Date: 10/14/2014

| Correlations | |
|---|---|
| Positive | + |
| Negative | − |
| No Correlation | |

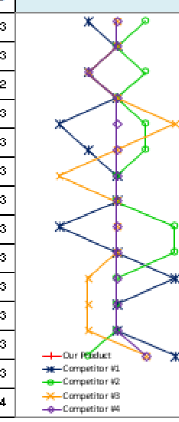
| Relationships | |
|---|---|
| Strong | ● |
| Moderate | ○ |
| Weak | ▽ |

| Direction of Improvement | |
|---|---|
| Maximize | ▲ |
| Target | ◇ |
| Minimize | ▼ |



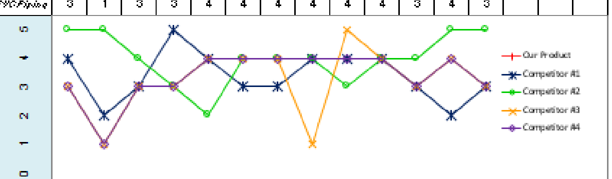
| | | WHO: Customers | | | | | | Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Direction of Improvement | ▲ | ▼ | ◇ | | | | | | | | | | | | | |
| Row # | Weight Chart | Relative Weight | DOE Solar Decathlon | Potential Buyer | Public Education | Team Members | Maximum Relationship | WHAT: Customer Requirements (explicit & implicit) / HOW: Engineering Specifications | Pipe Head Losses | Pipe Flexibility | Centralized | Years of Life | Durability/Strength | Seal Quality | Corrosion Resistance | Temperature Effects | Common Usage | Power Economy | Earthquake Safety | Weight | Number of parts | | | |
| 1 | III | 8% | 5 | 6 | 7 | 8 | 9 | Core Layout | ● | ○ | ● | ● | ▽ | ▽ | ▽ | ▽ | ▽ | ○ | ○ | ▽ | ○ | | | |
| 2 | II | 5% | 5 | 2 | 7 | 4 | 9 | Market Appeal | ▽ | ○ | ● | ● | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ▽ | ○ | | | |
| 3 | III | 7% | 5 | 4 | 5 | 9 | 9 | Engineering | ● | ○ | ○ | ● | ● | ● | ● | ● | ○ | ● | ● | ▽ | ○ | | | |
| 4 | III | 7% | 5 | 2 | 10 | 7 | 9 | Documentation | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ● | ▽ | ● | | | |
| 5 | II | 5% | 5 | 4 | 5 | 4 | 9 | Affordability | ○ | ○ | ○ | ● | ○ | ○ | ○ | ○ | ● | ● | ○ | ▽ | ● | | | |
| 6 | III | 6% | 3 | 7 | 5 | 6 | 9 | Accessibility | ▽ | ● | ● | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ● | | | |
| 7 | IIII | 10% | 5 | 10 | 8 | 9 | 9 | Appliances | ○ | ○ | ● | ● | ○ | ● | ○ | ○ | ▽ | ○ | ○ | ▽ | ▽ | | | |
| 8 | III | 6% | 5 | 6 | 6 | 3 | 3 | Ergonomics [noise] | ▽ | ○ | ○ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | ▽ | | | |
| 9 | II | 5% | 2 | 3 | 6 | 8 | 9 | Ease of Assembly | ▽ | ● | ● | ▽ | ▽ | ▽ | ▽ | ▽ | ● | ▽ | ▽ | ▽ | ● | | | |
| 10 | IIII | 10% | 8 | 8 | 7 | 9 | 9 | Efficiency | ● | ▽ | ● | ● | ● | ● | ▽ | ▽ | ▽ | ● | ▽ | ▽ | ● | | | |
| 11 | IIIII | 10% | 9 | 9 | 8 | 9 | 9 | Safety | ○ | ○ | ○ | ○ | ○ | ● | ● | ● | ○ | ○ | ● | ○ | ○ | | | |
| 12 | III | 7% | 8 | 5 | 6 | 5 | 9 | Environmental Sustainablilty | ▽ | ▽ | ▽ | ● | ● | ● | ○ | ○ | ▽ | ● | ○ | ▽ | ▽ | | | |
| 13 | IIII | 9% | 10 | 3 | 7 | 10 | 9 | Legality | ▽ | ▽ | ▽ | ● | ○ | ▽ | ○ | ○ | ▽ | ○ | ● | ▽ | ▽ | | | |
| 14 | II | 5% | 7 | 1 | 1 | 10 | 9 | Student Development | ● | ● | ● | ○ | ○ | ▽ | ○ | ○ | ▽ | ● | ○ | ▽ | ▽ | | | |

| NOW: Current Product Assessment - Customer Requirements | | | | | |
|---|---|---|---|---|---|
| Row # | Our Current Product | Competitor #1: Copper Piping | Competitor #2: PEX Piping | Competitor #3: PVC Piping | Competitor #4: CPVC |
| 1 | | 2 | 4 | 3 | 3 |
| 2 | | 3 | 3 | 3 | 3 |
| 3 | | 2 | 4 | 2 | 2 |
| 4 | | 3 | 3 | 3 | 3 |
| 5 | | 1 | 4 | 5 | 3 |
| 6 | | 2 | 4 | 3 | 3 |
| 7 | | 3 | 3 | 1 | 3 |
| 8 | | 3 | 3 | 3 | 3 |
| 9 | | 1 | 5 | 3 | 3 |
| 10 | | 3 | 5 | 3 | 3 |
| 11 | | 5 | 3 | 2 | 3 |
| 12 | | 3 | 3 | 2 | 3 |
| 13 | | 3 | 3 | 2 | 3 |
| 14 | | 5 | 2 | 4 | 4 |




| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOW MUCH: Target | < 5 Percent loss | Hand Bending without kinking | 70% of controls/valves accessible from core room | 80 | Exceeds code strength requirements | No leakage | No serious degradation of plumbing systems from corrosion after 20 years | No system concerns from temperature change | 80% of plumbers familiar with system | 90% efficiency | No catastrophic failures after magnitude 7.0 earthquake | reasonable human carrying load | reasonable assembly time and simplicity of system (less chance of leaks, | | | |
| Max Relationship | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | | | |
| Technical Importance Rating | 382.8 | 337.5 | 548.3 | 608.8 | 375.2 | 467.8 | 318.8 | 318.8 | 230.4 | 454.1 | 440.1 | 120.9 | 426.8 | | | |
| Relative Weight | 8% | 7% | 11% | 12% | 7% | 9% | 6% | 6% | 5% | 9% | 9% | 2% | 8% | | | |
| Weight Chart | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Competitor #1: *Copper Piping* | 4 | 2 | 3 | 5 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 2 | 3 | | | |
| Competitor #2: *PEX Piping* | 5 | 5 | 4 | 3 | 2 | 4 | 4 | 4 | 3 | 4 | 4 | 5 | 5 | | | |
| Competitor #3: *PVC Piping* | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 1 | 5 | 4 | 3 | 4 | 3 | | | |
| Competitor #4: *CPVC Piping* | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | | | |

Current Product Assesment - Engineering Specifications




| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

## Design Verification Plan and Report

| ME428 DVP&R Format | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Report | 12/2/2014 | | Sponsor: | Solar CalPoly | | | | | Component/Assembly | | Solar Decathlon Plumbing | REPORTING ENGINEER: | |
| **TEST PLAN** | | | | | | | | | | **TEST REPORT** | | | |
| | | | | | | SAMPLES TESTED | | TIMING | | TEST RESULTS | | | |
| Item No | Specification or Clause Reference | Test Description | Acceptance Criteria | Test Responsibility | Test Stage | Quantity | Type | Start date | Finish date | Test Result | Quantity Pass | Quantity Fail | NOTES |
| 1 | Building Code | Inspect design to ensure IRC, CSBC, and DOEBC legality | Meets IRC, CSBC, and DOEBC rules and requirements | Robert Burtt | | 1 | B | | | | | | |
| 2 | Minimum Supply Pressure | Lowest pressure in piping system | <= 50 psi | Tyler Dunaway | | 1 | B | | | | | | |
| 3 | Supply Pressure | Run supply pump to ensure meets calculated pressure (det. Item 2) | Within ± 10% of calculated source from Item #2 | Robert Burtt | | 1 | C | | | | | | |
| 4 | Fire Safety | Simulate sprinkler coverage in layout | Coverage of 90% of house or as required by fire protection code | Chris Lutze | | 1 | B | | | | | | |
| 5 | Fire Safety | Sprinkler line flow rate test | Sprinkler head flow rate <= line flow rate | Chris Lutze | | 1 | C | | | | | | |
| 6 | Fire Safety | Sprinkler line pressure test | Sprinkler line pressure > 7 psi | Chris Lutze | | 1 | C | | | | | | |
| 7 | Fuctionality | Waste Pump test | Waste can be pumped into, through, and out of horizontal pipe section | Robert Burtt | | 2 | C | | | | | | |
| 8 | | | | | | | | | | | | | |
| 9 | Building Code/Safety | Visual Inspection | Parts meet standards for system, correct parts and sizing installed in correct locations | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 10 | Efficiency/Durability | Leak test | Pressurize full system after assembly to ensure no leaks | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 11 | Fuctionality | Run test | Run appliances to make sure water is working correctly, house is functional | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |
| 12 | Appliances | Appliance flow rate test | Shower supplies 15 gallons over 10 minutes or more. Other appliances run at functional flow rates. | Robert Burtt, Chris Lutze, Tyler Dunaway | | 1 | C | | | | | | |

# Design Failure Mode and Effect Analysis

*Potential*
**Failure Mode and Effect Analysis**
**(Design FMEA)**

**Solar Decathalon System**
**Plumbing Subsystem**
**Mechanical Engineering Component**

**Design Responsibility:**

**Model Year(s)/Vehicle(s):**

**Key Date: 12/1/14**

**Core Team:** Robert Burtt, Tyler Dunaway, Chris Lutze

**FMEA Number:**

**Page 1 of 1**

**Prepared By: Robert Burtt, Tyler Dunaway, C**

**FMEA Date (Orig.) (Rev.)**

| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Potential Cause(s) / Mechanism(s) of Failure | Occur | Crit | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Action Results: Sev | Action Results: Occur | Action Results: Crit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pipes/Fixtures | Leak | Water damage | 8 | Poor installation | 3 | 24 | Proper installation | Tyler Dunaway | | | | |
| | Clog | No water flow | 7 | Kink/Sharp Bend | 2 | 14 | Proper design | Tyler Dunaway | | | | |
| | | | 7 | Particulates | 2 | 14 | Proper material choice | Tyler Dunaway | | | | |
| | Overheat | Deformation | 6 | Incorrect Design | 3 | 18 | Proper material choice | Tyler Dunaway | | | | |
| | Overpressure | Shrapnel | 10 | Incorrect Sizing | 2 | 20 | Determine correct pressures and flow rates | Tyler Dunaway | | | | |
| | | | | Material Failure | 1 | 0 | Proper material choice | Tyler Dunaway | | | | |
| | | Overflow to appliances | 6 | Incorrect Sizing | 4 | 24 | Proper line sizing, pressure, and flow | Tyler Dunaway | | | | |
| | Corrosion | Particulates | 3 | Lack of insulation/coating | 1 | 3 | Material choice/Coating choice | Tyler Dunaway | | | | |
| | | water damage | 8 | Lack of insulation/coating | 1 | 8 | Material choice/Coating choice | Tyler Dunaway | | | | |
| | | Inadequate flow | 6 | Lack of insulation/coating | 1 | 6 | Material choice/Coating choice | Tyler Dunaway | | | | |
| | | Rupture | 10 | Lack of insulation/coating | 1 | 10 | Material choice/Coating choice | Tyler Dunaway | | | | |
| | Fastening Failure | Water damage | 8 | Inccorect fastening choice | 3 | 24 | Proper line sizing, pressure, and flow | Tyler Dunaway | | | | |
| | | Lower Flow | 6 | Inccorrect fastener sizing | 2 | 12 | Proper line sizing, pressure, and flow | Tyler Dunaway | | | | |
| Pumps | Overheat | Equipment failure | 8 | Vibration | 3 | 24 | Anchor pump correctly, size pump to deal with flowrate and head losses | Robert Burtt | | | | |
| | | Deformation | 6 | Vibration / Friction | 2 | 12 | Anchor pump correctly, size pump to deal with flowrate and head losses | Robert Burtt | | | | |
| | Fracture | Equipment failure | 8 | Vibration / Friction | 2 | 16 | Anchor pump correctly, size pump to deal with flowrate and head losses | Robert Burtt | | | | |

*Potential*
**Failure Mode and Effect Analysis**
**(Design FMEA)**

**Solar Decathlon System**
**Plumbing Subsystem**
**Mechanical Engineering Component**

**FMEA Number:**

**Design Responsibility:**

**Page 1 of 1**

**Model Year(s)/Vehicle(s):**

**Key Date: 12/1/14**

**Prepared By: Robert Burtt, Tyler Dunaway, C**

**Core Team: Robert Burtt, Tyler Dunaway, Chris Lutze**

**FMEA Date (Orig.) (Rev.)**

| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Potential Cause(s) / Mechanism(s) of Failure | Occur | Crit | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Action Results: Sev | Action Results: Occur | Action Results: Crit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clog | Loss of flow | 7 | Incorrect Sizing | 3 | 21 | Size pump to deal with flowrate and head losses | Robert Burtt | | | | |
| | Cavitation | Equipment failure | 8 | Incorrect Flow, Rapid Pressure Change | 3 | 24 | Size pump to deal with flowrate and head losses | Robert Burtt | | | | |
| | | Lowered efficiency | 6 | Incorrect Flow, Rapid Pressure Change | 3 | 18 | Size pump to deal with flowrate and head losses, Calculate correct pump effeciency (AKA pump efficiency curves) | Robert Burtt | | | | |
| | | Lowered Life | 6 | Vibration, Incorrect Flow, Friction, Wear | 3 | 18 | Anchor pump correctly, size pump to deal with flowrate and head losses | Robert Burtt | | | | |
| | Corrosion | Equipment failure | 8 | Particulates, Cathode/Anode Reaction | 2 | 16 | Proper material choice, Proper installation | Robert Burtt | | | | |
| | | Lowered Life | 6 | Particulates, Cathode/Anode Reaction | 2 | 12 | Proper material choice, Proper installation | Robert Burtt | | | | |
| Appliances | Leak | Inadequate flow | 6 | Inadequate Pressure, Incorrect Fixturing, Improper Handling | 4 | 24 | Proper applience / line sizing choice | Robert Burtt | | | | |
| | | Flooding | 8 | Incorrect Fixturing | 1 | 8 | Proper applience / line sizing choice | Robert Burtt | | | | |
| | Clog | Inadequate flow | 6 | Particulates | 4 | 24 | Proper material choice, Proper installation | Robert Burtt | | | | |
| | Overpressure | Burst | 9 | Incorrect line size, line crimping/kinking | 1 | 9 | Proper material choice, Proper installation, Proper line sizing | Robert Burtt | | | | |
| | | Internal failure | 8 | Incorrect line size, line crimping/kinking | 2 | 16 | Proper material choice, Proper installation, Proper line sizing | Robert Burtt | | | | |

*Potential*
Failure Mode and Effect Analysis
(Design FMEA)

**Solar Decathalon System**
**Plumbing Subsystem**
**Mechanical Engineering Component**

**FMEA Number:**

**Design Responsibility:**

**Page 1 of 1**

**Model Year(s)/Vehicle(s):**

**Key Date: 12/1/14**

**Prepared By: Robert Burtt, Tyler Dunaway, Cl**

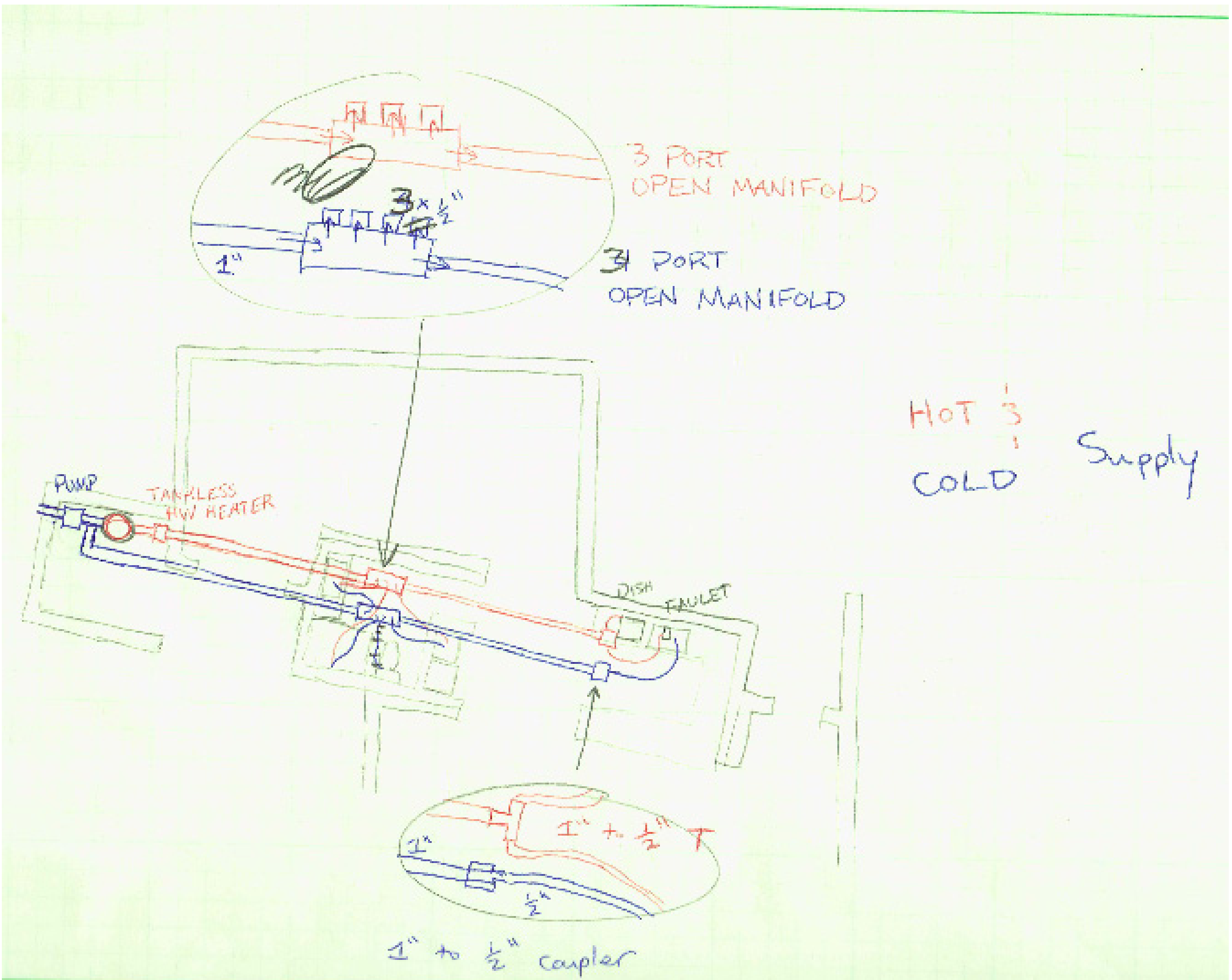
**Core Team: Robert Burtt, Tyler Dunaway, Chris Lutze**

**FMEA Date (Orig.) (Rev.)**

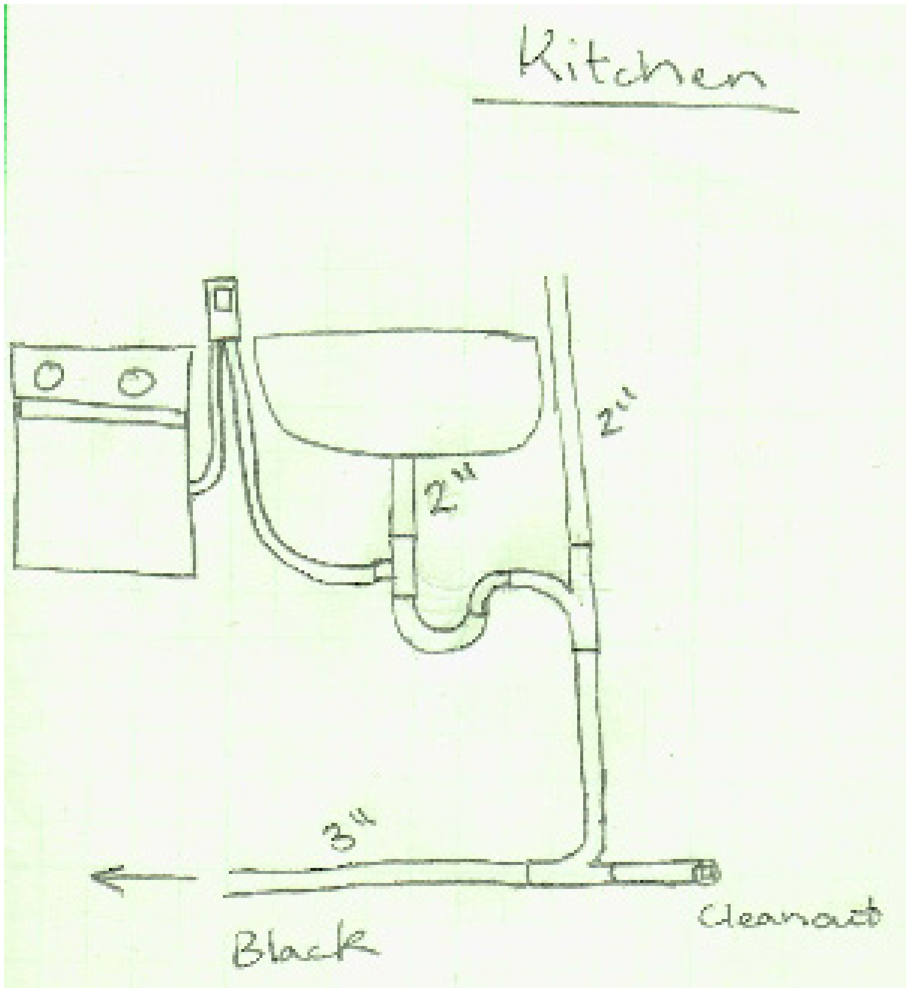
| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Potential Cause(s) / Mechanism(s) of Failure | Occur | Crit | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occur | Crit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Underpressure | Inadequate performance | 6 | Incorrect line size, line crimping/kinking | 3 | 18 | Proper material choice, Proper installation, Proper line sizing, Proper applience choice | Robert Burtt | | | | |
| Sprinklers | Overpressure | Pipe burst | 10 | Incorrect line size, line crimping/kinking | 2 | 20 | Proper material choice | Chris Lutze | | | | |
| | | Premature activation | 8 | Incorrect sprinkler head choice, temperature spike in house activates system | 1 | 8 | Proper pressure, Proper material / head choice | | | | | |
| | Underpressure | Inadequate coverage | 10 | Incorrect sprinkler head choice, line sizing incorrect | 2 | 20 | Proper line sizing, pressure, and flow | Chris Lutze | | | | |
| | Failure to trigger | Failure to provide coverage | 10 | Incorrect sprinkler head choice, line sizing incorrect, incorrect temperature of activation | 2 | 20 | Proper sprinkler choice | Chris Lutze | | | | |
| | Clog | Failure to provide coverage | 10 | Incorrect sprinkler head choice, line sizing incorrect, incorrect temperature of activation | 2 | 20 | Proper design | Chris Lutze | | | | |

## Plumbing Second Design Iterations

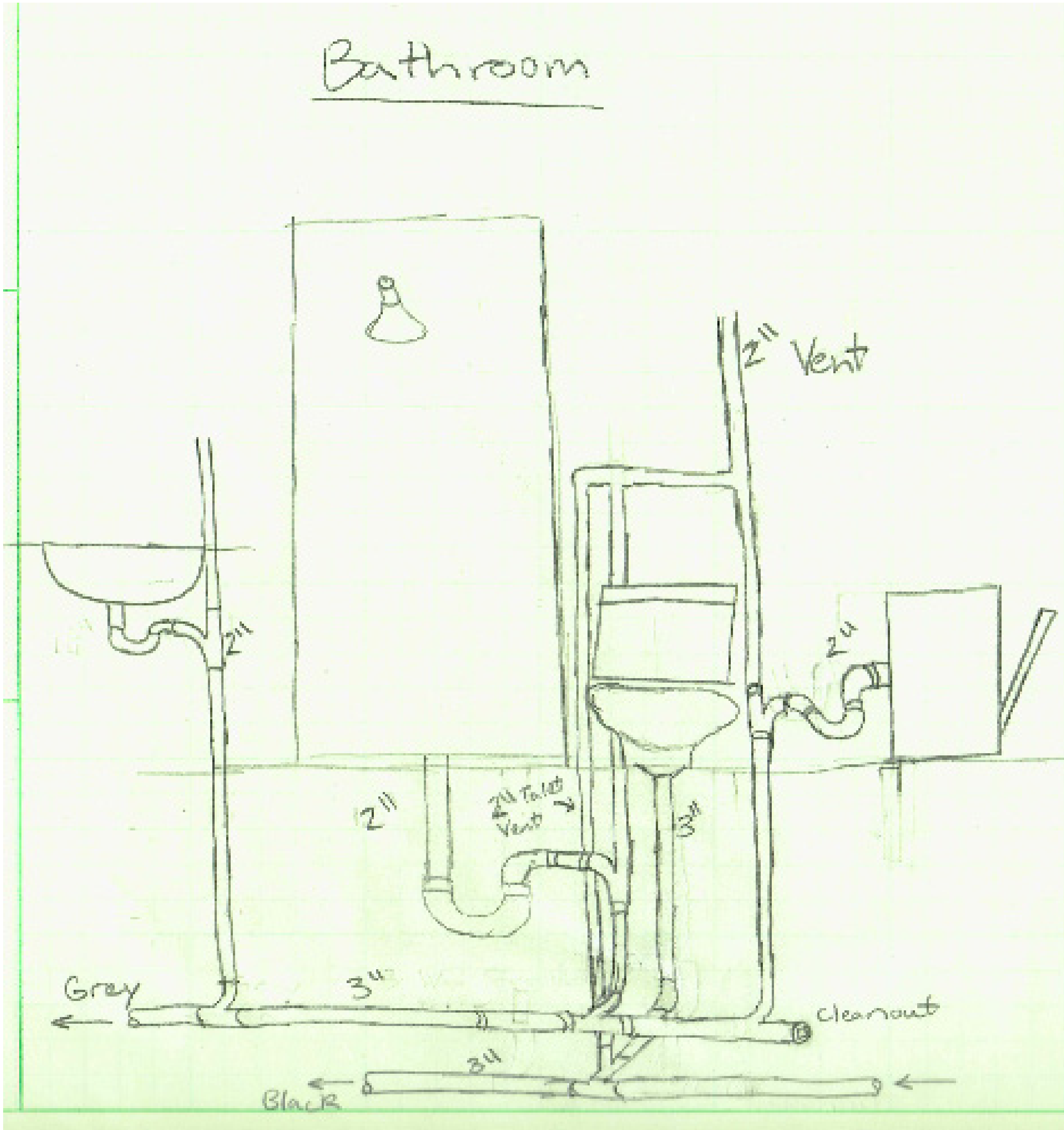
This appendix details the second design iteration that the plumbing subsystem generated during the design process. These designs were heavily utilized in the design of the Current Revit model.




Hot and Cold Supply Diagram

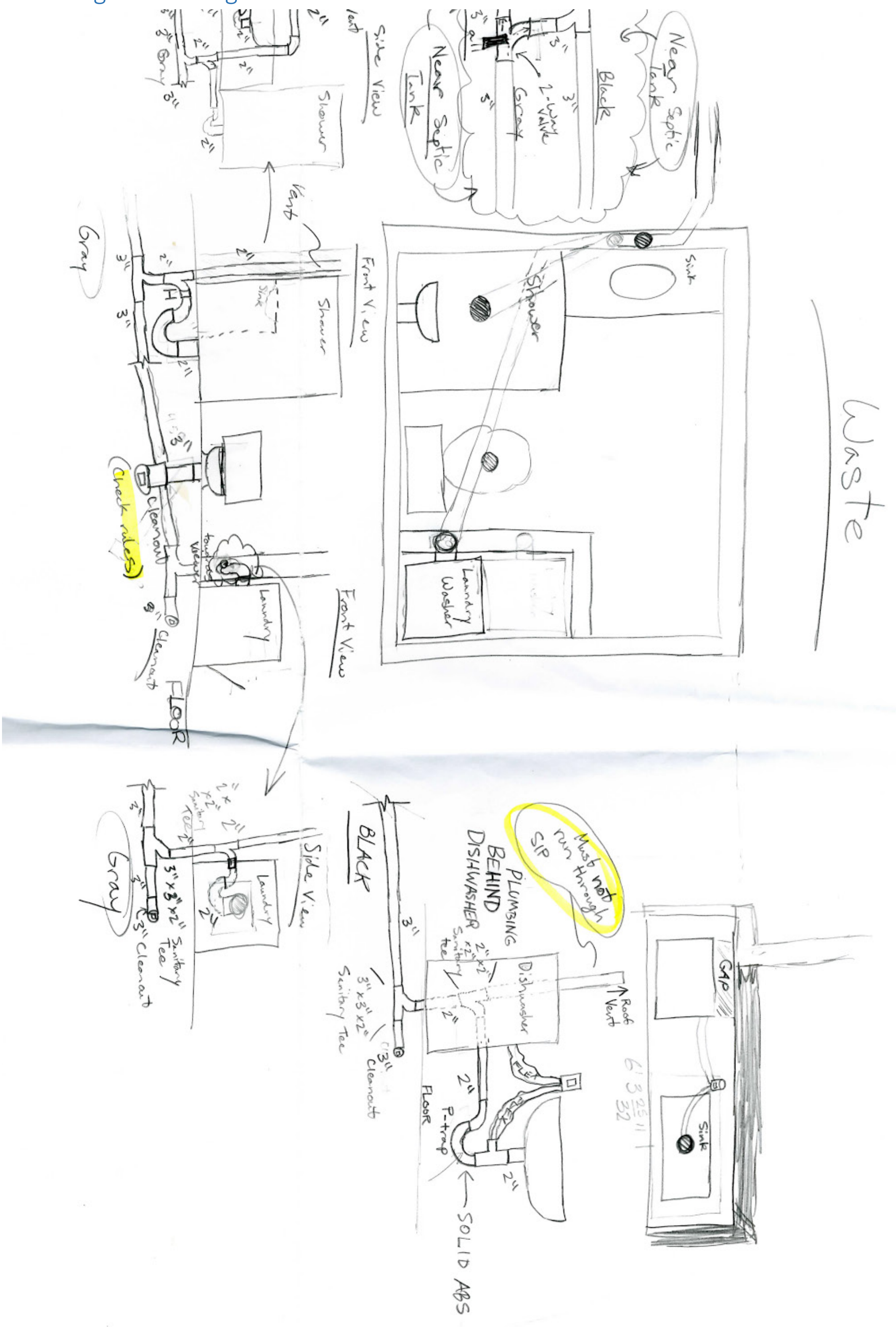


Kitchen Sink and Dishwasher Return and Vents Schematic



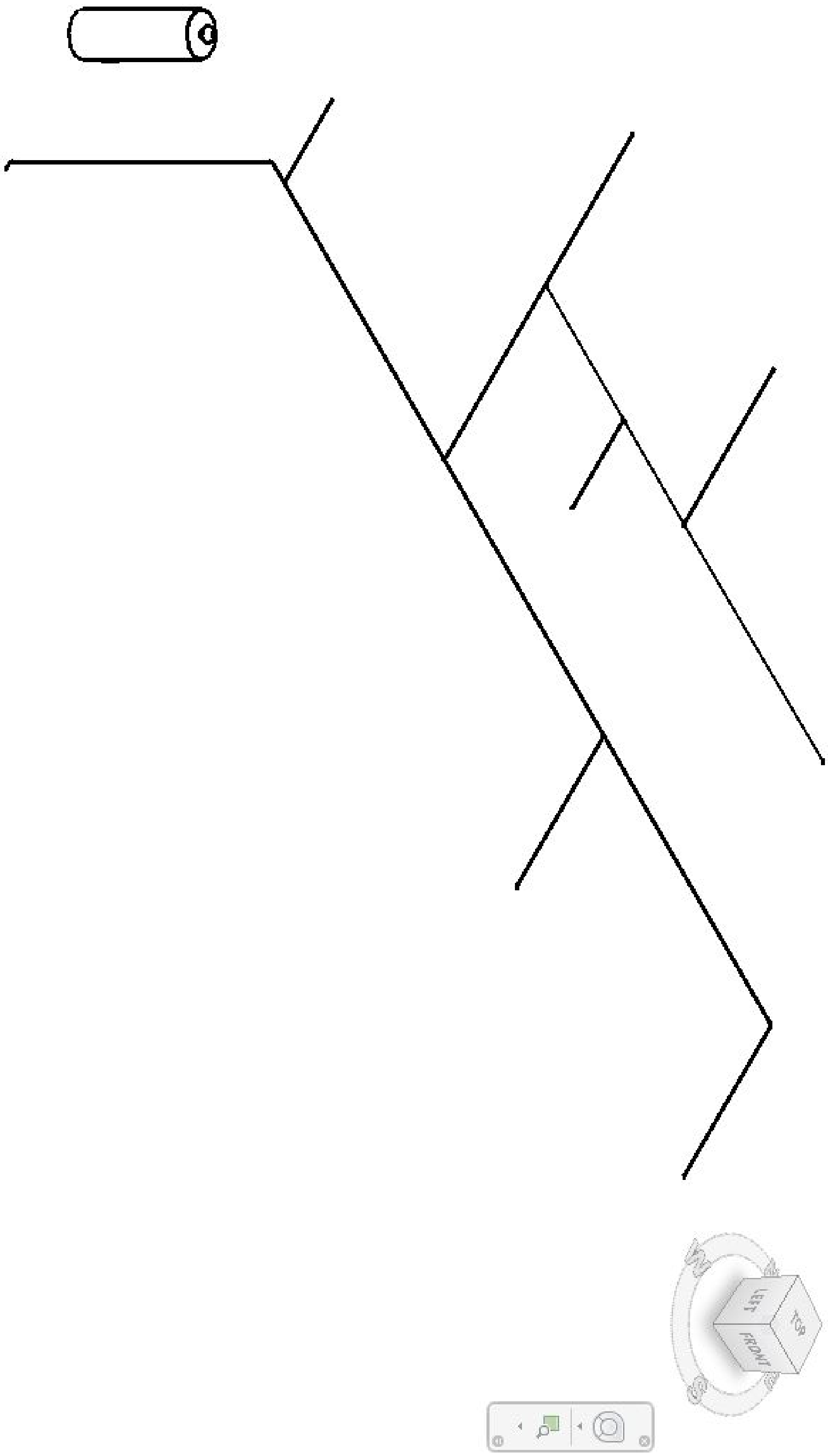
Bathroom Return and Vents Schematic

## Plumbing Third Design Iteration

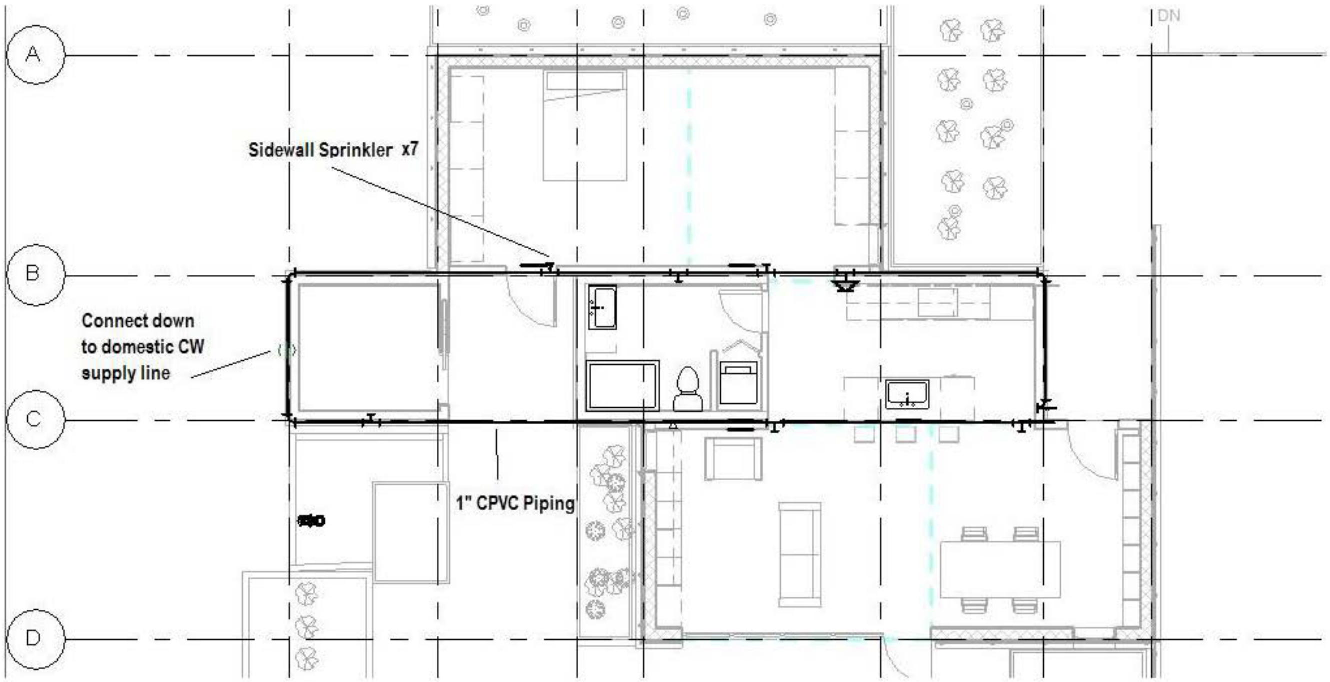


Supply Tank
(Norwesco Low Profile Tank)
2" female outlet
Utility Room @ Compact Equipment
Water Heater
Wall Tank (cold)
Supply Pump
Goes below floor
3/4" pex HOT
3/4" pex COLD
Through Floor
Through Wall
Shower
Toilet
Washer
3-Port Manifolds
Bedroom Office
= Above Floor
Move Washer here
move dryer to washer spot
Kitchen
Dishwasher
Sink

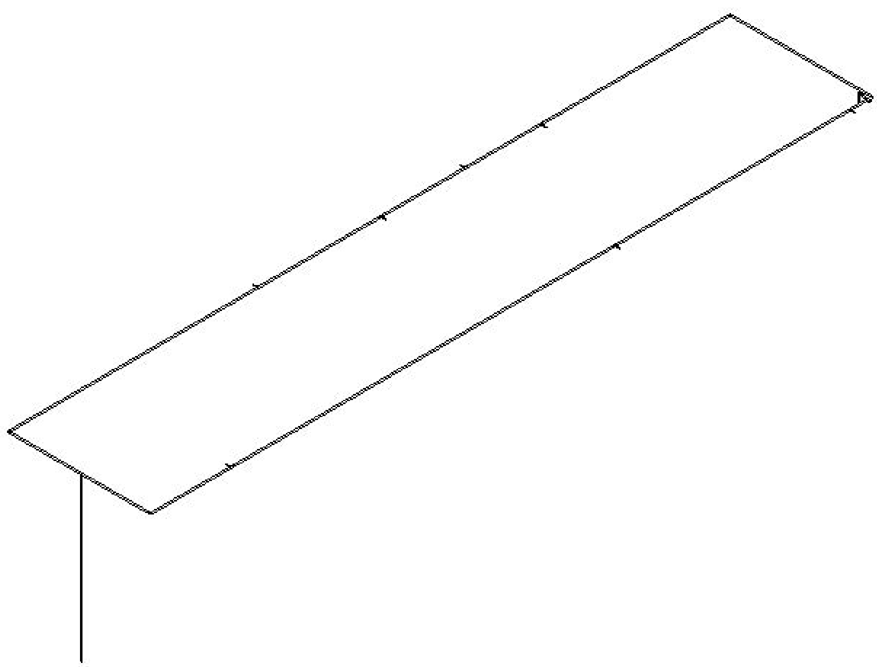
## Fire Suppression First Design Iteration



## Fire Suppression Looped Design Iteration



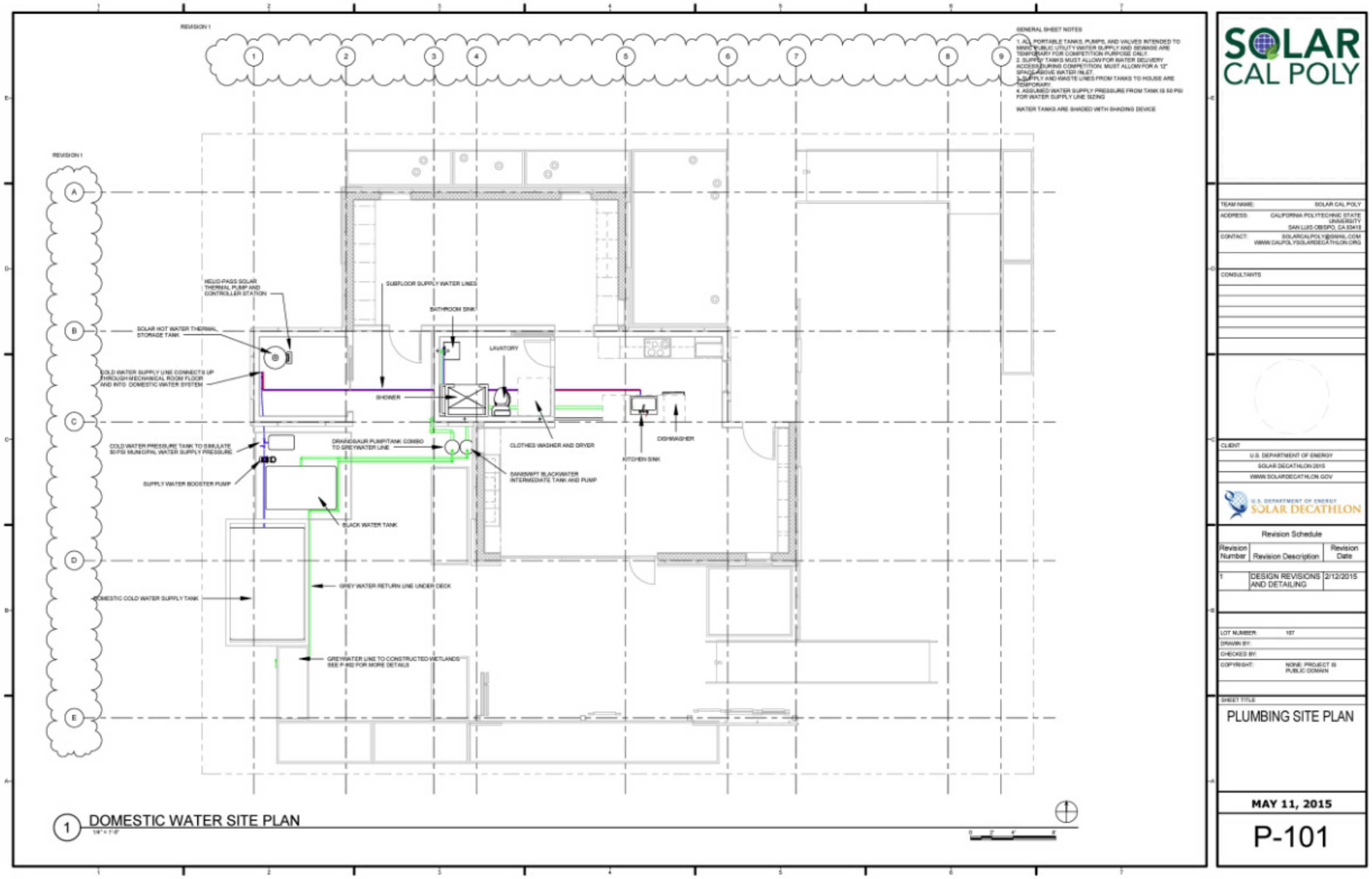

Fire Supression Site Plan - Update



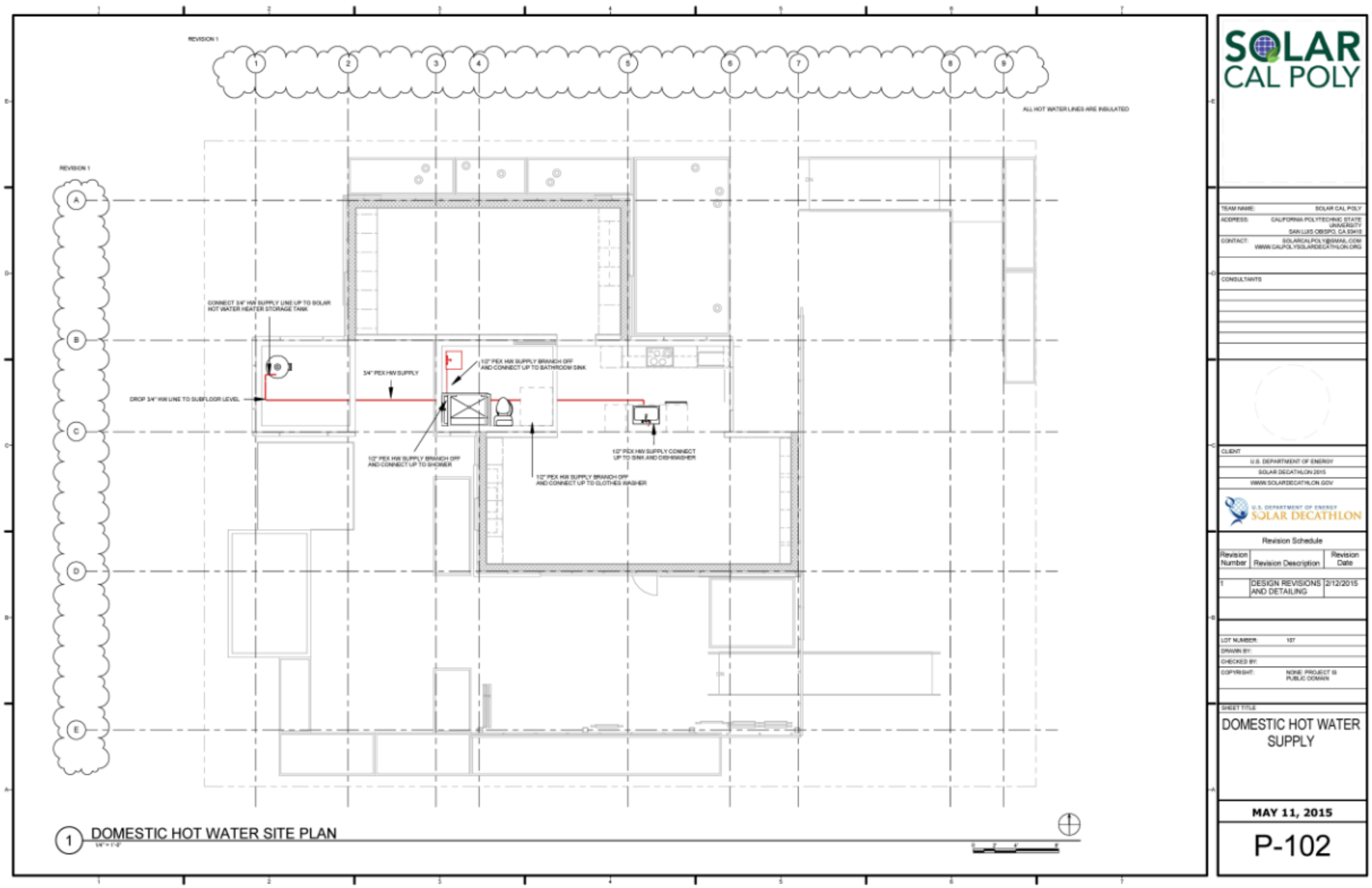
Fire Suppression Isometric - Update

# APPENDIX B – Construction Documents

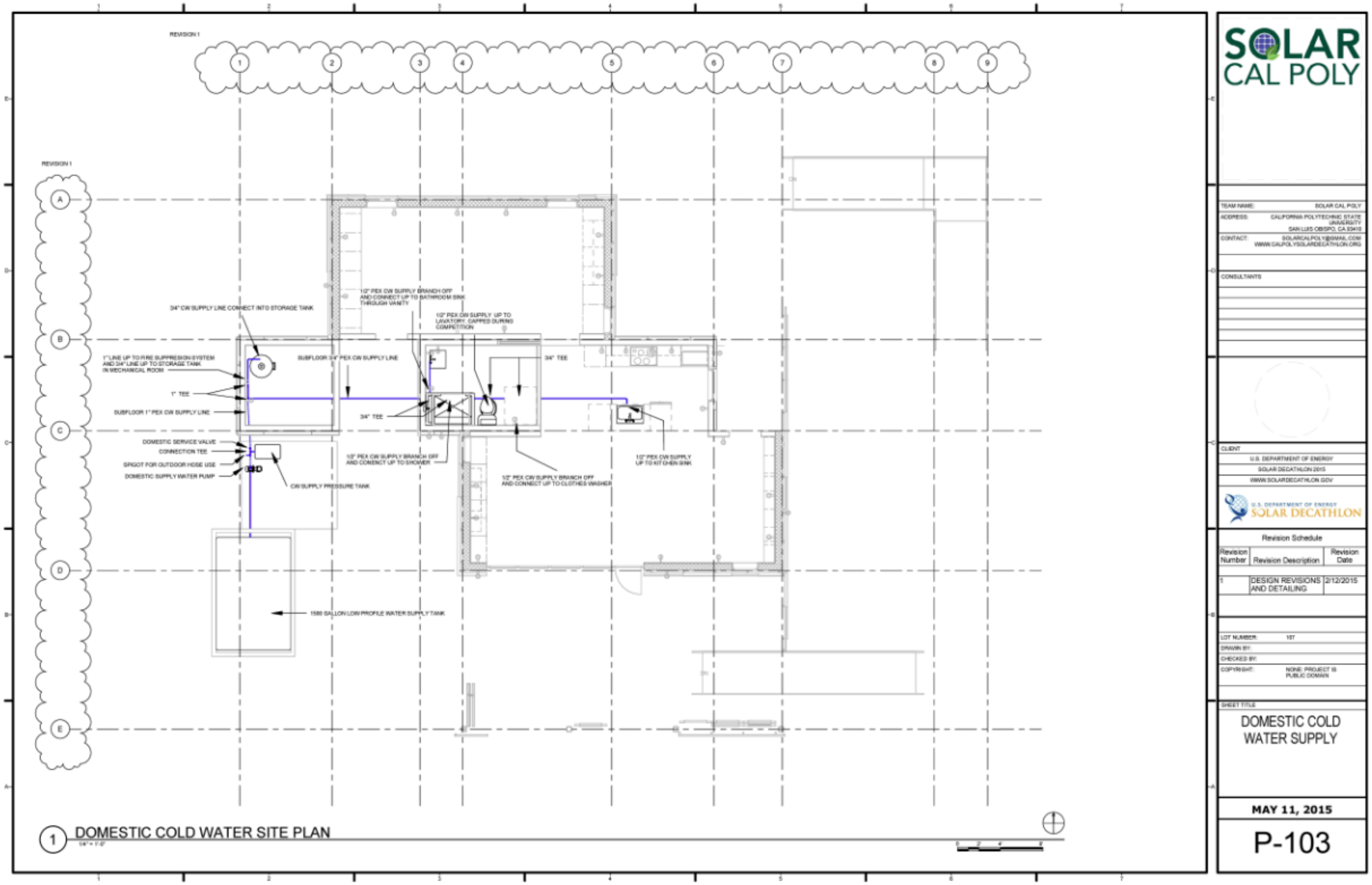
## Plumbing Site Plan



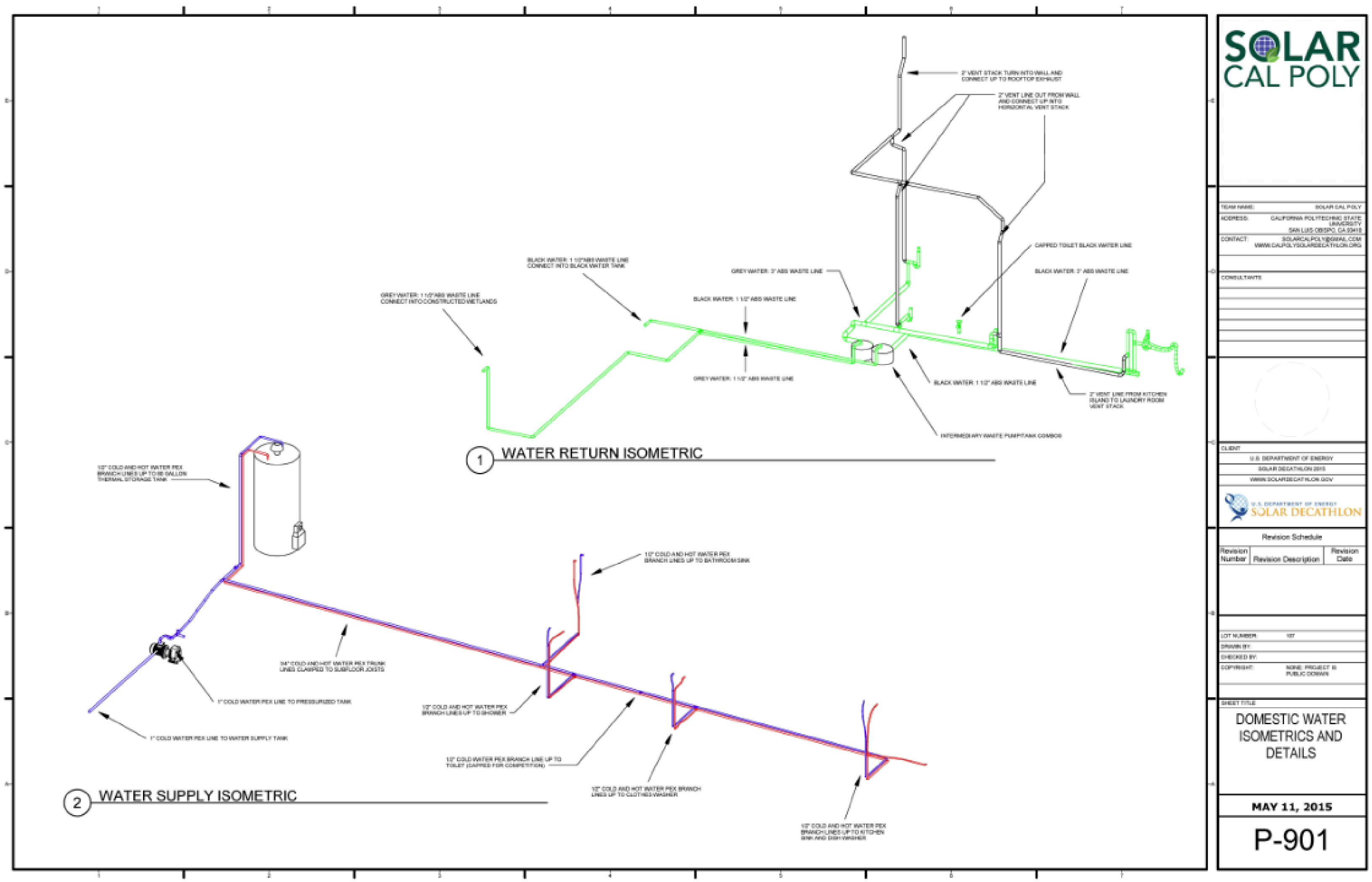
## Domestic Hot Water Supply Diagram



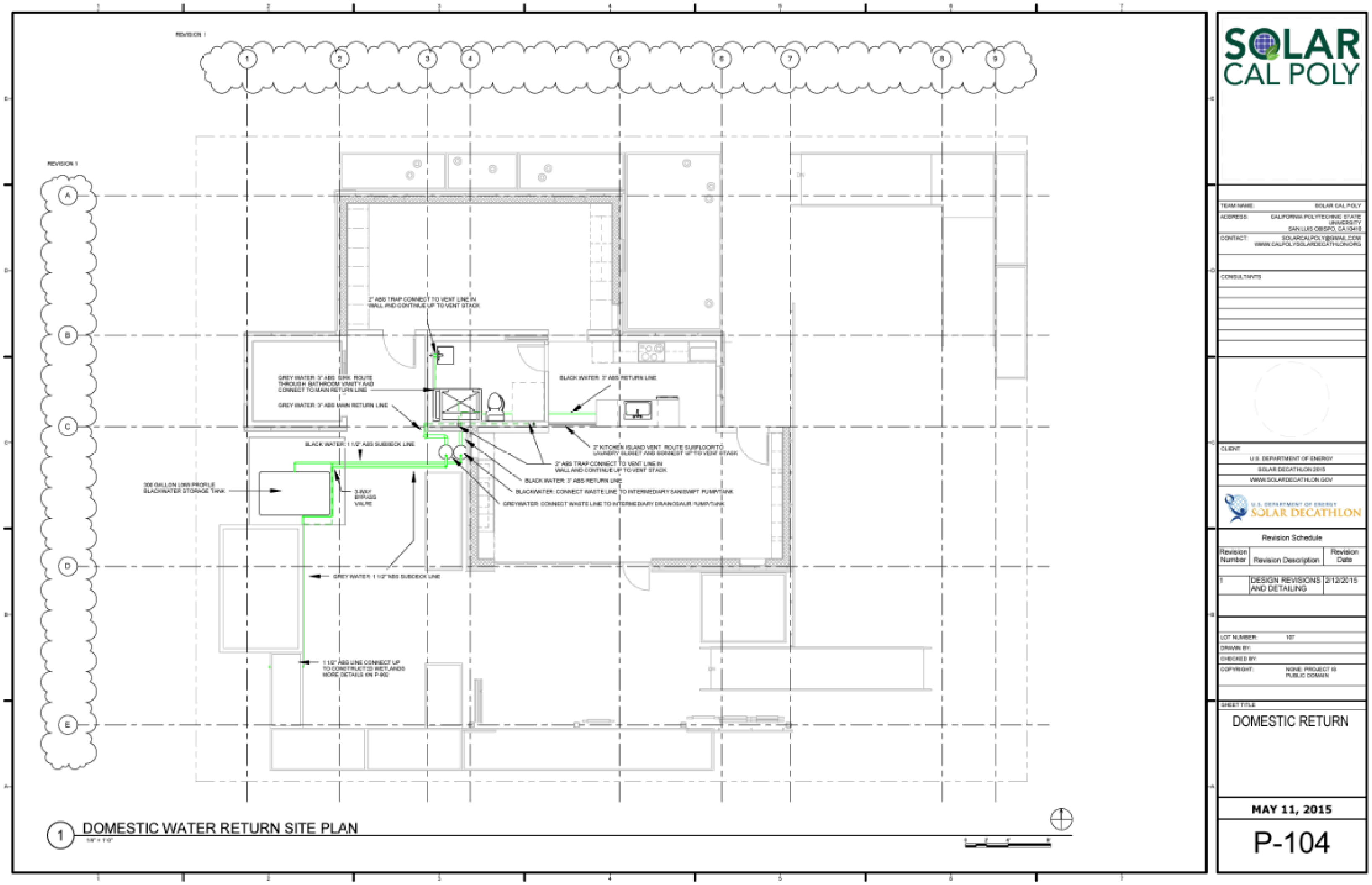
## Domestic Cold Water Supply Diagram



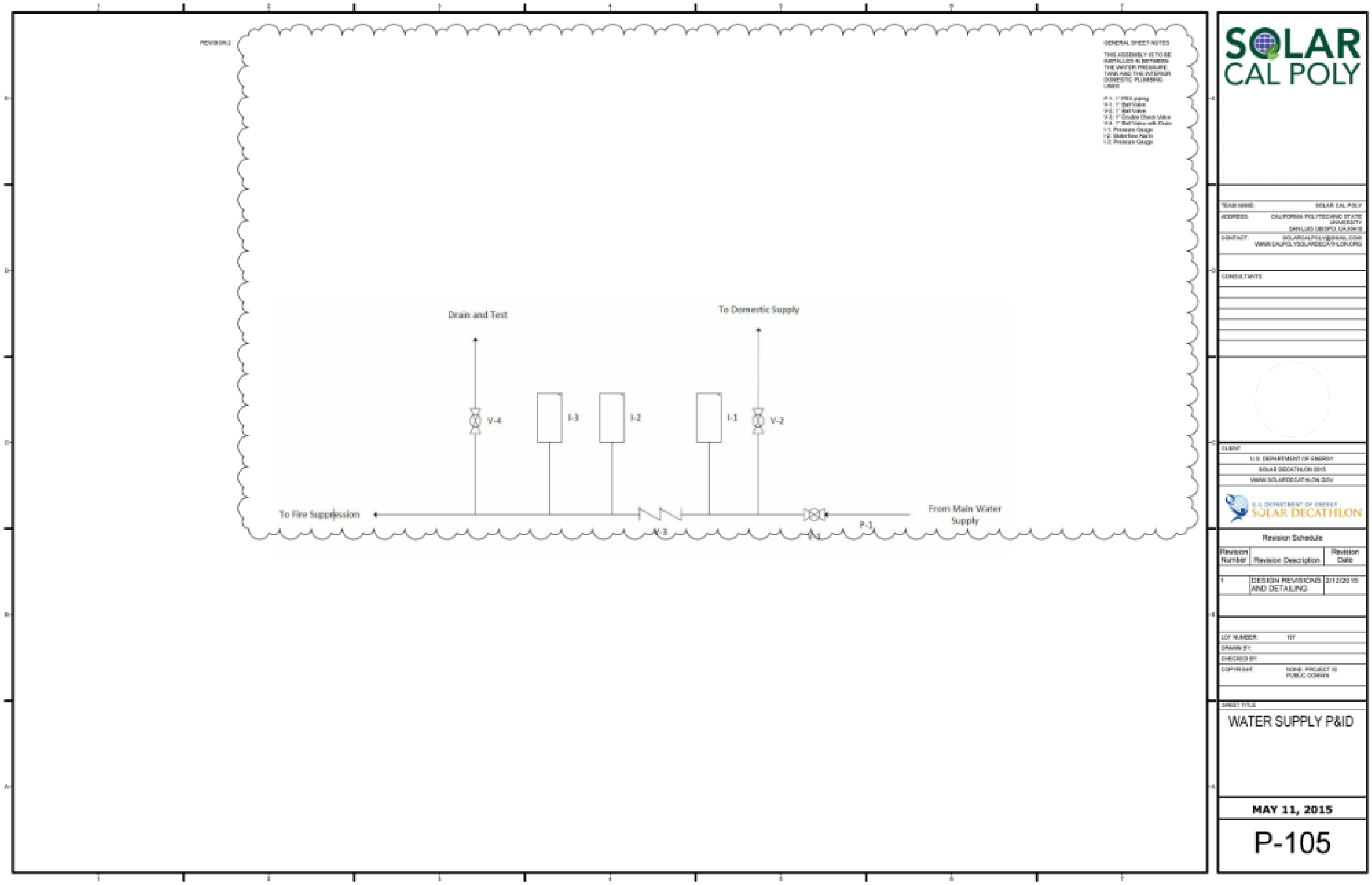
## Domestic Water Isometrics and Details



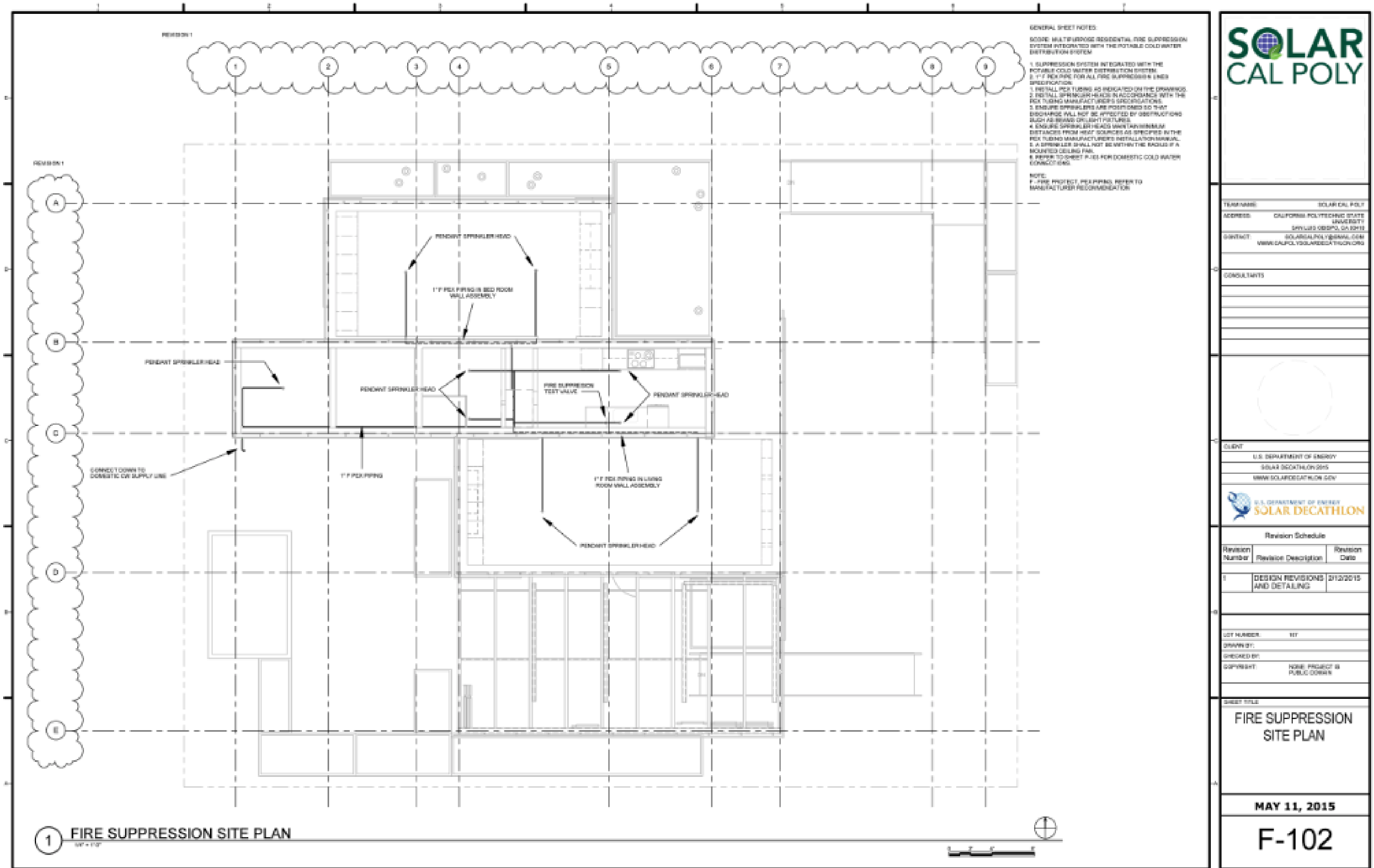
## Domestic Water Return Site Plan



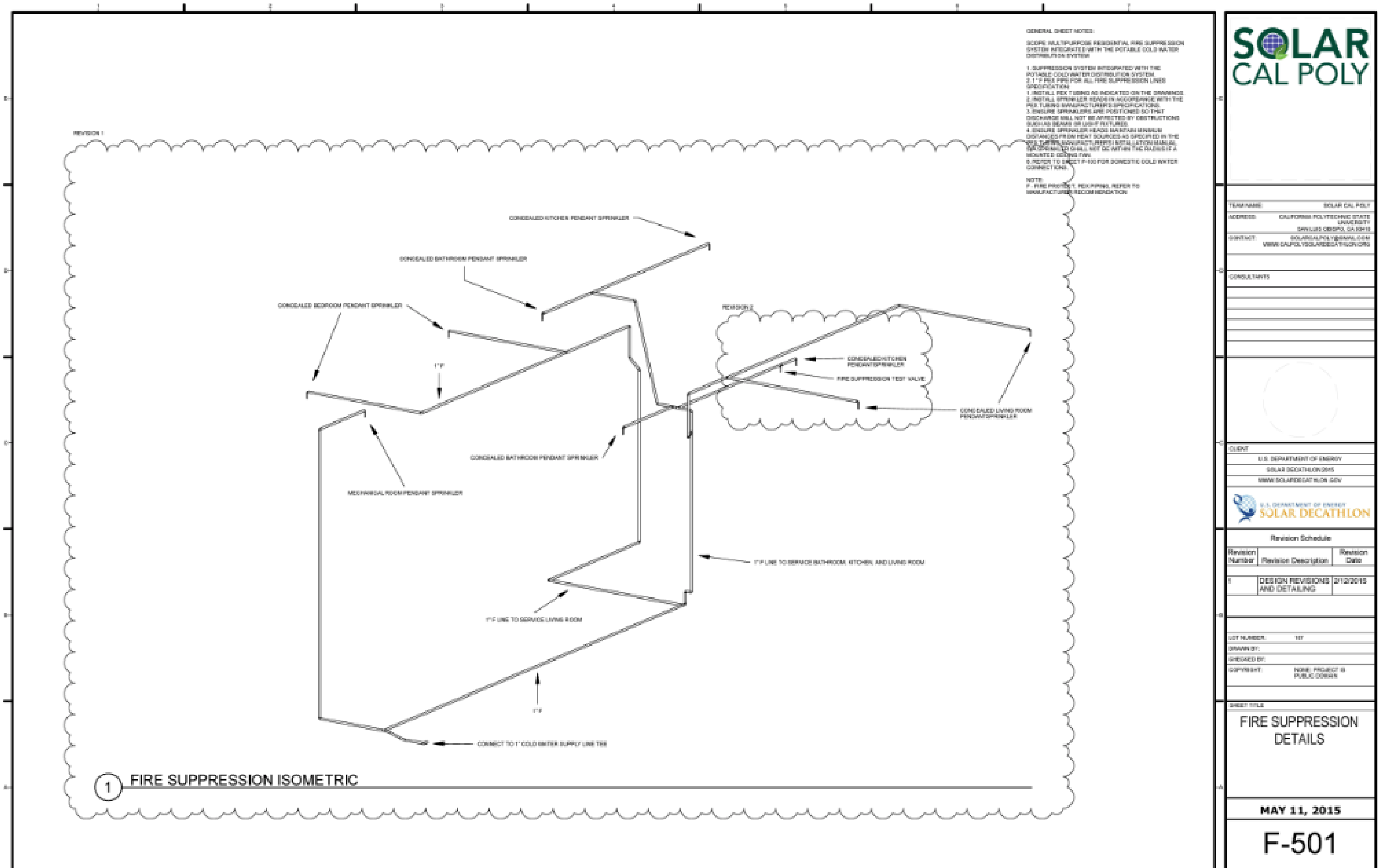
## Domestic Supply P&ID

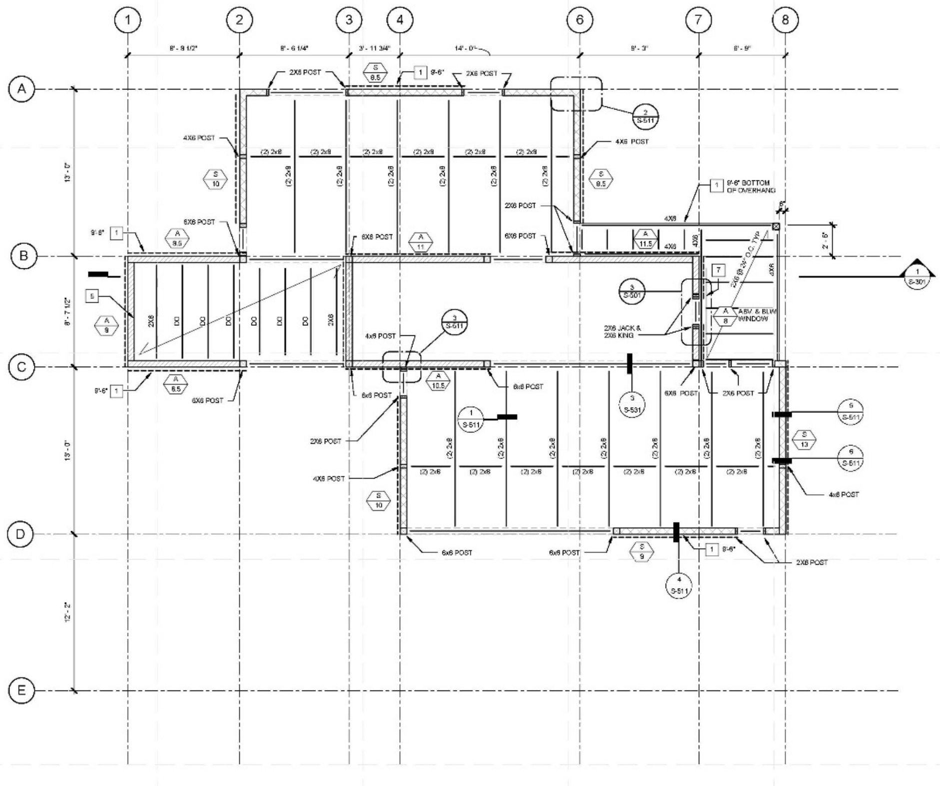


## Fire Suppression Site Plan



## Fire Suppression Isometric






1 LOW ROOF FRAMING PLAN
1/4" = 1'-0"

LOW ROOF FRAMING NOTES

1. PLATE HEIGHT AFF VERIFY WITH ARCHITECTURAL
2. PROVIDE (2) 2x8 HEADERS ABOVE ALL WINDOWS UNO
3. SIP ROOF SHALL BE 8 1/4" SIPS w/ 8d NIALS @ 6" O.C.
4. ALL BEARING WALLS SHALL BE 6 1/2" SIPS w/ 4X6 DFL #1 SPLIN AT ADJOINING PANELS OR 6" NOMINAL STUD FRAMED WALLS
5. PROVIDE 2X6 LEDGER AT FACE OF WALL
6. USE LUS26 SIMPSON HANGER FOR 2X6 CEILING JOISTS AT CENTER MODULE
7. USE CS18 X 6'-0" SIMPSON STRAP TO 2x BLOCKING ABOVE AND BELOW WINDOW OPENING
8. STRAP BREAKS IN TOP PLATE WITH CS16 x 36" UNO ON PLANS

SHEAR WALL SCHEDULE

| TYPE | SHEATHING/FRAMING | NAILING | POST | SILL PLATE | HOLD DOWNS |
|---|---|---|---|---|---|
| A | 1/2" STRUCUTURAL SHEATHING w/ 2X STUD FRAMING | 8d common @ 6" o.c. EN w/ 12" o.c. FIELD NAILING | 2-2x | 2x w/ 5/8" ATS @ 16" o.c. | HDU2 UNO |
| S | 6 1/2" SIP w/ 4x8 DF#1 SPLINES | 8d common @ 6" o.c. @ SIP EDGES | 4x | 2x w/ 5/8" ATS @ 16" o.c. | HDU2 |

SOLAR CALPOLY

TEAM NAME: SOLAR CALPOLY
ADDRESS: CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CA 93407
CONTACT: SOLARCALPOLY@GMAIL.COM
WWW.CALPOLYSOLARDECATHLON.ORG

CONSULTANTS

CLIENT
U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON 2015
WWW.SOLARDECATHLON.GOV

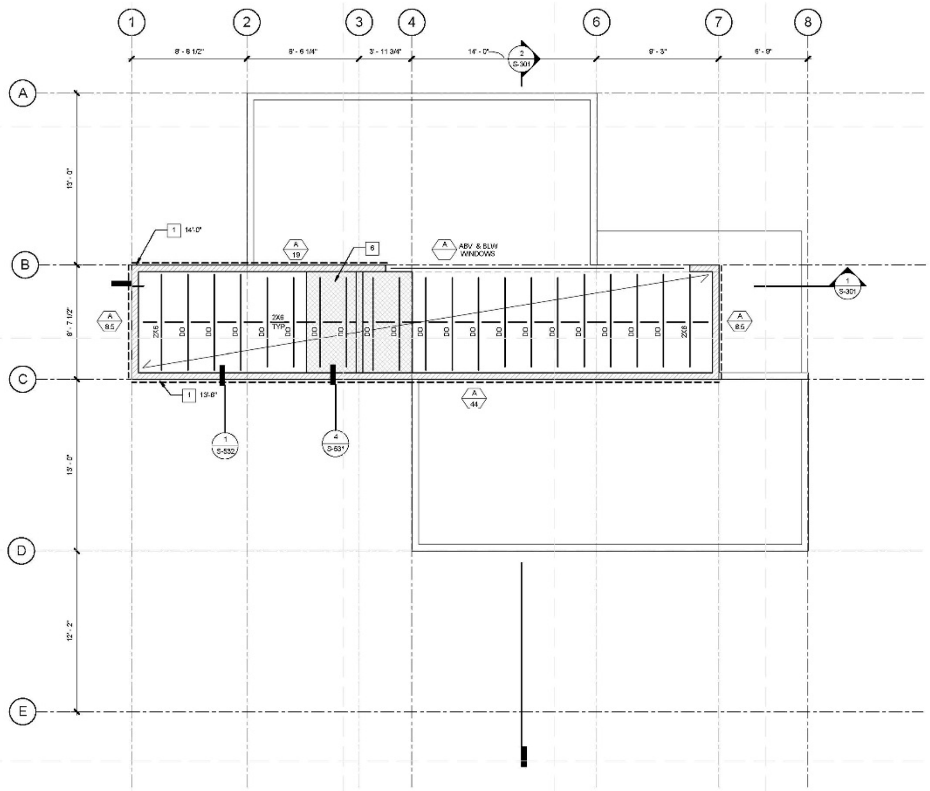
U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

| Revision Schedule | | |
|---|---|---|
| Revision Number | Revision Description | Revision Date |

LOT NUMBER: 107
DRAWN BY:
CHECKED BY:
COPYRIGHT: NONE: PROJECT IS PUBLIC DOMAIN

SHEET TITLE
LOW ROOF FRAMING

S-103A




1 HIGH ROOF FRAMING PLAN
1/4" = 1'-0"

HIGH ROOF FRAMING NOTES

1. PLATE HEIGHT VERIFY WITH ARCHITECTURAL
2. ALIGN BEAM WITH WALL ABOVE
3. 4X6 #1 BEAM WHERE APPLICABLE FOR PV ANCHOR
4. ROOF PANELS NAILED w/ 8d COMMON NAILS; 6" O.C. EDGE NAILING; 12" O.C. FIELD NAILING
5. USE LUS28 SIMPSON HANGER FOR 2X8 ROOF RAFTERS AT CENTER MODULE
6. EN ALL PANLES w/ 8D COMMON NAILS @ 4" o.c.
7. STRAP BREAKS IN TOP PLATE WITH CS16 x 36" UNO ON PLANS

SHEAR WALL SCHEDULE

| TYPE | SHEATHING/FRAMING | NAILING | POST | SILL PLATE | HOLD DOWNS |
|---|---|---|---|---|---|
| A | 1/2" STRUCUTURAL SHEATHING w/ 2X STUD FRAMING | 8d common @ 6" o.c. EN w/ 12" o.c. FIELD NAILING | 2-2x | 2x w/ 5/8" ATS @ 16" o.c. | HDU2 UNO |
| S | 6 1/2" SIP w/ 4x8 DF#1 SPLINES | 8d common @ 6" o.c. @ SIP EDGES | 4x | 2x w/ 5/8" ATS @ 16" o.c. | HDU2 |

SOLAR CALPOLY


TEAM NAME: SOLAR CALPOLY
ADDRESS: CALIFORNIA POLYTECHNIC STATE UNIVERSITY SAN LUIS OBISPO, CA 93407
CONTACT: SOLARCALPOLY@GMAIL.COM WWW.CALPOLYSOLARDECATHLON.ORG


CONSULTANTS

CLIENT
U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON 2015
WWW.SOLARDECATHLON.GOV

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

| Revision Schedule | | |
|---|---|---|
| Revision Number | Revision Description | Revision Date |

LOT NUMBER: 107
DRAWN BY:
CHECKED BY:


SHEET TITLE
HIGH ROOF FRAMING

S-103B

# APPENDIX C – Vendor List and Contact Information

## Home Depot

http://homedepot.com
1-805-596-0857

## Rheem

http://www.rheem.com

## Saniflo

http://www.saniflo.com
1-800-571-8191

## SharkBite

http://www.sharkbite.com
1-877-700-4242

## Viking

http://www.vikinggroupinc.com
1-800-968-9501

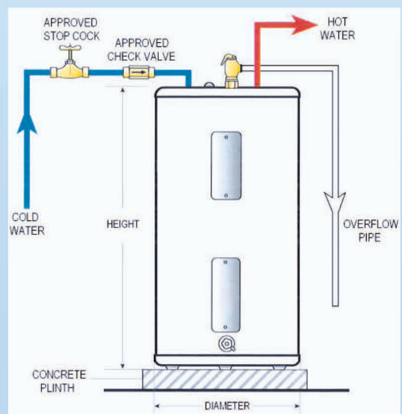
# APPENDIX D – Manufacturer Specification Sheets

## Rheemglas Fury

# Fury Rheemglas® Electric Water Heater

### Available in 113, 152, 190, 247, 304 and 456 Liter Tall Models

- Temperature and pressure relief valve included
- Isolated tank design reduces conductive heat loss
- High efficiency resistored heating elements
- Anode rod equalizes aggressive water action
- Electric junction box located above heating elements for easy installation
- Over-temperature protector cuts off power in excess temperature situations
- Automatic thermostat keeps water at desired temperature
- Foam insulation
- Dual Element and Thermostat
- Maximum working pressure of 150 PSI (10 BARS)




**FLOOR MOUNTED MODELS**

| MODEL | TANK CAPACITY | | VOLTAGE SINGLE PHASE | kW | HEATER DIMENSION | | OPERATING WEIGHT (kg) | SHIPPING DIMENSION | | | APPROX. SHIP WEIGHT (Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | USG | Litres | | | HEIGHT (mm) | DIAMETER (mm) | | L (mm) | B (mm) | Ht (mm) | |
| 82V30-2 | 30 | 114 | 240 | 4.5 | 1180 | 460 | 151 | 470 | 470 | 1200 | 36 |
| 82V40-2 | 40 | 151 | 240 | 4.5 | 1200 | 510 | 197 | 520 | 520 | 1225 | 43 |
| 82V52-2 | 50 | 189 | 240 | 4.5 | 1460 | 490 | 245 | 500 | 500 | 1490 | 49 |
| 82V66-2 | 65 | 246 | 240 | 5.5 | 1510 | 540 | 317 | 555 | 555 | 1530 | 68 |
| 82V80-2 | 80 | 303 | 240 | 5.5 | 1510 | 595 | 387 | 610 | 610 | 1530 | 80 |
| 82V120-2 | 120 | 454 | 240 | 5.5 | 1610 | 730 | 606 | 840 | 840 | 1750 | 147 |

In keeping with its policy of continuous progress and product improvement, Rheem reserves the right to make changes without notice.


**Rheem Manufacturing Company (Singapore) Pte Ltd**
No. 8 Pandan Crescent #02-02
Singapore 128464
Tel: 6872 1161 Fax: 6872 1151
Email: rheem@rheemmfg.com.sg
Website: www.rheemmfg.com.sg


Authorised Dealer

# SFA

275

02.13
IND1

**WARNING !**
PUMP WILL NOT EVACUATE UNLESS VENTED AS PER SPECIFICATIONS

**ATTENTION !**
PENSEZ À BIEN VENTILER LA POMPE COMME INDIQUÉ DANS LA NOTICE

The user should retain these instructions for future reference • A lire attentivement et à conserver à titre d'information

**This product must be installed in strict accordance with local plumbing codes.**
**Product should be installed by a licensed plumber.**
**Le produit doit être installé dans le respect des règlements sanitaires locaux.**
**Le produit doit être installé par un plombier qualifié.**

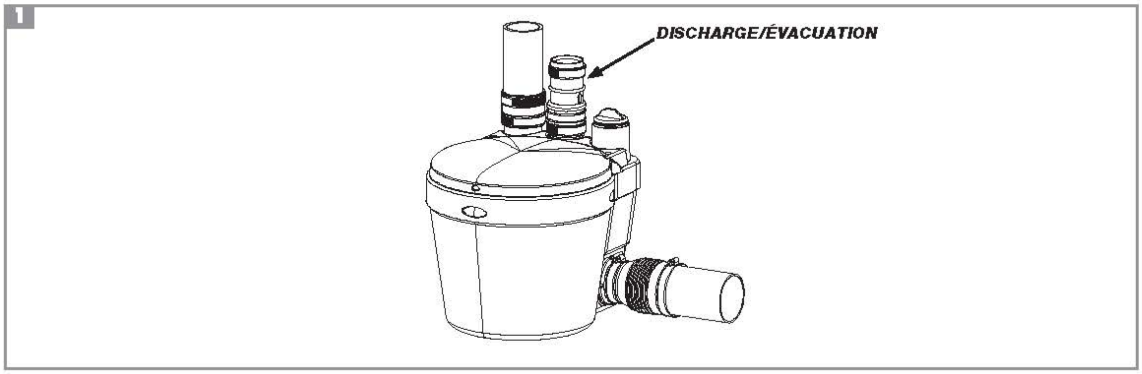
C US
226692

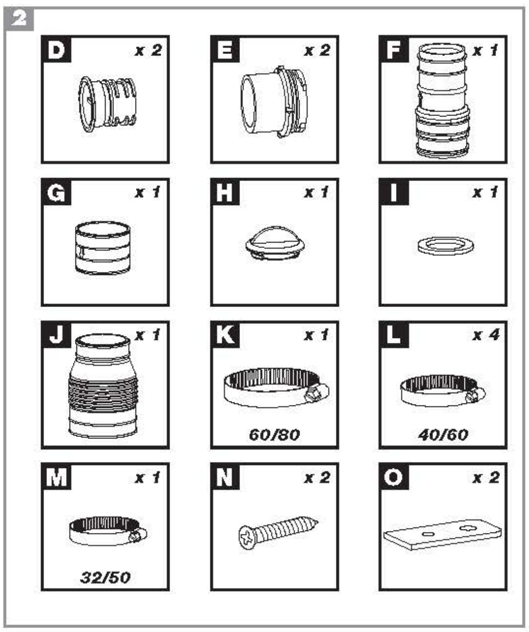
CDN USA

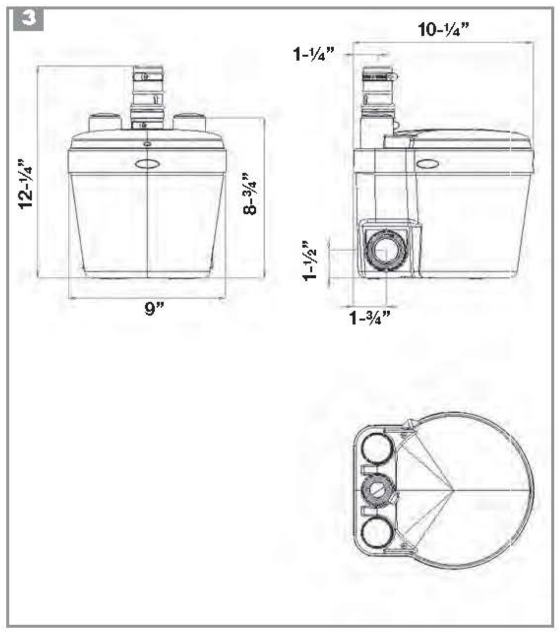
**INSTALLATION AND MAINTENANCE INSTRUCTIONS**
**INSTRUCTIONS D'INSTALLATION ET D'ENTRETIEN**

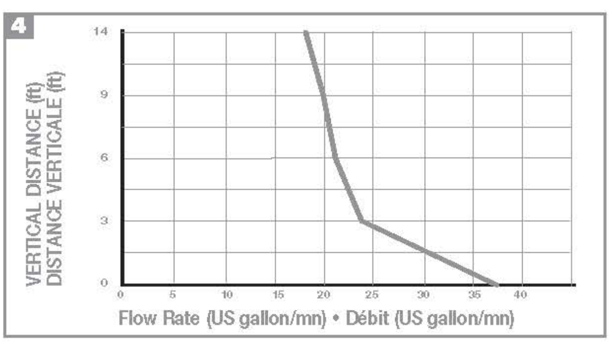
SANISWIFT®

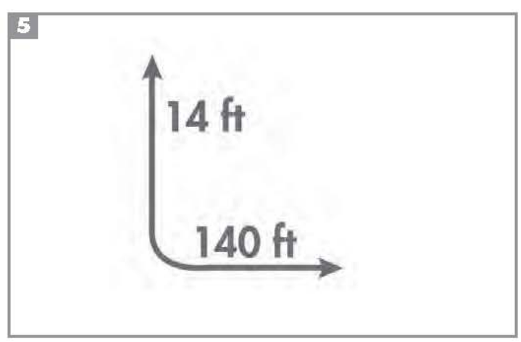
10922 275 NOTICE SANISWIFT 012013.indd 1 05/02/13 09:29

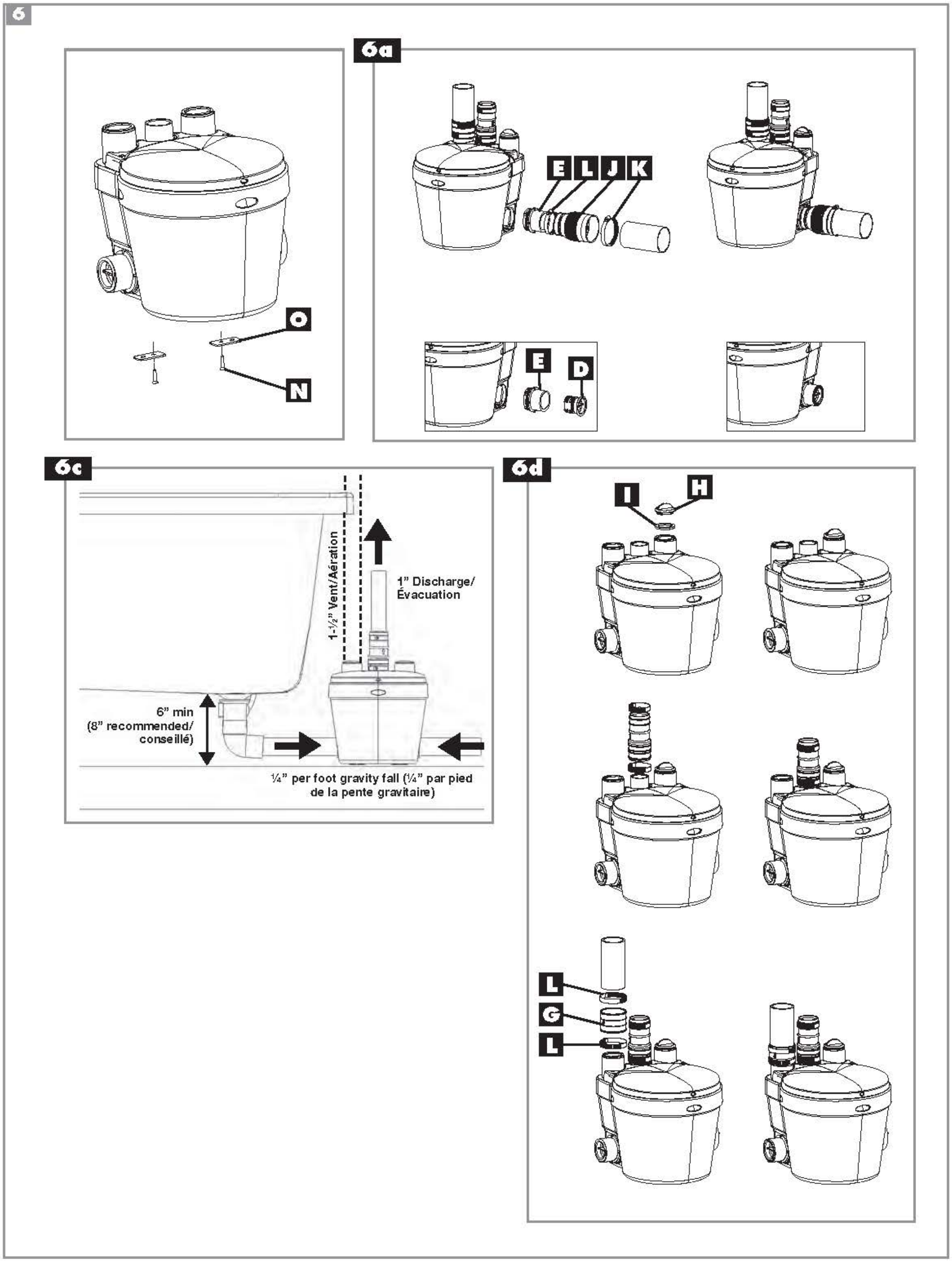

1
DISCHARGE/ÉVACUATION


2
D x 2
E x 2
F x 1
G x 1
H x 1
I x 1
J x 1
K x 1
60/80
L x 4
40/60
M x 1
32/50
N x 2
O x 2


3
10-¼"
1-¼"
12-¼"
8-¾"
9"
1-½"
1-¾"


4
VERTICAL DISTANCE (ft)
DISTANCE VERTICALE (ft)
14
9
6
3
0
0
5
10
15
20
25
30
35
40
Flow Rate (US gallon/mn) • Débit (US gallon/mn)


5
14 ft
140 ft


6
6a
E L J K
E
D
O
N
6c
1-½" Vent/Aération
1" Discharge/
Évacuation
6" min
(8" recommended/
conseillé)
¼" per foot gravity fall (¼" par pied
de la pente gravitaire)
6d
I
H
L
G
L

## 1 DESCRIPTION

The **SANISWIFT**® is a gray water pump that is ideally suitable for use in any section of the house where additional fixtures are needed. It will pump the waste water away from a variety of sources such as: laundry sink, washing machine (indirect connection), dishwasher, bar sink, etc.

## 2 SPARE PARTS

See fig. n°2 page 2.

## 3 DIMENSIONS

See fig. n°3 page 2.

## 4 PERFORMANCE CURVE

See fig. n°4 page 2.

## 5 DISCHARGE HEIGHT

See fig. n°5 page 2.

## 6 INSTALLATION

This appliance must be installed following our instruction manual and installation guidelines. It must also be installed in such a way as to ensure easy access for repair and maintenance and in accordance with local plumbing code: CSA B45.9; ASME A112.3.4.

### 6a CONNECTION TO SIDE INLETS

The pump has two side inlets (one on each side) that are meant to connect additional fixtures. To connect to the side inlets, one rubber coupling (1-1/2" x 2") is provided along with the clamps. Use this rubber coupling to connect the side inlet to the PVC pipe coming from the fixture. An additional rubber coupling (with clamps) will be needed if you want to use the other side inlet.

If either side inlet is not being used, ensure that you cap off the inlet not being used by screwing the end cap into the case until it is completely sealed.

### 6b CONNECTION TO INLETS (TOP)

To connect to the top inlets, one rubber coupling (1-1/2" x 1-1/2") is provided along with the clamps. Use this rubber coupling to connect the top inlet to the PVC pipe which should be from your vent connection. An additional rubber coupling (with clamps) will be needed if you want to use the other top inlet. If one of the top inlets is not being used, a cap is provided to cover this inlet.

### 6c CONNECTION TO A BATHTUB / SHOWER.

When adding a bathtub/shower, a base will have to be constructed. This base should be made out of a 2" x 6" (minimum) or 2"x 8" (recommended) on edge, to allow for the installation of a P-trap and the required 1/4" per foot gravity flow towards the pump unit.

### 6d DISCHARGE CONNECTION

The waste water being evacuated by this device must be discharged using a 1 inch diameter copper or plastic (PVC, CPVC) pipe. This pump is designed to handle 3/8" particles. The discharge pipe must be connected to a drain line or sewer line using an approved "Y" fitting designed for this purpose.

Make sure to only use 1" rigid pipe for the discharge as well as 45 degree elbows along installation. Do not use 90 degree elbows. If long sweeping elbows are not available, use two 45 degree elbows back-to-back to make a 90 degree turn.

Ensure that the angle of slope is 1/4" per foot for horizontal drain sections leading up to the main drain stack to ensure drainage by gravity.

Install an optional ball valve at the bottom of the drain pipe riser to allow shut off in case of repairs.

### 6e CONNECTION TO A VENTILATION SYSTEM

The unit has been designed with a vent connection on the top of the pump. All plumbing codes require a connection to a vent system. Connect your vent system using the provided 1-1/2" x 1-1/2" rubber coupling to connect to your PVC pipe.

Please note that the vent system should be a two-way air vent. The use of mechanical vents, air admittance valves or similar devices are not permitted as these are considered one-way air vent systems.

### 6f CONNECTION TO THE POWER SUPPLY

**CONNECT ONLY TO RECEPTACLE PROTECTED BY A GROUND FAULT CIRCUIT**

WARNING: **RISK OF ELECTRIC SHOCK - THIS PUMP IS SUPPLIED WITH GROUNDING CONDUCTOR AND GROUNDING TYPE ATTACHMENT PLUG. TO REDUCE THE RISK OF ELECTRICAL SHOCK BE CERTAIN THAT IT IS CONNECTED ONLY TO A PROPERLY GROUNDED- TYPE RECEPTACLE**

All electrical connections must comply with local codes in your region. The current must be single-phase 110-115 V, 15A. The electrical outlet must be located at the minimum distance of 40 inches from the shower or bath. Note to only connect this appliance to a ground fault circuit interrupter (GFCI).

## 7 STANDARDS

This model is eligible to bear the CSA mark shown with adjacent indicators "C" and "US". The "C" and "US" indicators adjacent to the CSA mark signify that the product has been tested according to the applicable CSA (CAN) and ANSI/UL standards for use in Canada and the USA. This includes products eligible bear the designation NTRL. NTRL (Nationally Recognized Testing Laboratory) is a designation awarded by the American Occupational Safety and Health Administration (OSHA) to laboratories authorized to award the certification according to American standards.

## 8 USE

The **SANISWIFT**® is designed to drain waste water from sinks, washing machines (**indirect only**), dishwashers, showers and baths.

The **SANISWIFT**® can pump hot water up to a maximum of 140°F (60°C). If the device operates with water temperatures higher than specified for a prolonged period, the thermal protector is automatically triggered and the device will cease to pump. In this case, wait for it to cool down (approximately one hour) so that it automatically restarts.

**Attention:** Never drain cooking grease, alkaline or acidic liquids, solvents, paints, oils, or bleaches that may jam or corrode this appliance.

Note that this pump is not suitable for underground installation and not to be installed in hazardous locations.

## 9 DISMANTLING

**(instructions intended for professionals only)**

Disconnect the power supply before attempting any work on the device.

This device does not require any specific maintenance. In case service is required, any work on the device must be carried out by a Saniflo-approved technician.

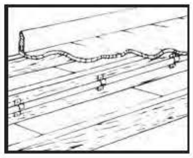
## 11 REPAIR GUIDE

| PROBLEM | CAUSE | SOLUTION |
| --- | --- | --- |
| The motor runs normally, but the water drains slowly. | The discharge pipe is blocked. Possible that the check valve is half closed. | Clean the discharge pipe Inspect the check valve. |
| The water drains slowly and the motor works intermittently. | Ventilation system blocked. | Inspect the ventilation system. |
| The pump doesn't start. The water doesn't evacuate. | There is no power going to the pump. Thermal overload cut out. | Wait for the thermal overload to disengage (about 20-30 minutes) |
| The motor hums and it does not evacuate the water. | A foreign body is blocking the impeller. Faulty capacitor. | Contact an authorized technician. |
| The water doesn't evacuate and the motor runs for a long time. | Evacuation pipe blocked. Partially blocked impeller. | Contact an authorized technician. |
| After discharging the water, the motor restarts several times before stopping completely. | Water is flowing back into the pump. The check valve doesn't close properly. | Drain clear water to free the check valve or remove the valve and clean it. |
| The motor runs noisily, without either stopping or pumping. | Siphoning or lack of counter pressure in the drainage pipe, creating an air pocket. Presence of a foreign body. | Modify the evacuation piping in such a way as to eliminate siphoning or increase the counter pressure (for example using smaller pipes, add a bend in the pipe). If the problem continues, contact an authorized technician. |
| The motor runs, but makes a strange noise. | A foreign body has fallen into the pump. | Contact an authorized technician. |
| The water backs up into the shower tray or bathtub. | The outflow by gravity in the pump is inadequate. Faulty inlet control flap or blockage in drain pipe. | Make sure that the gravity fall is at least 1/4“ per foot into the pump from the sanitary fixtures. |

## 12 ADVICE

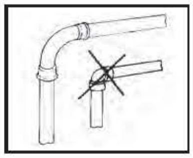
### PIPE SUPPORTS

All sanitary pipe work must be supported, in accordance with the pipe manufacturer's recommendations. Avoid dipping or trapping, which may cause the build up of residual "solids" and sub- sequent blockage.



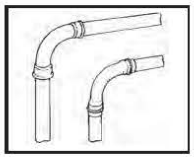
### BENDS

Where possible long sweeping bends should be used. Do not use short elbows. If sweeping 90° elbows are not available use two 45° elbows to make a 90° turn.



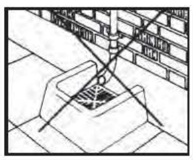
### PIPE WORK

All pipe work should be either copper, PVC or CPVC (Do not use flexible pipes). Hangers should not be less than four feet apart to prevent pipe rattling.



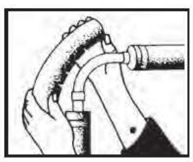
### DISCHARGE

Never discharge directly into an open drain, fixture, manhole or rainwater drainpipe. It is illegal for it constitutes a health hazard. Direct connections into sanitary waste systems only, shall be acceptable.



### FREEZING

Ensure all pipe work susceptible to freezing is adequately insulated or heated. In unheated buildings, the toilet, piping and macerating unit must be properly winterized with "RV or plumbers" anti-freeze or drained completely.



### ELECTRICITY

Before attempting any maintenance or servicing, the unit must be disconnected from the power source. The macerating system must be connected to a Ground Fault Circuit Interrupter.

### VERTICAL INSTALLATION FIRST

If vertical lift is required, this must precede the horizontal pipe run.

### EASY ACCESS

The unit should be accessible and removable in the event of maintenance being required. During the installation a full-port ball valve should be installed at the base of any vertical discharge pipe work from the unit to allow easy service of the unit.

### GRAVITY FALL

The unit accepts wastewater by gravity; it does not "vacuum" in water. All inlet pipe work must have a positive gravity fall, (1/4» per foot). All horizontal piping from the macerating unit must also have a positive gravity fall to allow free drainage when the pump stops.

### NO DIAGONAL "UPHILL" PIPE RUNS

All discharge pipe work from the unit should run either directly vertical upwards from it or in a horizontal plane (with a small gravity flow) to the point of discharge.
Pipe work should not be installed with diagonal upward slope from the unit to the point of discharge.

# LIMITED WARRANTY

## Warranty period two-year from date of purchase

Subject to the terms and conditions set out below, SFA-SANIFLO INC. (hereafter designated as the Company) warrants that it will repair or replace the product or any of its component parts, at the Compagny's discretion if it deems that the product or part it is defective or does not meet the rated performance due to a manufacturing or material default.

If replacement is to be issued, this will only be extended to the first year starting from the date of purchase. Warranty repairs will apply after such date up to the warranty's date of conclusion.

**CONDITIONS**

The conditions of this guarantee are:

1. The product must not have been subjected to misuse, neglect, accident or damaging products, in accordance with the paragraph «USAGE» of these Installation Instructions.
2. The product must have been connected to a single phase 120V, 60Hz electrical supply.
3. The alleged fault or defect must be notified to the company, within the warranty period.

**PART OR PRODUCT EXCHANGE**

The product will be exchange, free of charge, at the original resellers place of business only, upon the followings conditions being fullfilled:

1 The customer need a «return authorization» number from the company to authorize and validate the exchange.

2 The customer must supply a copy of their invoice to validate the request for an exchange.

**LIMITATIONS**

1. Cost of disconnection and reconnection (ie labor charges) are not covered by the warranty and are end-users responsability.
2. Cost of mail or freight when a part or parts of the system have to be repaired at the company are not covered by this warranty.
3. In no event shall the company be reliable for any special, incidental or consequential damage, loss, or injury of whatsoever nature or kind arising from or in connection with the product or any component thereof.
4. The guarantee is transferable only when the product remains at the same premises as where it was installed initialy.

Except as set forth in this Limited Warranty, the company disclaims all other warranties, express or implied, with respect to the product or any component thereof including, but not limited to, all implied warranties for merchantability and fitness for a particular purpose

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For service or for further inquiries, please call or contact any of the following addresses:

**United States**
SFA-SANIFLO INC.
105 Newfield Avenue, Suite A
Edison, NJ 08837

| | |
|---|---|
| Toll Free: | 1-800-571-8191 |
| Telephone: | 1-732-225-6070 |
| Fax: | 1-732-225-6072 |
| E-mail.: | sfasales@saniflo.com |
| Web Site: | www.saniflo.com |

**Canada**
SFA-SANIFLO INC.
1-685 Speedvale Avenue West
Guelph ON
N1K 1E6

| | |
|---|---|
| Toll Free: | 1-800-363-5874 English |
| Toll Free: | 1-800-877-8538 French |
| Telephone: | 1-519-824-1134 |
| Fax: | 1-519-824-1143 |
| E-mail.: | sales@saniflo.com |
| Web Site: | www.saniflo.ca |

Specifications: HB001 • Issue Date May 2009

CASH ACME

# SharkBite® Barb Connection System

## PEX Barb Fittings, Manifolds, Valves, Clamp or Crimp Rings and Tools

### DESCRIPTION

When lower material cost is desired, the SharkBite® barb connection system is the best option for connecting PEX tubing in water distribution systems.

### FEATURES AND BENEFITS

Broad line of fittings, manifolds, regulator, thermostatic and ball valves:
*A typical barb system offers the lowest material cost*

CLAMP ring connections *(see Installation Guide for details)*:
*The time saving clamp rings and tool offer reduced equipment cost, one tool clamps all sizes and the necessity to check each fitting ring with a go/no-go gauge is eliminated*

CRIMP ring connections *(see Installation Guide for details)*:
*Copper crimp rings and the heavy duty tool with interchangeable jaws does not require calibration and allows each joint to be checked with a go/no-go gauge*

### SPECIFICATION

Using the PEX plastic tubing cutters to cut the tubing to length, making sure that you have a good square cut. Slide the correct size Sharkbite® clamp or crimp ring over the tube approximately 2" past the end of the tubing. Push the tubing onto the Sharkbite® barbed fitting until it touches the fitting shoulder. Position the clamp or crimp ring 1/8"-1/4" from the end of the tube. When making clamp connections, position the open jaws of the Clamp Tool over the raised tabs of the Clamp ring and squeeze. Verify the connection is secure by visually checking the clamp tab. Make Crimp connections by placing the jaws of the Crimp Tool over the copper crimp ring and squeezing until the jaws close completely. Verify that the connection is secure using the go/no-go gauge.

### TYPICAL INSTALLATION*


Make a square cut.


Slide clamp or crimp ring over tube.


Push the PEX tubing onto the fitting against the fitting shoulder.


Position Clamp Tool jaws over raised tab of clamp ring and squeeze.

Position Crimp Tool jaws over crimp ring and squeeze.


Verify connection is secure. Use go/no-go gauge on crimp rings.

*Refer to the PEX Installation Guide for detailed information.

### SPECIFICATION DATA

Materials:
Barb fittings . . . . . . . . . . . . . . . . . . . . .DZR Brass
Clamp rings . . . . . . . . . . . . . . . . . . . . .Stainless Steel
Crimp rings . . . . . . . . . . . . . . . . . . . . .Copper

### CERTIFICATIONS

The SharkBite® barb fittings and crimp rings meet ASTM F1807 requirements. The SharkBite® barb fitting clamp rings meet ASTM F2098 requirements. All SharkBite® PEX system components are listed to the NSF 14 Standard by NSF® International.

SharkBite®

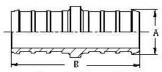
Cash Acme • 2400 7th Avenue SW • Cullman, AL 35055-0278 • 1-877-700-4242 • Fax: 1-877-700-4280 • www.cashacme.com

A Division of the Reliance Worldwide Corporation

CASH ACME

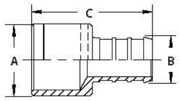
# SharkBite® Barb Connection System

## PEX Barb Fittings, Manifolds, Valves, Clamp or Crimp Rings and Tools



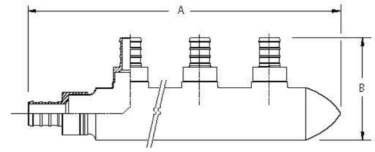

Coupling Dimensions

| P/N | A | B |
|---|---|---|
| UC006 | 3/8" | 1.4" |
| UC008 | 1/2" | 1.4" |
| UC016 | 3/4" | 1.4" |
| UC020 | 1" | 1.7" |



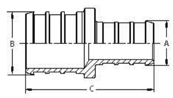

Sweat Adaptor Dimensions

| P/N | A | B | C |
|---|---|---|---|
| UC600 | 1/2" F | 1/2" | 1.38" |
| UC606 | 3/4" F | 3/4" | 1.56" |
| UC607 | 1/2" M | 1/2" | 1.29" |
| UC608 | 3/4" M | 3/4" | 1.50" |
| UC609 | 1" M | 1" | 1.88" |



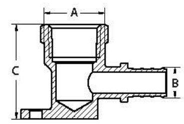

Barb Manifold Dimensions
(1" trunk, 3/4" barb inlet & outlet, 1/2" barb ports - 2" on center)

| P/N | type | A | B |
|---|---|---|---|
| 22783 | 3 port closed | 8.53" | 2.29" |
| 22785 | 4 port closed | 10.53" | |
| 22787 | 6 port closed | 14.53" | |
| 22789 | 8 port closed | 18.53" | |
| 22784 | 3 port open | 9.9" | |
| 22786 | 4 port open | 11.9" | |
| 22788 | 6 port open | 15.9" | |
| 22790 | 8 port open | 19.9" | |



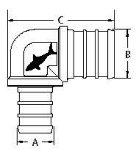

Reducing Coupling Dimensions

| P/N | A | B | C |
|---|---|---|---|
| UC009 | 3/8" | 1/2" | 1.4" |
| UC058 | 1/2" | 3/4" | 1.4" |
| UC060 | 3/4" | 1" | 1.56" |



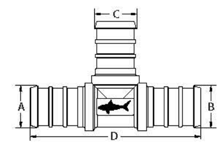

Drop Ear Elbow Dimensions

| P/N | A | B | C |
|---|---|---|---|
| UC120 | 1/2" FNPT | 1/2" | 1.6" |



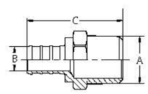

Elbow Dimensions

| P/N | A | B | C |
|---|---|---|---|
| UC246 | 3/8" | 3/8" | .95" |
| UC248 | 1/2" | 1/2" | .96" |
| UC256 | 3/4" | 3/4" | 1.1" |
| UC260 | 1" | 1" | 1.3" |
| UC274 | 1/2" | 3/4" | 1.7" |




Tee Dimensions

| P/N | A | B | C | D |
|---|---|---|---|---|
| UC360 | 3/8" | 3/8" | 3/8" | 1.89" |
| UC362 | 1/2" | 1/2" | 1/2" | 1.96" |
| UC370 | 3/4" | 3/4" | 3/4" | 2.12" |
| UC374 | 1" | 1" | 1" | 2.67" |
| UC412 | 3/4" | 3/4" | 1/2" | 2.12" |
| UC414 | 1" | 3/4" | 3/4" | 2.5" |
| UC416 | 1" | 1" | 3/4" | 2.67" |
| UC444 | 3/4" | 1/2" | 3/4" | 2.17" |
| UC454 | 3/4" | 1/2" | 1/2" | 2.13" |

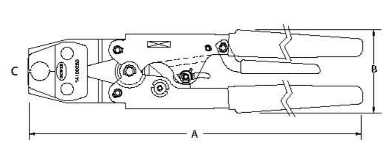



Straight Connector Dimensions

| P/N | A | B | C |
|---|---|---|---|
| UC120 | 1/2" MNPT | 1/2" | 1.6" |

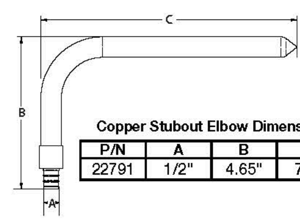
Clamp Dimensions

| P/N | A |
|---|---|
| UC952 | 3/8" |
| UC953 | 1/2" |
| UC955 | 3/4" |
| UC956 | 1" |



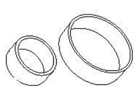

CLAMP Tool Dimensions

| P/N | A | B | C (use for clamp sizes) |
|---|---|---|---|
| UC961 | 10-15/16" | 2-1/8" | 3/8", 1/2", 5/8", 3/4", 1" |



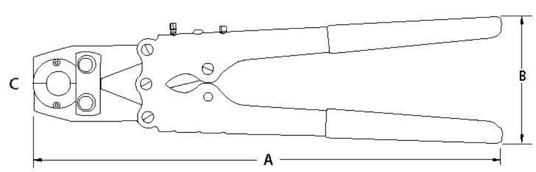

Copper Stubout Elbow Dimensions

| P/N | A | B | C |
|---|---|---|---|
| 22791 | 1/2" | 4.65" | 7.8" |



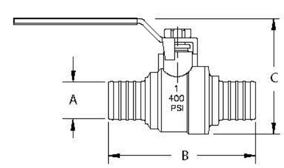
Crimp Ring Dimensions

| P/N | A |
|---|---|
| 23101 | 3/8" |
| 23102 | 1/2" |
| 23103 | 3/4" |
| 23104 | 1" |




CRIMP Tool Dimensions

| P/N | A | B | C (interchangeable jaw sizes) |
|---|---|---|---|
| 23100 | 18-1/2" | 5" | 3/8", 1/2", 5/8", 3/4", 1" |




Barb Ball Valve

| P/N | A | B | C |
|---|---|---|---|
| 22461 | 1/2" | 3.32 | 2.46 |
| 22462 | 3/4" | – | – |
| 22463 | 1" | 3.70 | 3.27 |

SharkBite®
*Plumbing Solutions*

# SHARKBITE® PUSH-FIT CONNECTION SYSTEM


## Push To Connect Fittings for Copper, PEX and CPVC

## Specification Submittal Package for Potable Water and Hydronic Heating

**www.sharkbite.com**

## Table of Contents

# SHARKBITE PUSH-FIT CONNECTION SYSTEM

## SYSTEM DATA SHEET

**System Description**
The SharkBite Push-Fit quick-connect plumbing system is the easiest and most dependable way to join copper, CPVC or PEX pipe in any combination—with no soldering, clamps, unions or glue. Available in an assortment of over 200 fittings and sizes ranging from ¼" to 2" copper tube size (CTS).

**Applications**
Tubing: Hard drawn copper pipe Type K, L and M and annealed Type M not to exceed 3/8 nominal complying with ASTM B 88, PEX tubing complying with ASTM F 876 or CSA B137.5, or CVPC tubing complying with ASTM D 2846 or CSA B137.6. SharkBite fittings are approved for installations above and below ground applications. Please consult with local code for final approval. Failure to comply with the above types of pipe or application could result in connection failures.

**Operating Parameters**
Operating Pressure: 200 PSI Max
Operating Temperature: 200°F Max

**Approved Applications**
- Potable Water
- Hydronic Heating (w/ Glycol concentration up to 100%)

**System Benefits**
- Instant push-fit connection for increased ease of use
- No soldering, clamps, unions or glue needed
- Reduces installation time with no tightening of nuts, clamps and unions.
- Connects three types of pipe in any combination
- No mapping of system
- Can be installed wet or dry
- Rotatable after installation
- Approved for behind the wall and underground applications.
- Removable after installation
- Clean, professional installation

**Fittings**
SharkBite push-fit fittings are available in 200+ configurations including: Couplings, Elbows, Tees, Reducers, Threaded Adapters, Caps, Stops, Stub Outs, Ball Valves, Slips, Water Heater Hoses and Valves with SharkBite Connections. Made from Lead Free Dezincification Resistant (DZR) brass and available in sizes ¼" – 2" CTS.

**Push-Fit Technology**
The SharkBite fitting works via a two stage process that ensures a quick, easy connection.
- The tubing passes through the release collar and then through the stainless steel grab ring.
- The tube is pushed through an o-ring protector that aligns the tube. It then passes through a specially formulated o-ring that compresses between the pipe and the wall of the fitting before it reaches the tube stop.

**How to Make a Connection**
1. Cut the pipe. Make sure the cut is square and even.
2. Deburr the end of the pipe to remove any sharp edges. Sharp edges can cut the o-ring and lead to leaks.
3. Mark the pipe with the proper insertion depth (see below for reference).
4. Push the pipe into the fitting. The mark made on the pipe should rest against the collar of the fitting, ensuring a proper seal.

| FITTING SIZE | INSERTION DEPTH |
|---|---|
| 1/4" | 0.813" |
| 3/8" | 0.875" |
| 1/2" | 0.938" |
| 5/8" | 1.125" |
| 3/4" | 1.125" |
| 1" | 1.313" |
| 1-1/4" | 2.000" |
| 1-1/2" | 2.250" |
| 2" | 2.500" |

**Tube Liner**
SharkBite fittings ranging in sizes 3/8" to 1" come with an integral tube liner preinstalled for use with PEX pipe. SharkBite sizes 1-1/4" to 2" do not come with tube liners preinstalled and are sold separately. The tube liner must be used when PEX piping is utilized.

**Tools**
Tools are available to make the installation process easier.
- SharkBite depth & deburring tool for 1/4" to 1" CTS
- SharkBite depth & deburring tool for 1-1/4" to 2" CTS
- SharkBite disconnect clip (1 size per tubing)
- SharkBite disconnect tongs (1 size per tubing)

**History**
SharkBite was launched in the Australian market in 1999 and in the North America market in 2004, ushering in a new way to do plumbing. Reliance Worldwide, an ISO 9001 organization, is one of the world's largest manufacturers of thermostatic water control valves and has been a major world supplier of hot water safety valves for over 50 years.

**Warranty**
SharkBite fittings carry a 25 year warranty against any manufacturer's defect as long as the item has been installed per installation instructions and comply with local code. Please contact Customer Service for more information.

**IAPMO**
http://pld.iapmo.org/default.asp
(Select Listee Name and enter "Reliance Worldwide")

**For more information on SharkBite products, contact:**
Reliance Worldwide Corporation
2727 Paces Ferry Road
Building 2, Suite 1800
Atlanta, GA 30339
United States: 1-877-700-4242
Canada: 1-888-820-0120
Web: www.sharkbite.com

## ENGINEERING SPECIFICATIONS

The push-fit fitting shall be installed on hard drawn copper type K, L and M complying with ASTM B88, cross-linked polyethylene pipe (PEX) complying with ASTM F 876 or CSA B137.5 or CPVC piping complying with ASTM D 2846 or CSA B137.6. The fitting shall be made of lead free dezincification brass and compliant with ASSE 1061, NSF/ANSI 61 and NSF/ANSI 372. The fitting shall consist of an EPDM O-ring, a grade 316 stainless steel grab ring, and contain a polysulfone tube liner for PEX applications. The fitting shall be used in a potable water system or a hydronic heating water distribution up to 200 psi and 200°F. The fitting shall be a SharkBite fitting.

**PART 1: GENERAL**

1.1 SUMMARY

A. Push-Fit Connection System for Potable Water Distribution and Hydronic Heating Water Distribution

1.2 DEFINITIONS

A. ASME: American Society of Mechanical Engineers
B. ASSE: American Society of Safety Engineers
C. ASTM: American Society for Testing and Materials
D. CSA: Canadian Standards Association
E. EPDM: Ethylene Propylene Diene Monomer
F. IAPMO: International Association of Plumbing and Mechanical Officials
G. NSF: National Sanitation Foundation

1.3 REFERENCES

A. ASSE 1061: Performance Requirements for Push-Fit Fittings
B. NSF/ANSI Standard 61: Certification for Drinking Water System Components – Health Effects
C. NSF/ANSI Standard 14: Plastics Piping System Components and Related Materials
D. NSF/ANSI Standard 372: Lead Content Certification
E. ASTM B 88: Standard Specifications for Seamless Copper Water Tube
F. ASTM F 876: Standard Specification for Cross-linked Polyethylene (PEX) Tubing
G. CSA B137.5: Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Applications
H. CSA B137.6
I. ASTM D 2846: Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot-and Cold-Water Distribution Systems.
J. IAPMO: Uniform Plumbing Code
K. IAPMO: National Plumbing Code of Canada
L. IAPMO: International Plumbing Code
M. AWWA C904: Cross-Linked Polyethylene (PEX) Pressure Pipe, ½ In. (12mm) Through 3 In. (.76 mm) for Water Service.

1.4 QUALITY ASSURANCE

A. Installer shall be well informed on installation instructions prior to installing.
B. The installation of tubing and fittings for hot and cold water distribution systems shall conform to the requirements of the ICC International Plumbing Code or IAPMO Uniform Plumbing Code.
C. The piping shall be cut square, even and have no rough edges.

1.5 WARRANTY

A. SharkBite Push-Fit Fittings have a 25 year limited warranty from point of sale.

B. All products must be installed in accordance with all applicable codes and in accordance with any local, state, provincial or federal requirements.

C. The installing contractor must use construction techniques compliant with applicable codes to install the range of products and use the product(s) within the design parameters specified in any installation guidelines and technical notes for the applicable system. This shall include field pressure testing prior to concealing with concrete or by other means.

D. Products must not be installed in a system that may operate at temperatures or at pressures that exceed the printed rating on the product, packaging or installation instructions.

E. Evidence of tampering, mishandling, neglect, accidental damage, freeze damage or unauthorized modifications or repairs that cause damage to RWC warranted products void any warranty coverage of those particular products. It is expressly understood that failure as a result of any freezing fluids within the pipes does not constitute a defect in material or workmanship and shall not be covered by this warranty.

F. Although RWC provides a plumbing system to facilitate a complete installation, other manufacturers tubing and/or fittings may be installed in any given installation provided manufacturing of the tubing and/or fittings demonstrates compliance with the applicable ASTM standards, and the product has been certified by a recognized third-party testing agency. The RWC product in the given installation will continue to be covered under this warranty. **NOTE**: RWC will be responsible only for proven defects in material or workmanship in RWC products. Problems in products manufactured by another company should be reported to that manufacturer.

G. For full warranty information, please see page 30.

**PART 2: PRODUCTS**

2.1 MANUFACTURERS

A. RWC, 2727 Paces Ferry Road, Building 2, Suite 1800, Atlanta, GA 30339
Telephone: 1-877-700-4242, Website: www.sharkbite.com

2.2 MATERIAL

A. Tubing Standard: Copper tubing shall be hard drawn Type K, L, or M and annealed Type M copper complying with ASTM B 88.

B. Tubing Standard: Cross-linked polyethylene pipe (PEX) shall conform to ASTM F 876 or CSA B137.5.

C. Tubing Standard: CPVC tubing shall conform to ASTM D 2846 or CSA B137.6.

D. O-ring shall be made from EPDM.

E. Grab ring shall be made from Grade 316 Stainless Steel.

F. Push-fitting: Brass fitting shall comply with ASSE 1061 and NSF/ANSI 61.

2.3 SOURCE QUALITY

A. All fittings in contact with drinking water shall be listed by a third party agency to NSF 61.

**PART 3: EXECUTION**

3.1 EXAMINATION
A. If installing PEX pipe, ensure that the tube liner has been installed.
B. Ensure the fitting is free from any damage, including but not limited to damaged or missing O-ring, cracked brass forging or deformed grab ring.

3.2 PREPARATION
A. The tubing shall be cut square to ensure a proper connection.
B. The tubing shall be free of dirt, debris or scale buildup. Any burrs shall be removed using a deburring tool.
C. Mark the piping to use as verification of proper insertion into the fitting.

3.3 INSTALLATION
A. Push-fit fitting shall be installed in accordance with the manufacturer's installation instructions.
B. Pressure Rating: Install components having a pressure rating equal to or less than the system operating pressure.
C. Threaded Joints: Threaded joints shall have thread seal tape applied to the male threads only. Tighten joint with a wrench and backup wrench as required.
D. Pipe Protection: Provide protection against abrasion where tubing/fitting is in contact with other building materials (including burial) by wrapping with an approved tape, pipe insulation or otherwise suitable method of isolation.
E. Hydronic Heating: Glycol mixture for hydronic heating application is acceptable up to and including 100%.
F. Behind the wall installation: Pressure test system for no less than 24 hours to ensure no leakage.
G. Removal and reuse of push-fit fitting is allowed when executed in accordance with manufacturer's installation instructions.

3.4 FIELD QUALITY CONTROL
A. Water Testing: The copper tubing system shall be water tested for joint tightness. The piping system shall be filled with water. The system shall be pressurized to the maximum pressure and length of time required by the code or standard. The system shall have no leaks at the rated pressure.


## THE SHARKBITE DESIGN (1/4" – 1")

The SharkBite Fitting incorporates a number of unique and patented features.


## WHY SHARKBITE?

- **Instant push-fit connection for increased ease-of-use:**
    - No soldering, clamps, unions, or glue required.
- **Fittings certified to 200 PSI and 200°F (93°C):**
    - Proven durability and quality.
- **Fits copper tubing, and CTS CPVC and PEX:**
    - Connects all three types in any combination.
- **Integral tube liner for PEX installations:**
    - Integrated design means no loose components, ensures secure, reliable connection.
- **Design certified and agency listed:**
    - Inspector friendly, peace of mind!
- **Compact, robust DZR brass body:**
    - Foundation of a strong, corrosion resistant, durable fitting.
- **Design certified to ANSI/NSF-61 and ASSE 1061 product standard for use in potable water and hydronic heating water distribution:**
    - Quality engineered and manufactured.
- **Approved to be used underground and behind walls without access panels.**
    - Designed for hydronic heating as well as potable water distribution.

## CONNECTING A SHARKBITE FITTING

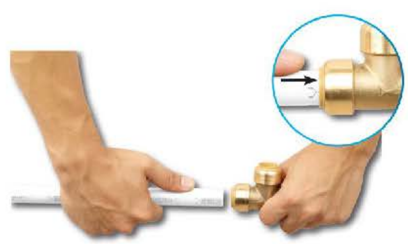
1. Cut the desired length of pipe.
    - Make sure cuts are square and even.

2. Deburr the end of the pipe to remove any sharp edges.
    - This will ensure that the o-ring will not be damaged upon insertion of the pipe.

3. Using a depth gauge, mark the pipe.
    - A 1" mark on the pipe can be used as a guideline. Proper insertion depths are listed below.
    - This will let you know if your connection is successful.

| Pipe Size | Insertion Depth |
|---|---|
| 1/4" | 0.813" |
| 3/8" | 0.875" |
| 1/2" | 0.938" |
| 5/8" | 1.125" |
| 3/4" | 1.125" |
| 1" | 1.313" |


4. Push the pipe into the fitting.
    - The mark you made on the pipe should rest against the edge of the fitting.



## DISCONNECTING A FITTING

**With the Disconnect Clip**

1. Place the SharkBite disconnect clip around the tube with the non-branded side against the release collar.

2. Push the clip against the release collar and pull the tube with a twisting action to release the tube.

**With Disconnect Tongs**

1. Place the teeth around the fitting assembly. The fork end with the SharkBite brand logo should be positioned around the tube and the other end around the neck of the fitting.

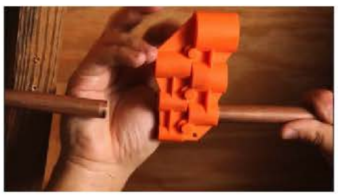
2. Squeeze the tool with one hand and pull the tube with a twisting action with the other hand to release the tube.

Check the fitting and tube end for damage. The fitting and tubing should be free of damage, foreign objects and marks on the outside diameter. If the tubing is damaged or marked, then cut and use a new section of tubing.

## SHARKBITE SLIP PRODUCTS

Slip fittings simplify repair by doing the job that two couplings and extra pipe would do. Only one end of the coupling has a stop, allowing the other end to slide freely over the end of a pipe. The fitting can be released with a disconnect tool and slid back onto the other end of the pipe for successful leak repair.


Cut out the section of the pipe needing repair (no more than 2” in length).



Using the SharkBite Deburring & Depth Gauge, clean the edges of the copper pipe. Use the gauge to mark the proper insertion depth on the pipe.

On the side of the fitting marked “SLIP END,” slide the copper pipe into the fitting until it bottoms out.

Place the SharkBite Disconnect Clip on the copper pipe, on the same side as the “SLIP END.” As you are pressing the clip to release the fitting, slide the SharkBite fitting to meet the other copper pipe.

Continue to slide the fitting until the non-slip end bottoms out. Ensure the fitting lines up with the mark you made. Also ensure the Slip End of the fitting has not proceeded past the depth mark you originally made.

## SHARKBITE SLIP PRODUCTS

In addition to slip coupling and tees, we also have slip ball valves and slip pressure regulators available to ease installation woes.

To see an installation video on installing a slip fitting, please visit:

http://www.youtube.com/watch?v=lgdBv5BK5dQ&list=PL0ABAD0AF076CFA60&feature=c4-overview-vl

## SHARKBITE FOR CONCEALED AREAS

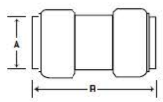
SharkBite fittings can be utilized in underground applications and as manufactured joints without access panels, per IAPMO Certificate of Listing File No. 4630.

If burying SharkBite, it is recommended:

Fitting should be wrapped with an impervious material, chloride-free tape or tightly wrapped and sealed insulation works well to prevent direct contact with the backfill. Backfill should be free of rocks, debris or any sharp objects that may cause damage through impact or abrasion.

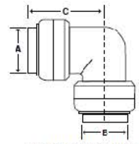
It is also recommended to pressure test the system for 24 hours before closing up any inaccessible location.

## DIMENSIONS



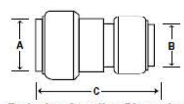
Straight Coupling Dimensions

| P/N | A | B |
|---|---|---|
| U004 | 1/4" | 1.59" |
| U006 | 3/8" | 1.84" |
| U008 | 1/2" | 2" |
| U016 | 3/4" | 2.36" |
| U020 | 1" | 2.72" |



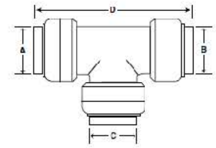
Elbow Dimensions

| P/N | A | B | C |
|---|---|---|---|
| U244 | 1/4" | 1/4" | 1.16" |
| U276 | 1/4" | 3/8" MIP | 1.16" |
| U246 | 3/8" | 3/8" | 1.28" |
| U272 | 1/2" | 3/8" | 1.43" |
| U248 | 1/2" | 1/2" | 1.36" |
| U256 | 3/4" | 3/4" | 1.64" |
| U260 | 1" | 1" | 1.933" |
| U274 | 3/4" | 1/2" | 1.373" |
| U280 | 1/2" | 1/2" MNPT | 1.21" |
| U308 | 1/2" | 1/2" FNPT | 1.21" |



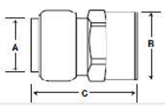
Reducing Coupling Dimensions

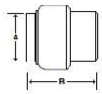
| P/N | A | B | C |
|---|---|---|---|
| U009 | 3/8" | 1/2" | 2.0" |
| U058 | 3/4" | 1/2" | 2.2" |
| U060 | 1" | 3/4" | 2.51" |



Tee Dimensions

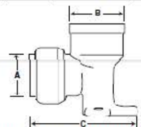
| P/N | A | B | C | D |
|---|---|---|---|---|
| U358 | 1/4" | 1/4" | 1/4" | 2.30" |
| U360 | 3/8" | 3/8" | 3/8" | 2.77" |
| U362 | 1/2" | 1/2" | 1/2" | 2.72" |
| U363 | 1/2" | 1/2" | 3/8" | 2.85" |
| U364 | 3/8" | 3/8" | 1/2" | 2.77" |
| U370 | 3/4" | 3/4" | 3/4" | 3.24" |
| U374 | 1" | 1" | 1" | 3.84" |
| U412 | 3/4" | 3/4" | 1/2" | 3.04" |
| U416 | 1" | 1" | 3/4" | 3.63" |
| U444 | 3/4" | 1/2" | 3/4" | 3.08" |
| U454 | 3/4" | 1/2" | 1/2" | 2.92" |





End Stop Dimensions

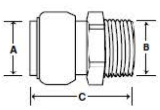
| P/N | A | B |
|---|---|---|
| U512 | 3/8" | 1.11" |
| U514 | 1/2" | 1.08" |
| U518 | 3/4" | 1.32" |
| U520 | 1" | 1.52" |



Drop Ear Elbow Dimensions

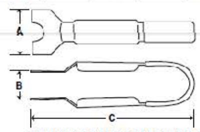
| P/N | A | B | C |
|---|---|---|---|
| U249 | 1/2" | 1/2" | 2.20" |
| U332 | 3/8" | 1/2" FNPT | 1.83" |
| U334 | 1/2" | 1/2" FNPT | 1.77" |
| U335* | 1/2" | 1/2" FNPT | 2.0" |
| U340 | 3/4" | 3/4" FNPT | 2.5" |

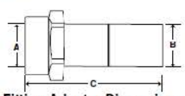
*Hy-Ear Elbow



Connector Dimensions

| P/N | A | B | C |
|---|---|---|---|
| U066 | 1/4" | 1/2" FNPT | 1.61" |
| U068 | 1/2" | 3/4" FNPT | 1.75" |
| U070 | 3/8" | 1/2" FNPT | 1.73" |
| U072 | 1/2" | 1/2" FNPT | 1.64" |
| U092 | 3/4" | 1/2" FNPT | 1.83" |
| U088 | 3/4" | 3/4" FNPT | 1.88" |
| U094 | 1" | 1" FNPT | 2.17" |
| U110 | 1/4" | 1/2" MNPT | 1.64" |
| U118 | 3/8" | 1/2" MNPT | 1.77" |
| U120 | 1/2" | 1/2" MNPT | 1.64" |
| U116 | 1/2" | 3/4" MNPT | 1.75" |
| U134 | 3/4" | 3/4" MNPT | 1.89" |
| U138 | 3/4" | 1/2" MNPT | 1.90" |
| U140 | 1" | 1" MNPT | 2.48" |
| U142 | 1" | 3/4" MNPT | 2.11" |



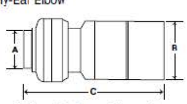


Fitting Adapter Dimensions

| P/N | A | B | C |
|---|---|---|---|
| U766 | 3/4" FNPT | 3/4" | 2.83" |
| U772 | 1" FNPT | 1" | 2.83" |

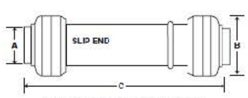
Disconnect Tong Dimensions

| P/N | Fits SharkBite | A | B | C |
|---|---|---|---|---|
| U711 | 1/2" | 1.7" | 2" | 6.5" |
| U713 | 3/4" | 1.7" | 2" | 6.5" |
| U715 | 1" | 1.7" | 2" | 6.5" |



Fitting Reducer Dimensions

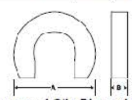
| P/N | A | B | C |
|---|---|---|---|
| U719 | 3/8" | 1/2" | 2.08" |
| U721 | 3/8" | 3/4" | 2.27" |
| U722 | 1/2" | 1" | 3" |
| U724 | 3/4" | 1" | 2.5" |




Slip Coupling* Dimensions

| P/N | A | B | C |
|---|---|---|---|
| U3008 | 1/2" | 1.075" | 4.46" |
| U3016 | 3/4" | 1.355" | 4.42" |
| U3020 | 1" | 1.64" | 4.5" |

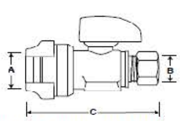
*For use with copper only.



Disconnect Clip Dimensions

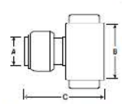
| P/N | Size | A | B |
|---|---|---|---|
| U706 | 1/4" | 1.10" | 0.3" |
| U708 | 3/8" | 1.22" | 0.3" |
| U710 | 1/2" | 1.22" | 0.3" |
| U712 | 3/4" | 1.72" | 0.4" |
| U714 | 1" | 2" | 0.4" |

Note: Disconnect Clips sold separately



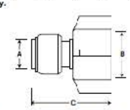
Straight Stop (*Chrome Plated*) Dimensions

| P/N | A | B | C |
|---|---|---|---|
| 23037-0000 | 1/2" | 3/8" compression | 2.68" |



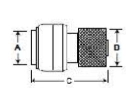
Ballcock Connector Dimensions
(*Chrome Plated*)

| P/N | A | B | C |
|---|---|---|---|
| U3531 | 1/4" | 7/8" ballcock | 1.58" |



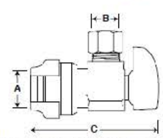
Faucet Connector Dimensions
(*Chrome Plated*)

| P/N | A | B | C |
|---|---|---|---|
| U3525 | 1/4" | 1/2" NPS | 1.56" |



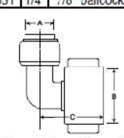
Stop Connector Dimensions
(*Chrome Plated*)

| P/N | A | B | C |
|---|---|---|---|
| U3523 | 1/4" | 9/16" X 24 UNEF | 1.61" |



Angle Stop (*Chrome Plated*) Dimensions

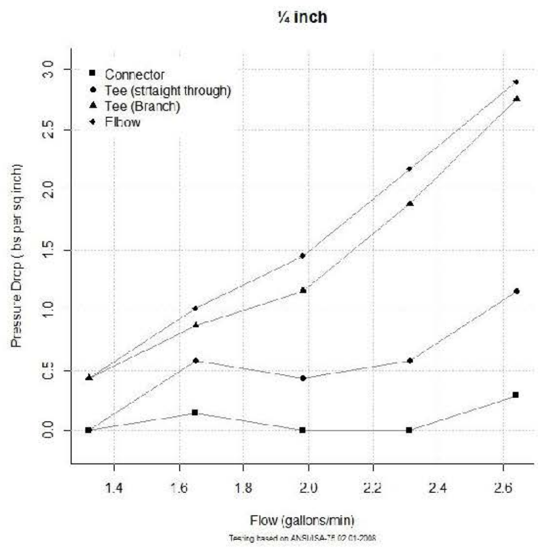
| P/N | A | B | C |
|---|---|---|---|
| 23036-0000 | 1/2" | 3/8" compression | 2.58" |

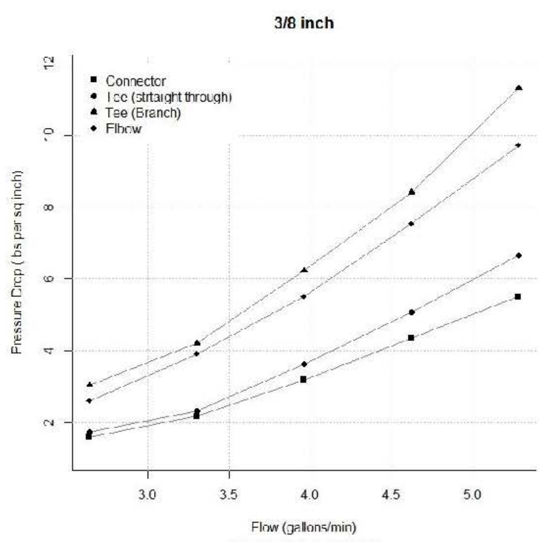


Ballcock Elbow Dimensions
(*Chrome Plated*)

| P/N | A | B | C |
|---|---|---|---|
| U3537 | 1/4" | 7/8" ballcock | 1.05" |

## PRESSURE LOSS AND FLOW RATES

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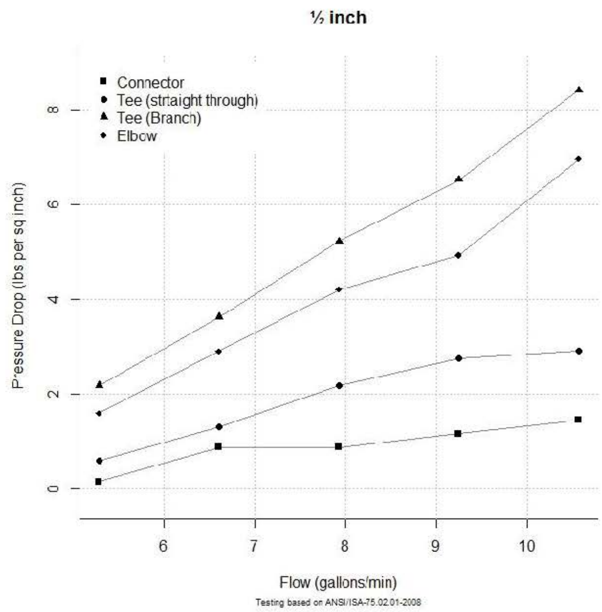
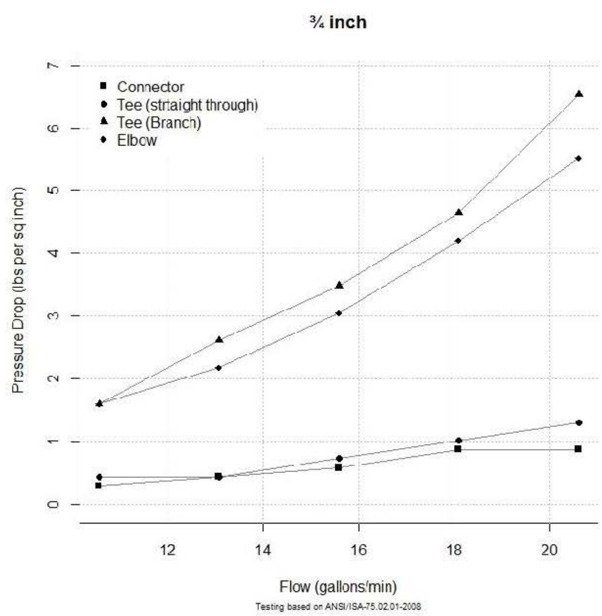
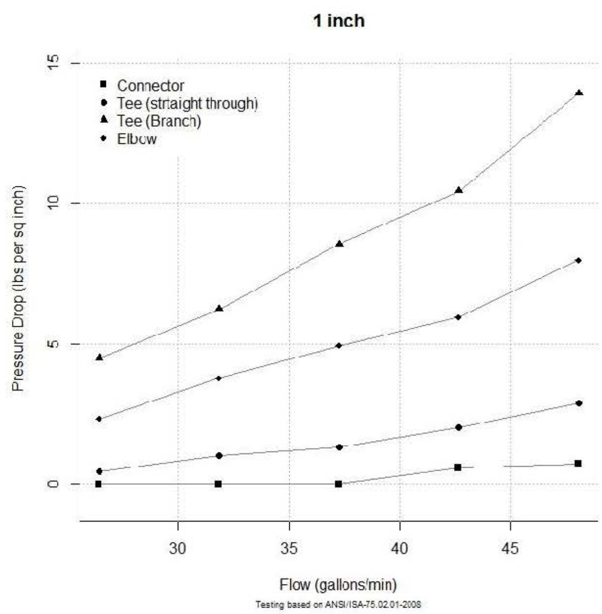

½ inch
Connector
Tee (striaight through)
Tee (Branch)
Elbow
Pressure Drop (lbs per sq inch)
0
2
4
6
8
6
7
8
9
10
Flow (gallons/min)
Testing based on ANSI/ISA-75.02.01-2008

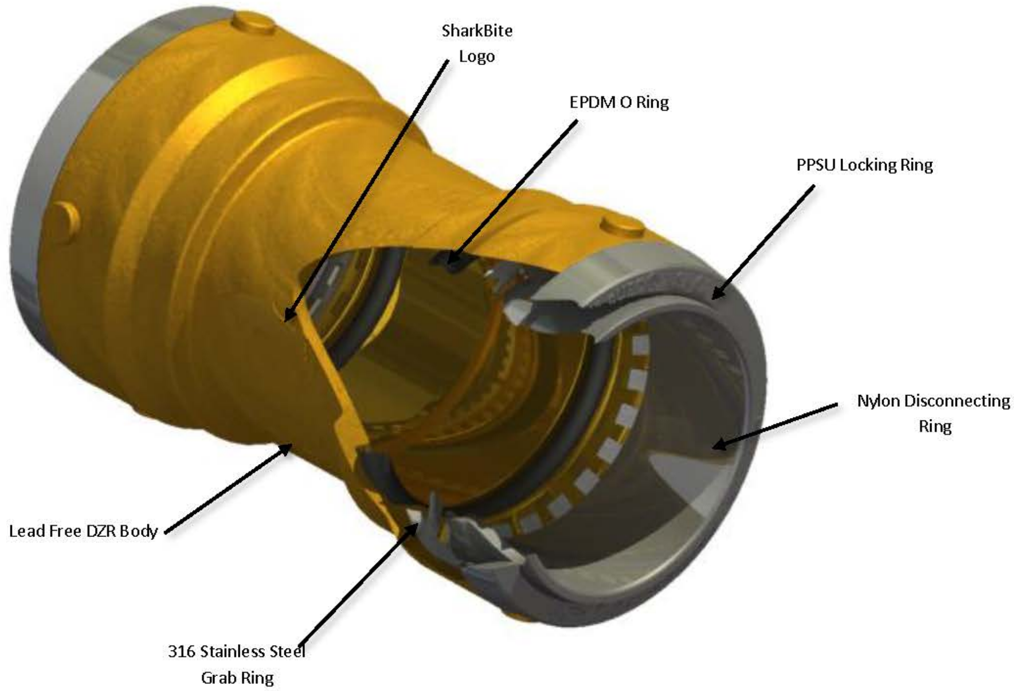

¾ inch
Connector
Tee (striaight through)
Tee (Branch)
Elbow
Pressure Drop (lbs per sq inch)
0
1
2
3
4
5
6
7
12
14
16
18
20
Flow (gallons/min)
Testing based on ANSI/ISA-75.02.01-2008

14


1 inch
Connector
Tee (straight through)
Tee (Branch)
Elbow
Pressure Drop (lbs per sq inch)
0
5
10
15
30
35
40
45
Flow (gallons/min)
Testing based on ANSI/ISA-75.02.01-2008

15

## THE SHARKBITE 2XL DESIGN (1-1/4" – 2")



## WHY SHARKBITE 2XL?

- **Quick Connect:**
  - No tools, soldering, clamps, unions or glue required. Cut pipe square, de-burr to remove rough edges/debris, mark the pipe for correct depth and push to get a pressure ready connection every time.
- **Quick Disconnect:**
  - Disconnect in seconds by sliding the De-Mount Tool down the pipe to engage the demount lugs and rotate clockwise to lock the open position leaving both hands free, you can now remove the pipe.
- **SAFE-Recessed Release Collar:**
  - Commercial SharkBite require a special Demount Tool and cannot be accidentally disconnected/released.
- **Extensive Range Including Slip Feature on Couplings and Tee's:**
  - When repairing or tapping into existing pipe with "Push-Fittings" you must be able to either move the fitting or the pipe to ensure the pipe is engaged fully into the fitting. With rigid pipe like copper the only way with "Push-Fittings" is to have a SLIP feature to allow easy installation when tapping into existing pipe.
- **Easy Installation:**
  - Unlike the tool intensive connection methods there is NO need to send multiple fitters to a job, SharkBite 2XL has been designed to be installed or removed by one person. All fittings are lubricated for easy connection and by fitting the De-Mount Tool before engaging the pipe the force required can be reduced further. With the De-Mount Tool locked on you also have hands free disconnection. WET OR DRY: No waiting for copper tube to dry before soldering or glue to cure, SharkBite makes an instant connection in seconds.
- **No Tools:**
  - Unlike alterative tool intensive connections systems, SharkBite has no special tooling required for installation.
- **No Time:**
  - Fastest connection - CUT-PUSH-DONE.
  - Easy access to small or tight places.
  - No Flame - Does not require fire permit or fire marshal.
- **No Waste:**
  - Should you make an error or simply want to change your installation, no problem for SharkBite. Simply remove and re-use. (Fittings used for repeated testing must not be used in any permanent application).
- **Fittings Cannot be Disassembled:**
  - SharkBite 2XL Fittings are factory assembled and components cannot be removed.
- **Long Pipe Engagement:**
  - Provides pipe support against lateral pipe forces.
- **Lead Free (LF) Dezincifcation Resistance (DZR) Brass:**
  - Exceeds current no lead legislation - AB1953 or NSF372. Suitable for underground installation subject to local code authorites/inspectors. Dezincification properties (DZR) exceed ISO6509 and NSF-14.
- **Environmentally Friendly:**
  - Remove and re-use fittings, no need to be scrapped. No heat is required for installation.

## HOW TO MAKE A SHARKBITE 2XL CONNECTION

1. Cut copper, CPVC or PEX using a quality tuber or pipe cutter with a sharp blade.

2. Remove burrs and ensure pipe surface is free of scratches and any debris. It is critical that pipe be marked with the correct insertion depth as listed below:

   1-1/4" Pipe Insertion Depth = 2"

   1-1/2" Pipe Insertion Depth = 2-1/4"

   2" Pipe Insertion Depth = 2-1/2"

3. Align pipe with the fitting, insert pipe while rotating either pipe or fitting.

4. SharkBite 2XL PEX Stiffener must be inserted into PEX pipe prior to fitting.

Connection is complete when pipe is fully inserted with depth insertion marked on pipe is still visible at the head of the fitting

## DISCONNECTING A SHARKBITE 2XL CONNECTION

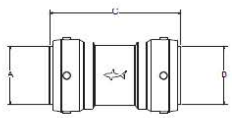
1. Place the Shark Shifter De-Mount Tool on the pipe just above the connection. Then slide the tool down to engage lugs on the head of the fitting.

2. Rotate the Shark Shifter De-Mount Tool clockwise to lock onto the lugs. This will lock the Shark Shifter De-Mount Tool in place.

3. Rotate the Shark Shifter De-Mount Tool clockwise to lock onto the lugs. This will lock the Shark Shifter De-Mount Tool in place.

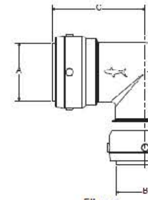
With the Shark Shifter De-Mount Tool Withdraw locked in place, pull the pipe from the fitting. Rotate the Shark Shifter De-Mount Tool counter-clockwise to remove the fitting.

## SHARKBITE 2XL DIMENSIONS



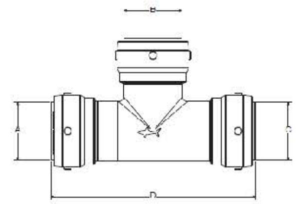
Coupling

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB0135 | 1¼″ | 1¼″ | 3.26″ | 0.84 |
| SB0141 | 1½″ | 1½″ | 4.37″ | 1.15 |
| SB0154 | 2″ | 2″ | 4.80″ | 1.56 |
| SB013528 | 1¼″ | 1″ | 3.26″ | 0.69 |
| SB014135 | 1½″ | 1¼″ | 4.37″ | 1.02 |
| SB015441 | 2″ | 1½″ | 4.80″ | 1.42 |



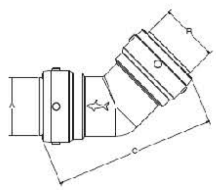
Elbow

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB0235 | 1¼″ | 1¼″ | 2.80″ | 1.07 |
| SB0241 | 1½″ | 1½″ | 3.16″ | 1.52 |
| SB0254 | 2″ | 2″ | 3.60″ | 2.18 |



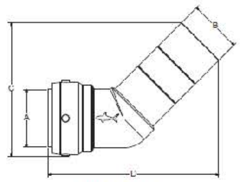
Tee

| P/N | A | B | C | D | Weight |
|---|---|---|---|---|---|
| SB0335 | 1¼″ | 1¼″ | 1¼″ | 6.50″ | 1.61 |
| SB0341 | 1½″ | 1½″ | 1½″ | 6.70″ | 2.26 |
| SB0354 | 2″ | 2″ | 2″ | 7.99″ | 3.07 |
| SB03353516 | 1¼″ | ½″ | 1¼″ | 6.70″ | 1.25 |
| SB03353522 | 1¼″ | ¾″ | 1¼″ | 6.70″ | 1.28 |
| SB03353528 | 1¼″ | 1″ | 1¼″ | 6.70″ | 1.42 |
| SB03414122 | 1½″ | ¾″ | 1½″ | 7.39″ | 1.78 |
| SB03414128 | 1½″ | 1″ | 1½″ | 7.39″ | 1.92 |
| SB03414135 | 1½″ | 1¼″ | 1½″ | 7.39″ | 2.08 |
| SB03545428 | 2″ | 1″ | 2″ | 7.99″ | 2.55 |
| SB03545435 | 2″ | 1¼″ | 2″ | 7.99″ | 2.72 |
| SB03545441 | 2″ | 1½″ | 2″ | 7.99″ | 2.86 |



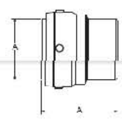
45° Elbow

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB0535 | 1¼″ | 1¼″ | 5.15″ | 0.97 |
| SB0541 | 1½″ | 1½″ | 5.77″ | 1.35 |
| SB0554 | 2″ | 2″ | 6.50″ | 1.91 |



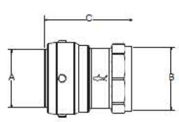
Street 45° Elbow

| P/N | A | B | C | D | Weight |
|---|---|---|---|---|---|
| SB0735 | 1¼″ | 1¼″ | 4.24″ | 5.45″ | 0.97 |
| SB0741 | 1½″ | 1½″ | 4.70″ | 6.05″ | 1.35 |
| SB0754 | 2″ | 2″ | 5.30″ | 6.74″ | 1.91 |



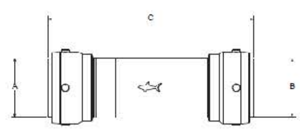
End Stop

| P/N | Size | A | Weight |
|---|---|---|---|
| SB0435 | 1¼″ | 2.35″ | 0.57 |
| SB0441 | 1½″ | 2.62″ | 0.82 |
| SB0554 | 2″ | 2.89″ | 1.25 |



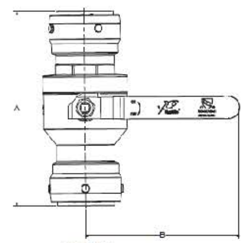
Female Connector

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB113532F | 1¼″ | 1¼″ FNPT | 2.98″ | 0.77 |
| SB114140F | 1½″ | 1½″ FNPT | 3.21″ | 0.92 |
| SB115450F | 2″ | 2″ FNPT | 3.42″ | 1.23 |



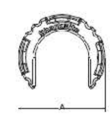
Slip Coupling

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB0635 | 1¼″ | 1¼″ | 6.59″ | 1.20 |
| SB0641 | 1½″ | 1½″ | 7.40″ | 1.71 |
| SB0654 | 2″ | 2″ | 7.98″ | 2.33 |



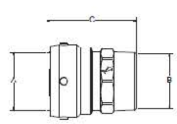
Ball Valve

| P/N | Size | A | B | Weight |
|---|---|---|---|---|
| SBBV435 | 1¼″ | 6.08″ | 5.10″ | 2.06 |
| SBBV441 | 1½″ | 6.79″ | 6.10″ | 2.99 |
| SBBV154 | 2″ | 7.58″ | 6.16″ | 4.45 |



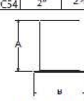
Demount Clip

| P/N | Size | A | Weight |
|---|---|---|---|
| SBDC35 | 1¼″ | 2.70″ | 0.07 |
| SBDC41 | 1½″ | 2.94″ | 0.08 |
| SBDC54 | 2″ | 2.45″ | 0.09 |



Male Connector

| P/N | A | B | C | Weight |
|---|---|---|---|---|
| SB113532M | 1¼″ | 1¼″ MNPT | 3.03″ | 0.71 |
| SB114140M | 1½″ | 1½″ MNPT | 3.20″ | 0.89 |
| SB115450M | 2″ | 2″ MNPT | 3.43″ | 1.20 |

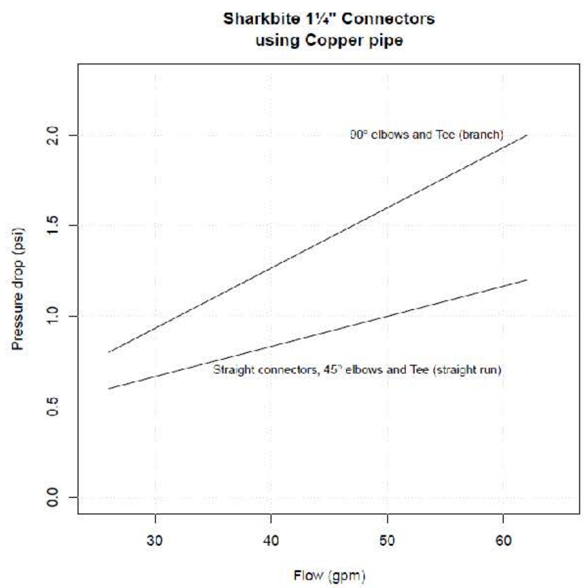


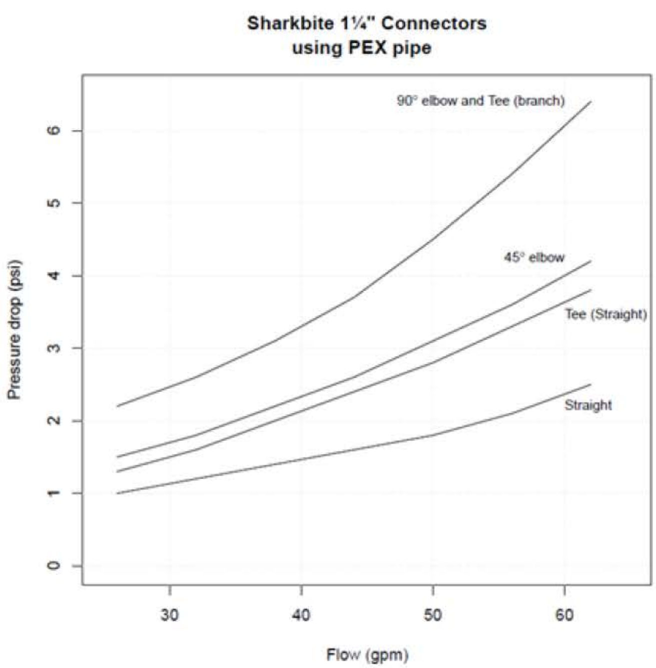
Pex Stiffener

| P/N | Size | A | B | Weight |
|---|---|---|---|---|
| SBLT35 | 1¼″ | 1.65″ | 1.34″ | 0.08 |
| SBLT41 | 1½″ | 1.89″ | 1.59″ | 0.10 |
| SBLT54 | 2″ | 2.09″ | 2.09″ | 0.15 |

* All weights are in pounds

## SHARKBITE 2XL PRESSURE LOSS AND FLOW RATES

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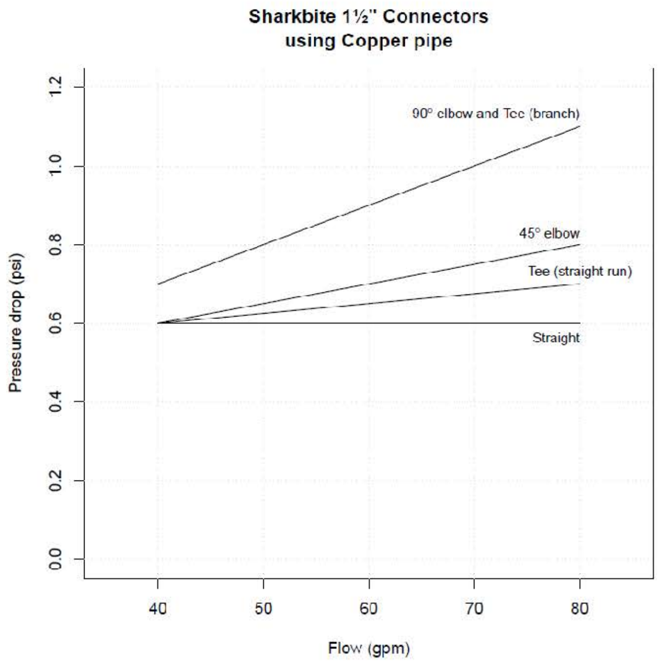
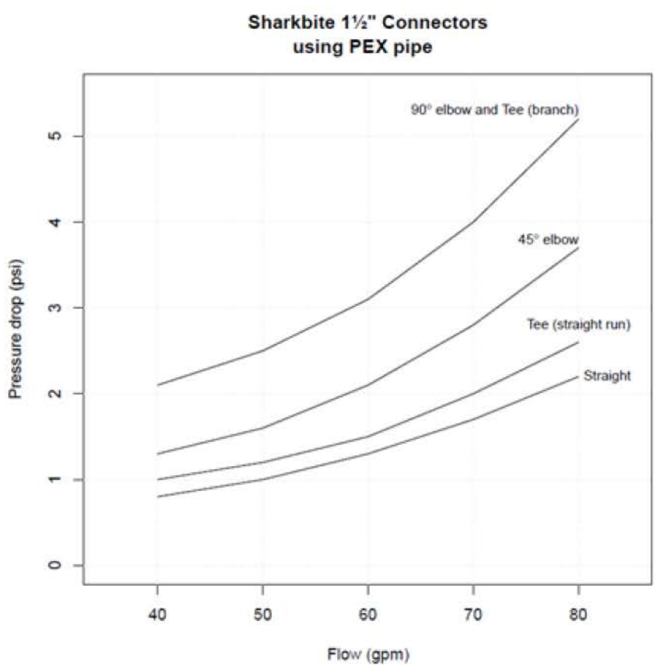
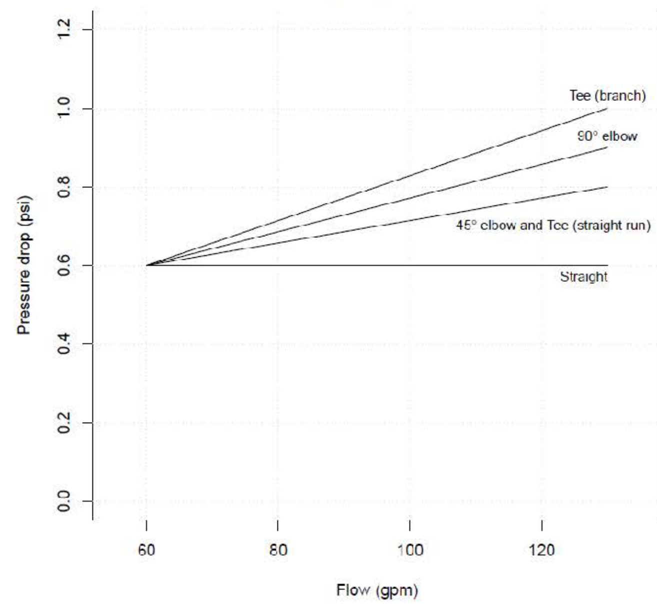

Sharkbite 1½" Connectors
using Copper pipe
90° elbow and Tee (branch)
45° elbow
Tee (straight run)
Straight
Pressure drop (psi)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
40
50
60
70
80
Flow (gpm)

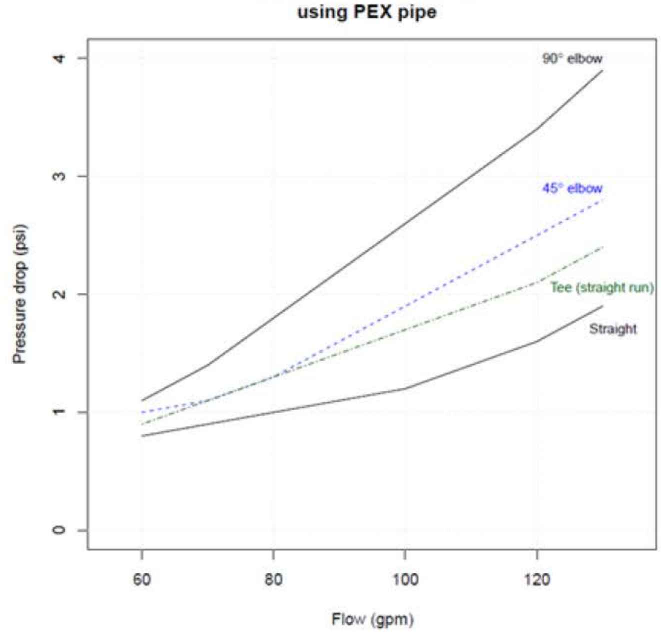

Sharkbite 1½" Connectors
using PEX pipe
90° elbow and Tee (branch)
45° elbow
Tee (straight run)
Straight
Pressure drop (psi)
0
1
2
3
4
5
40
50
60
70
80
Flow (gpm)

22

Sharkbite 2" Connectors
using Copper pipe




Sharkbite 2" Connectors
using PEX pipe

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## SHARKBITE PEX TUBING

SharkBite PEX tubing is a cross-linked polyethylene tubing for a wide range of residential and commercial plumbing applications. Manufactured without an oxygen barrier for potable water systems (available in white, blue, and red) and with an oxygen barrier for radiant floor and hydronic heating applications (available in orange). The oxygen diffusion barrier applied to the exterior limits oxygen permeation through the tubing wall in hydronic heating applications which prevents corrosion of ferrous metal parts in the heating system.

**FEATURES AND BENEFITS**

- Flexible: Easy to install and service.
- Quieter: Minimizes noise caused by water hammer.
- Resists corrosion and scale buildup: Improves the performance of the plumbing system.
- Fewer fittings required: Reduces total installation cost.
- Fewer joints: Reduces the chances of call backs.
- Pressure test immediately: No waiting for glue to dry or joints to cool

A repeating SharkBite imprint pattern provides a visual aid to determine if the tube has been inserted all the way into the SharkBite Push-Fit Fitting. This feature only works if the tubing is cut between the SharkBite imprint pattern.

**CERTIFICATIONS**

The SharkBite tubing with and without oxygen barrier is approved for use in all model codes in the US and Canada for use in hydronic and potable water systems and is certified to the following standards:

- NSF 14/61,
- NSF P171,
- ASTM F 876,
- ASTM F 877,
- CSA B137.5
- AWWA C904.

## PEX PIPE SPECS AND DIMENSIONS

| Model | Nominal Tubing Size | | | | Length | | Bend Radius | | Fluid Capacity Per 100’ | | Package Weight | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | | OD | | FT | M | in | mm | gal | ltrs | lbs | kgs |
| | in | mm | in | mm | | | | | | | | |
| Blue PEX (Coil) | | | | | | | | | | | | |
| U860B100 | 1/2 | 13 | 5/8 | 16 | 100 | 30.48 | 5 | 127 | 0.96 | 3.63 | 5.5 | 2.5 |
| U860B300 | 1/2 | 13 | 5/8 | 16 | 300 | 91.44 | 5 | 127 | 0.96 | 3.63 | 14.5 | 6.6 |
| U860B500 | 1/2 | 13 | 5/8 | 16 | 500 | 152.4 | 5 | 127 | 0.96 | 3.63 | 24 | 10.9 |
| U870B100 | 3/4 | 19 | 7/8 | 22 | 100 | 30.48 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870B300 | 3/4 | 19 | 7/8 | 22 | 300 | 91.44 | 7 | 178 | 1.9 | 7.19 | 31.5 | 14.4 |
| U870B500 | 3/4 | 19 | 7/8 | 22 | 500 | 152.4 | 7 | 178 | 1.9 | 7.19 | 45 | 20.4 |
| U880B100 | 1 | 25 | 1-1/8 | 29 | 100 | 30.48 | 10 | 254 | 3.1 | 11.73 | 18 | 8.2 |
| U880B300 | 1 | 25 | 1-1/8 | 29 | 300 | 91.44 | 10 | 254 | 3.1 | 11.73 | 54 | 24.6 |
| U880B500 | 1 | 25 | 1-1/8 | 29 | 500 | 152.4 | 10 | 254 | 3.1 | 11.73 | 90 | 40.8 |
| Red PEX (Coil) | | | | | | | | | | | | |
| U860R100 | 1/2 | 13 | 5/8 | 16 | 100 | 30.48 | 5 | 127 | 0.96 | 3.63 | 5.5 | 2.5 |
| U860R300 | 1/2 | 13 | 5/8 | 16 | 300 | 91.44 | 5 | 127 | 0.96 | 3.63 | 14.5 | 6.6 |
| U860R500 | 1/2 | 13 | 5/8 | 16 | 500 | 152.4 | 5 | 127 | 0.96 | 3.63 | 24 | 10.9 |
| U870R100 | 3/4 | 19 | 7/8 | 22 | 100 | 30.48 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870R300 | 3/4 | 19 | 7/8 | 22 | 300 | 91.44 | 7 | 178 | 1.9 | 7.19 | 31.5 | 14.4 |
| U870R500 | 3/4 | 19 | 7/8 | 22 | 500 | 152.4 | 7 | 178 | 1.9 | 7.19 | 45 | 20.4 |
| U880R100 | 1 | 25 | 1-1/8 | 29 | 100 | 30.48 | 10 | 254 | 3.1 | 11.73 | 18 | 8.2 |
| U880R300 | 1 | 25 | 1-1/8 | 29 | 300 | 91.44 | 10 | 254 | 3.1 | 11.73 | 54 | 24.6 |
| U880R500 | 1 | 25 | 1-1/8 | 29 | 500 | 152.4 | 10 | 254 | 3.1 | 11.73 | 90 | 40.8 |
| White PEX (Coil) | | | | | | | | | | | | |
| U860W100 | 1/2 | 13 | 5/8 | 16 | 100 | 30.48 | 5 | 127 | 0.96 | 3.63 | 5.5 | 2.5 |
| U860W300 | 1/2 | 13 | 5/8 | 16 | 300 | 91.44 | 5 | 127 | 0.96 | 3.63 | 14.5 | 6.6 |
| U860W500 | 1/2 | 13 | 5/8 | 16 | 500 | 152.4 | 5 | 127 | 0.96 | 3.63 | 24 | 10.9 |
| U870W100 | 3/4 | 19 | 7/8 | 22 | 100 | 30.48 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870W300 | 3/4 | 19 | 7/8 | 22 | 300 | 91.44 | 7 | 178 | 1.9 | 7.19 | 31.5 | 14.4 |
| U870W500 | 3/4 | 19 | 7/8 | 22 | 500 | 152.4 | 7 | 178 | 1.9 | 7.19 | 45 | 20.4 |
| U880W100 | 1 | 25 | 1-1/8 | 29 | 100 | 30.48 | 10 | 254 | 3.1 | 11.73 | 18 | 8.2 |

# SHARKBITE PUSH-FIT CONNECTION SYSTEM

| Model | Nominal Tubing Size | | | | Length | | Bend Radius | | Fluid Capacity Per 100' | | Package Weight | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | | OD | | FT | M | in | mm | gal | ltrs | lbs | kgs |
| | in | mm | in | mm | | | | | | | | |
| White PEX (Coil) | | | | | | | | | | | | |
| U880W300 | 1 | 25 | 1-1/8 | 29 | 300 | 91.44 | 10 | 254 | 3.1 | 11.73 | 54 | 24.6 |
| U880W500 | 1 | 25 | 1-1/8 | 29 | 500 | 152.4 | 10 | 254 | 3.1 | 11.73 | 90 | 40.8 |
| U885W100 | 1-1/4 | 31.75 | 1-3/8 | 35 | 100 | 30.48 | 7 | 175 | 4.67 | 17.68 | 25 | 11.34 |
| U890W100 | 1-1/2 | 38.1 | 1-5/8 | 41 | 100 | 30.48 | 8 | 206 | 6.5 | 24.61 | 35 | 15.88 |
| U895W100 | 2 | 50.8 | 2-1/4 | 54 | 100 | 30.48 | 11 | 270 | 11.4 | 43.15 | 60 | 27.22 |
| Blue PEX (Straight Lengths) | | | | | | | | | | | | |
| U860B5 | 1/2 | 13 | 5/8 | 16 | 5 | 1.52 | 5 | 127 | 0.96 | 3.63 | 3 | 1.4 |
| U860B10 | 1/2 | 13 | 5/8 | 16 | 10 | 3.04 | 5 | 127 | 0.96 | 3.63 | 6 | 2.7 |
| U860B20 | 1/2 | 13 | 5/8 | 16 | 20 | 6.09 | 5 | 127 | 0.96 | 3.63 | 12 | 5.5 |
| U870B5 | 3/4 | 19 | 7/8 | 22 | 5 | 1.52 | 7 | 178 | 1.9 | 7.19 | 5.25 | 2.5 |
| U870B10 | 3/4 | 19 | 7/8 | 22 | 10 | 3.04 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870B20 | 3/4 | 19 | 7/8 | 22 | 20 | 6.09 | 7 | 178 | 1.9 | 7.19 | 21 | 9.5 |
| U880B5 | 1 | 25 | 1-1/8 | 29 | 5 | 1.52 | 10 | 254 | 3.1 | 11.73 | 4.5 | 2 |
| U880B10 | 1 | 25 | 1-1/8 | 29 | 10 | 3.04 | 10 | 254 | 3.1 | 11.73 | 8.8 | 4 |
| U880B20 | 1 | 25 | 1-1/8 | 29 | 20 | 6.09 | 10 | 254 | 3.1 | 11.73 | 17.4 | 7.9 |
| Red PEX (Straight Lengths) | | | | | | | | | | | | |
| U860R5 | 1/2 | 13 | 5/8 | 16 | 5 | 1.52 | 5 | 127 | 0.96 | 3.63 | 3 | 1.4 |
| U860R10 | 1/2 | 13 | 5/8 | 16 | 10 | 3.04 | 5 | 127 | 0.96 | 3.63 | 6 | 2.7 |
| U860R20 | 1/2 | 13 | 5/8 | 16 | 20 | 6.09 | 5 | 127 | 0.96 | 3.63 | 12 | 5.5 |
| U870R5 | 3/4 | 19 | 7/8 | 22 | 5 | 1.52 | 7 | 178 | 1.9 | 7.19 | 5.25 | 2.5 |
| U870R10 | 3/4 | 19 | 7/8 | 22 | 10 | 3.04 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870R20 | 3/4 | 19 | 7/8 | 22 | 20 | 6.09 | 7 | 178 | 1.9 | 7.19 | 21 | 9.5 |
| U880R5 | 1 | 25 | 1-1/8 | 29 | 5 | 1.52 | 10 | 254 | 3.1 | 11.73 | 4.5 | 2 |
| U880R10 | 1 | 25 | 1-1/8 | 29 | 10 | 3.04 | 10 | 254 | 3.1 | 11.73 | 8.8 | 4 |
| U880R20 | 1" | 25 | 1-1/8 | 29 | 20 | 6.09 | 10 | 254 | 3.1 | 11.73 | 17.4 | 7.9 |
| White PEX (Straight Lengths) | | | | | | | | | | | | |
| U860W10 | 1/2 | 13 | 5/8 | 16 | 10 | 3.04 | 5 | 127 | 0.96 | 3.63 | 6 | 2.7 |
| U860W20 | 1/2 | 13 | 5/8 | 16 | 20 | 6.09 | 5 | 127 | 0.96 | 3.63 | 12 | 5.5 |
| U870W5 | 3/4 | 19 | 7/8 | 22 | 5 | 1.52 | 7 | 178 | 1.9 | 7.19 | 5.25 | 2.5 |
| U870W10 | 3/4 | 19 | 7/8 | 22 | 10 | 3.04 | 7 | 178 | 1.9 | 7.19 | 10.5 | 4.8 |
| U870W20 | 3/4 | 19 | 7/8 | 22 | 20 | 6.09 | 7 | 178 | 1.9 | 7.19 | 21 | 9.5 |
| U880W5 | 1 | 25 | 1-1/8 | 29 | 5 | 1.52 | 10 | 254 | 3.1 | 11.73 | 4.5 | 2 |
| U880W10 | 1 | 25 | 1-1/8 | 29 | 10 | 3.04 | 10 | 254 | 3.1 | 11.73 | 8.8 | 4 |
| U880W20 | 1 | 25 | 1-1/8 | 29 | 20 | 6.09 | 10 | 254 | 3.1 | 11.73 | 17.4 | 7.9 |
| U885W20 | 1-1/4 | 31.75 | 1-3/8 | 35 | 20 | 6.10 | 7 | 175 | 4.76 | 7.68 | 25 | 11.34 |
| U890W20 | 1-1/2 | 38.1 | 1-5/8 | 41 | 20 | 6.10 | 8 | 206 | 6.5 | 24.61 | 35 | 15.88 |
| U895W20 | 2 | 50.8 | 2-1/4 | 54 | 20 | 6.10 | 11 | 270 | 11.4 | 43.15 | 36 | 16.33 |

## IAPMO RESEARCH AND TESTING, INC.

5001 E. Philadelphia Street, Ontario, CA 91761-2816 • (909) 472-4100 • Fax (909) 472-4244 •
www.iapmort.org

ANSI Accredited Program PRODUCT CERTIFICATION #0202

SCC Accredited CB-P/S OCPS Accrédité CCN

# CERTIFICATE OF LISTING

IAPMO Research and Testing, Inc. is a product certification body which tests and inspects samples taken from the supplier's stock or from the market or a combination of both to verify compliance to the requirements of applicable codes and standards. This activity is coupled with periodic surveillance of the supplier's factory and warehouses as well as the assessment of the supplier's Quality Assurance System. This listing is subject to the conditions set forth in the characteristics below and is not to be construed as any recommendation, assurance or guarantee by IAPMO Research and Testing, Inc. of the product acceptance by Authorities Having Jurisdiction.

Effective Date: July 2013 -Rev. 1/8/2014- Void After: July 2014

Product: Push Fit Fittings File No. 4630

Issued To: Cash Acme/Reliance Worldwide
2400 7TH AVE SW
CULLMAN, AL 35055

Identification: Each fitting shall have the following information marked on it where it will be visible after it has been installed:
Name of manufacturer or trademark.
When a fitting is not suitable for all four (4) materials, it shall be marked as follows for the materials for which they are suitable:
Copper or Cu
CPVC
PEX
PE-RT
When push-fit connectors are used on plumbing devices, the markings are permitted to be on the plumbing device.

Fittings CTS or smaller are permitted to use a permanent label complying with the requirements of UL 969 or CSA C22.2 N. 0.15 to display the required markings.

The markings shall be permanent.

The product shall also bear the cUPC mark.

Characteristics: Push fit fittings that have a quick assembly push fit mechanism that can be used with Copper, PEX and CPVC tubing and pipes. Fittings for use in domestic and commercial application for both potable water distribution systems and hydronic heating systems. Push fit fittings can be utilized in underground applications and as manufactured joints without access panels. To be installed in accordance with the manufacturer's instructions and the latest edition of the Uniform Plumbing Code and the National Plumbing Code of Canada.

Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025.

Products are in compliance with the following code(s):

Uniform Plumbing Code (UPC)
National Plumbing Code of Canada
International Plumbing Code (IPC)

Products are in compliance with the following standard(s):

ASSE 1061-2011

MODELS:

Note: The requirements of Section 609.3.2 in the Uniform Plumbing Code are satisfied for push fit fittings by section 301.4.1 of the same Uniform Plumbing Code when installed in accordance with the manufacturer's installation guides.

Note: All 1/2" through 1" models comply with ANSI/NSF 14.

For a complete list of compliant models and the most up to date listing, please visit
http://pld.iapmo.org/file_info.asp?file_no=0004630

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# CERTIFICATE OF LISTING

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Effective Date: October 2013 -Rev. 12/4/2013- Void After: October 2014

Product: Lead Free Plumbing Products File No. 6544

Issued To: CASH ACME/RELIANCE WORLDWIDE
2400 7TH AVE SW
CULLMAN, AL 35055

Identification: Each product shall bear permanent and legible markings to identify the manufacturer. This marking shall be the trade name, trademark, or other mark known to identify the manufacturer. The product and/or product packaging may also bear the term "Lead Plumbing Law", "Complies with Lead Plumbing Law", or either "Lead Free" or "Low Lead" above or in close proximity to the appropriate IAPMO R&T certification mark, or the term "Certified by IAPMO R&T". The product packaging may also bear a grey dot, a check mark with circle, or any other home centers marking requirements.

Characteristics: Products may include any pipe, pipe fitting, solder, flux, or other plumbing products providing water for human consumption. Products listed below are to be installed in accordance with the manufacturer's instruction. These products have been verified with weighted average lead content <=0.25%; Solder and flux lead content <=0.2%.

Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025.

Products are in compliance with the following standard(s):

Section 1417(d) of the Safe Drinking Water ActThe lead content requirements of Section 116875 of the California Health & Safety Code
NSF/ANSI 372-2010

For a complete list of compliant models and the most up to date listing, please visit
http://pld.iapmo.org/file_info.asp?file_no=0006544

# IAPMO RESEARCH AND TESTING, INC.

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ANSI Accredited Program PRODUCT CERTIFICATION #0202

SCC Accredited CB-P/S OCPS Accrédité CCN

NSF/ANSI 61

## CERTIFICATE OF LISTING

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| | | |
|---|---|---|
| Effective Date: | December 2013 -Rev. 2/20/2014- | Void After: December 2014 |
| Product: | Drinking Water System Components - Health Effects | File No. N-4630 |
| Issued To: | Cash Acme/Reliance Worldwide<br>2400 7TH AVE SW<br>CULLMAN, AL 35055 | |
| Identification: | Each product shall be permanently and legibly marked with the manufacturer's name or trademark. The product may also be marked with the standard designation "NSF/ANSI 61". | |
| Characteristics: | Materials or products that come into contact with drinking water and/or drinking water treatment chemicals. Products and materials may include process media, protective materials, joining and sealing materials, pipes and related products, mechanical devices used with treatment/transmission/distribution systems, and mechanical plumbing devices. To be installed in accordance with the manufacturer's instruction.<br><br>Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025. | |

Products are in compliance with the following standard(s):

NSF/ANSI 61-2011

For a complete list of compliant models and the most up to date listing, please visit
http://pld.iapmo.org/file_info.asp?file_no=N4630

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5001 E. Philadelphia Street, Ontario, CA 91761-2816 • (909) 472-4100 • Fax (909) 472-4244 •
www.iapmort.org

ANSI Accredited Program PRODUCT CERTIFICATION #0202

SCC Accredited CB-P/S OCPS Accrédité CCN

# CERTIFICATE OF LISTING

IAPMO Research and Testing, Inc. is a product certification body which tests and inspects samples taken from the supplier's stock or from the market or a combination of both to verify compliance to the requirements of applicable codes and standards. This activity is coupled with periodic surveillance of the supplier's factory and warehouses as well as the assessment of the supplier's Quality Assurance System. This listing is subject to the conditions set forth in the characteristics below and is not to be construed as any recommendation, assurance or guarantee by IAPMO Research and Testing, Inc. of the product acceptance by Authorities Having Jurisdiction.

| | | |
|---|---|---|
| Effective Date: | October 2013 -Rev. 11/6/2013- | Void After: October 2014 |
| Product: | Crosslinked Polyethylene Water Distribution System (PEX) | File No. 7143 |
| Issued To: | CASH ACME/RELIANCE WORLDWIDE<br>2400 7TH AVE SW<br>CULLMAN, AL 35055 | |
| Identification: | The tubing shall be marked with the manufacturer's name or trademark, ASTM F876 and ASTM F877 PEX, pressure rating at 180° F, nominal size, standard dimension ratio and a code number identifying the compound and the date of manufacture. The fittings shall be marked with the manufacturer's name or trademark, and ASTM F877. Both tubing and fittings shall be marked with the cUPC® certification mark. | |
| Characteristics: | Crosslinked polyethylene plastic hot and cold water distribution systems made in one standard dimension ratio and intended for a maximum of 100 psi water service up to and including a maximum working temperature of 180° F. Components are comprised of tubing and/or fittings. To be installed in accordance with the manufacturer's instructions and the requirements of the latest edition of the Uniform Plumbing Code.<br><br>Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025. | |

Products are in compliance with the following code(s):

Uniform Plumbing Code (UPC®)
National Plumbing Code of Canada
International Plumbing Code (IPC®)

Products are in compliance with the following standard(s):
ASTM F877-2011a and CSA B137.5-2009

For a complete list of compliant models and the most up to date listing, please visit
http://pld.iapmo.org/file_info.asp?file_no=0007143

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## WARRANTY

**Limited Warranty – SharkBite® and Cash Acme® Products**

**What Does This Warranty Cover?**
Subject to conditions outlined in this statement, RWC (in the USA, Reliance Worldwide Corporation and in Canada, Reliance Worldwide Canada Inc.) warrants SharkBite® and Cash Acme® products, when used and installed in accordance with the requirements set forth below, to be free from defects in material and workmanship for the applicable warranty period.

**How Long Does The Warranty Coverage Last?**

| Product(s) | Warranty Period (from the date of sale) |
|---|---|
| SharkBite® PEX Tubing | Twenty-Five (25) years |
| SharkBite® Push-Fit Fittings | Twenty-Five (25) years |
| SharkBite® Brass PEX Barbed-Fittings | Five (5) years |
| SharkBite® Copper PEX Manifolds | Five (5) years |
| All other SharkBite® products | Two (2) years |
| All Cash Acme® products | One (1) year |

Proof of purchase is required to validate the warranty period. If proof of purchase is not available, the warranty period shall default to the date of manufacture for each product. **NOTE:** Warranty is applicable to product installed in the country it was purchased.

**What Are The Conditions Of This Warranty?**

1. All products must be installed in accordance with all applicable codes and in accordance with any local, state, provincial or federal requirements.
2. The installing contractor must use construction techniques compliant with applicable codes to install the range of products and use the product(s) within the design parameters specified in any installation guidelines and technical notes for the applicable system. This shall include field pressure testing prior to concealing with concrete or by other means.
3. Products must not be installed in a system that may operate at temperatures or at pressures that exceed the printed rating on the product, packaging or installation instructions.
4. Evidence of tampering, mishandling, neglect, accidental damage, freeze damage or unauthorized modifications or repairs that cause damage to RWC warranted products void any warranty coverage of those particular products. It is expressly understood that failure as a result of any freezing fluids within the pipes does not constitute a defect in material or workmanship and shall not be covered by this warranty.
5. Although RWC provides a plumbing system to facilitate a complete installation, other manufacturers tubing and/or fittings may be installed in any given installation provided manufacturing of the tubing and/or fittings demonstrates compliance with the applicable ASTM standards, and the product has been certified by a recognized third-party testing agency. The RWC product in the given installation will continue to be covered under this warranty. **NOTE**: RWC will be responsible only for proven defects in material or workmanship in RWC products. Problems in products manufactured by another company should be reported to that manufacturer.

**How Do You Get Service?**
In order to be eligible for service under this warranty you must return the defective product (with shipping charges prepaid) to the original place of purchase. You also must include the model number of the product, the original date of purchase, proof of purchase and the nature of the problem. Products returned without shipping charges prepaid will be refused. For questions or inquires to the Manufacturer, in the U.S. call 1-877-700-4242 and in Canada 1-888-820-0120.

**What Will RWC Do?**
If, after inspection, we find that a product covered by this limited warranty has failed due to a defect in material or workmanship during the specified warranty period, we will repair or replace, at our sole option, free of charge, the defective product during normal working hours and through a place of business as determined by RWC. This shall constitute the sole and exclusive remedy for any defective product.

**What Does This Warranty Not Cover?**
RWC shall not be responsible for any incidental, indirect, contingent, special or consequential damages, including without limitation, lost profits or the cost of repairing or replacing other property which is damaged if these warranted products do not work properly, other costs resulting from labor charges, delays, vandalism, negligence, fouling caused by foreign material, damage from adverse water conditions, adverse chemical environments, or any other circumstances over which has no control. This limitation applies even if RWC could have foreseen or has been advised of the possibility of these damages. This warranty shall be invalidated by any abuse, misuse, misapplication or improper installation of the product.

**How Does State/Provincial Law Apply?**
Some States/Provinces do not allow limitations on how long an implied warranty lasts, and some States/Provinces do not allow the exclusion or limitation of incidental or consequential damages. Therefore, the above limitations may not apply to you. This Limited Warranty gives you the specific legal rights, and you may have other rights that vary from State/Province to State/Province. You should consult applicable State/Provincial laws to determine your rights.

**SO FAR AS IS CONSISTENT WITH APPLICABLE STATE/PROVINCIAL/FEDERAL LAW, THE EXPRESS WARRANTY SET FORTH HEREIN IS THE ONLY WARRANTY GIVEN BY RWC WITH RESPECT TO THE SHARKBITE® AND CASH ACME® PRODUCTS AND RWC MAKES NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, AND HEREBY SPECIFICALLY DISCLAIMS ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

SharkBite®
Plumbing Solutions

RWC.com
Reliance Worldwide Corporation

**Reliance Worldwide USA**
**2727 Paces Ferry Road SE Suite 1800 Building 2**
**Atlanta, GA 30339**
**Phone: 1-877-700-4242 • Fax: 1-877-700-4280**
**www.rwc.com**

SharkBite Plumbing Solutions
SharkBite 2XL

**www.sharkbite.com**

**Manufactured and Distributed by Reliance Worldwide Corporation**
v. 4.0

Tyco Flush Horizontal Sidewall Sprinkler

**tyco** | **Worldwide Contacts** | www.tyco-fire.com

# RAPID RESPONSE Series LFII Residential Sprinklers 4.2 K-factor Flush Horizontal Sidewall Wet Pipe Systems

## General Description

The TYCO RAPID RESPONSE Series LFII Residential Flush Horizontal Sidewall Sprinklers (TY2384) are decorative, fast response, fusible solder sprinklers designed for use in residential occupancies such as homes, apartments, dormitories, and hotels. When aesthetics is the major consideration, the Series LFII Sprinklers (TY2384) should be the first choice.

The Series LFII Residential Sprinklers (TY2384) are intended for use in the following scenarios:

- wet-pipe residential sprinkler systems for one- and two family dwellings and manufactured homes per NFPA 13D;
- wet-pipe residential sprinkler systems for residential occupancies up to and including four stories in height per NFPA 13R
- wet-pipe sprinkler systems for the residential portions of any occupancy per NFPA 13

The flush design of the Series LFII Residential Sprinklers (TY2384) features a separable escutcheon providing 3/16 inch (4,8 mm) horizontal adjustment. This adjustment reduces the accuracy to which the pipe nipples to the sprinklers must be cut to help assure a perfect fit installation.

The Series LFII Residential Sprinklers (TY2384) have been designed with heat sensitivity and water distribution characteristics proven to help in the control of residential fires and to improve the chance for occupants to escape or be evacuated.

**IMPORTANT**

*Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.*

**NOTICE**

*The Series LFII Residential Flush Horizontal Sidewall Sprinklers (TY2384) described herein must be installed and maintained in compliance with this document and with the applicable standards of the National Fire Protection Association, in addition to the standards of any authorities having jurisdiction. Failure to do so may impair the performance of these devices.*

*The owner is responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or sprinkler manufacturer should be contacted with any questions.*

## Sprinkler Identification Number (SIN)

TY2384

## Technical Data

**Approvals**
UL and C-UL Listed

For details on approvals, refer to the Design Criteria section.

**Maximum Working Pressure**
175 psi (12,1 bar)

**Discharge Coefficient**
K= 4.2 GPM/psi$^{1/2}$ (60,5 LPM/bar$^{1/2}$)

**Temperature Rating**
162°F (72°C)

**Horizontal Adjustment**
3/16 inch (4,8 mm)

**Finishes**
Signal White
Jet Black
Chrome

**Physical Characteristics**
Body . . . . . . . . . . . . . . . . Copper Alloy
Deflector . . . . . . . . . . . . . . . . Copper
Valve Cap . . . . . . . . . . . . Copper Alloy
Orifice Seal . . . . . . . . . . . . . . . . PTFE
Heat Collectors . . . . . . . . . . . Copper

## Operation

The sprinkler assembly contains a small fusible solder element. When exposed to sufficient heat from a fire, the solder melts and enables the internal components of the sprinkler to fall away. At this point the sprinkler activates with the deflector dropping into its operated position (Figure 1C), permitting water to flow.

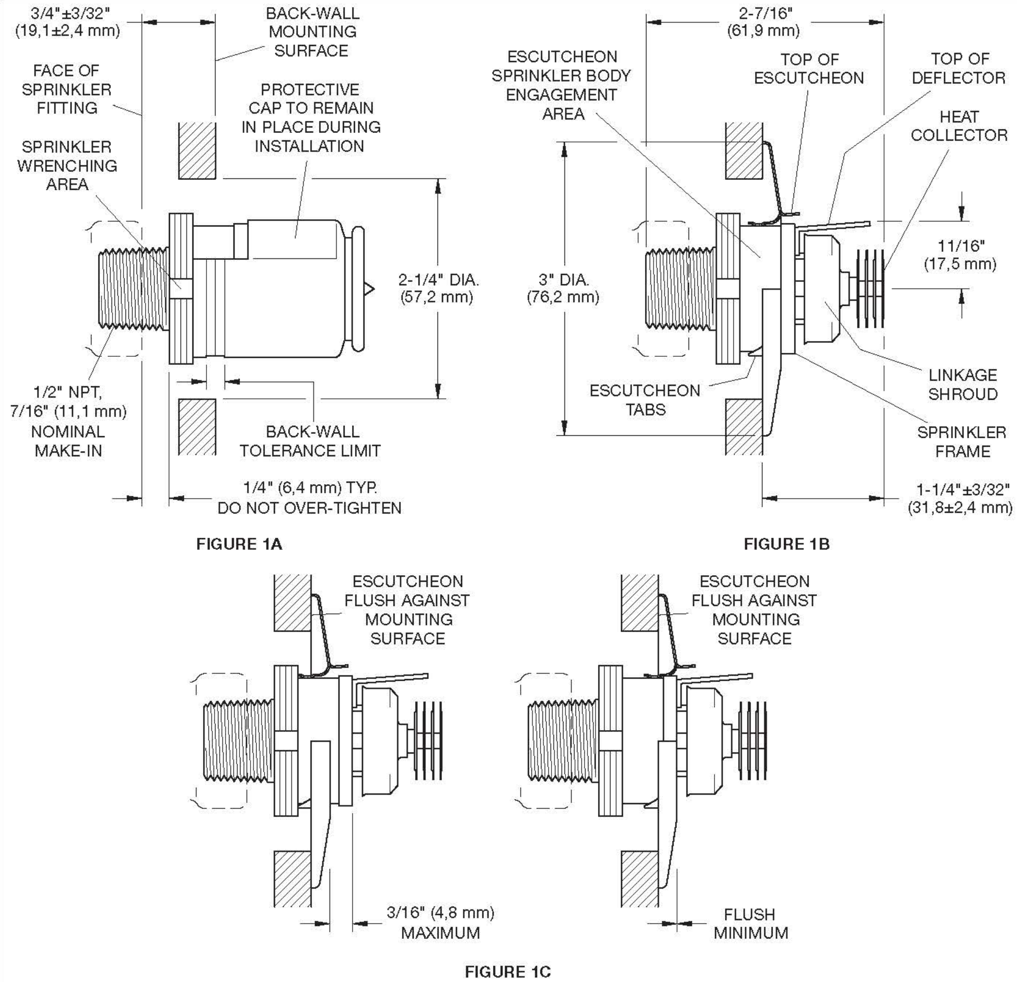



***FIGURE 1***
***RAPID RESPONSE SERIES LFII RESIDENTIAL***
***FLUSH HORIZONTAL SIDEWALL SPRINKLER (TY2384)***

| Maximum Coverage Area (a) Width x Length (d) Ft. x Ft. (m x m) | Maximum Spacing Ft. (m) | WET PIPE SYSTEM Minimum Flow and Residual Pressure(b, c) | | | | |
|---|---|---|---|---|---|---|
| | | Ordinary Temp. Rating 162°F/72°C | | Deflector to Ceiling | Installation Type | Minimum Spacing Ft. (m) |
| | | Flow GPM (L/min) | Pressure PSI (bar) | | | |
| 12 x 12 (3,7 x 3,7) | 12 (3,7) | 13 (49,2) | 9.6 (0,66) | 4 to 6 Inches | Flush | 8 (2,4) |
| 14 x 14 (4,3 x 4,3) | 14 (4,3) | 16 (60,6) | 14.5 (1,00) | | | |
| 16 x 16 (4,9 x 4,9) | 16 (4,9) | 20 (75,7) | 22.7 (1,57 bar) | | | |

(a) For coverage area dimensions less than or between those indicated, it is necessary to use the minimum required flow for the next highest coverage area for which hydraulic design criteria are stated.

(b) Requirement is based on minimum flow in GPM (LPM) from each sprinkler. The associated residual pressures are calculated using the nominal K-factor. Refer to Hydraulic Design Criteria Section for details.

(c) For NFPA 13 residential applications, the greater of 0.1 gpm/ft$^2$ over the design area or the flow in accordance with the criteria in this table must be used.

(d) The Width x Length dimension refers to the Width (backwall where the sprinkler is located) times the Length (horizontal throw of sprinkler).

***TABLE A***
***WET PIPE SYSTEM***
***SERIES LFII RESIDENTIAL FLUSH HORIZONTAL SIDEWALL SPRINKLERS (TY2384)***
***NFPA 13D, 13R, AND 13 HYDRAULIC DESIGN CRITERIA***

# Design Criteria

The TYCO RAPID RESPONSE Series LFII Residential Flush Horizontal Sidewall Sprinklers (TY2384) are UL and C-UL Listed for installation in accordance with this section.

**Residential Sprinkler Design Guide**
When conditions exist that are outside the scope of the provided criteria, refer to the Residential Sprinkler Design Guide TFP490 for the manufacturer's recommendations that may be acceptable to any authority having jurisdiction.

**System Type**
Only wet-pipe systems may be utilized.

**Ceiling Type**
Smooth flat horizontal, or beamed, or sloped, in accordance with the 2013 Edition of NFPA 13D, 13R, or 13 as applicable.

**Hydraulic Design (NFPA 13D and 13R)**
For systems designed to NFPA 13D or NFPA 13R, the minimum required sprinkler flow rate are given in Table A as a function of temperature rating and the maximum allowable coverage areas. The sprinkler flow rate is the minimum required discharge from each of the total number of "design sprinklers" as specified in NFPA 13D or NFPA 13R.

**Hydraulic Design (NFPA 13)**
For systems designed to NFPA 13, the number of design sprinklers is to be the four most hydraulically demanding sprinklers. The minimum required discharge from each of the four sprinklers is to be the greater of the following:

- The flow rates given in Table A for NFPA 13D and 13R as a function of temperature rating and the maximum allowable coverage area.
- A minimum discharge of 0.1 gpm/ft$^2$ over the "design area" comprised of the four most hydraulically demanding sprinklers for the actual coverage areas being protected by the four sprinklers.

**Obstruction to Water Distribution**
Sprinklers are to be located in accordance with the obstruction rules of NFPA 13D, 13R, and 13 as applicable for residential sprinklers as well as with the obstruction criteria described within the Technical Data Sheet TFP490.

**Operational Sensitivity**
The sprinklers are to be installed in the flush position per Figure 1 with the provided escutcheon.

In addition the top-of-deflector-to-ceiling distance is to be within the range (Refer to Table A) being hydraulically calculated.

**Sprinkler Spacing**
The minimum spacing between sprinklers is 8 feet (2,4 m). The maximum spacing between sprinklers cannot exceed the length of the coverage area (Refer to Table A) being hydraulically calculated (e.g., maximum 12 feet for a 12 ft. x 12 ft. coverage area, or 16 feet for a 16 ft. x 16 ft. coverage area).

**Precautionary Warnings for Corrosive Environments**
The Series LFII Residential Flush Horizontal Sidewall Sprinkler (TY2384) must be installed in a non-corrosive environment. The improper use of corrosive agents such as flux, or other products that contain chloride ions, whether applied internally or externally to the sprinkler system, may result in corrosion of the sprinkler head, or stress corrosion cracking, which in turn may cause the sprinklers heads to develop leaks, operate unexpectedly, or not operate properly.

Accordingly, it is essential that the Series LFII Residential Flush Horizontal Sidewall Sprinkler (TY2384) be installed only by experienced fire sprinkler engineers, who comply fully with NFPA 13, 13D, 13R and 25, ASTM B 813, ASTM B 828 and Copper Development Association (CDA).

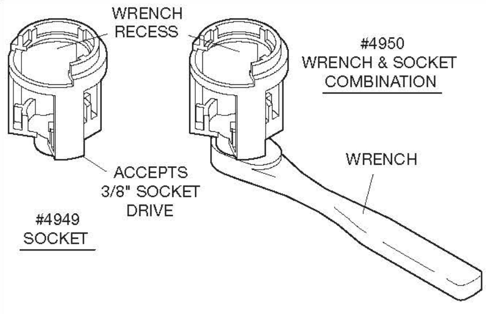



***FIGURE 2***
***SPRINKLER SOCKET AND WRENCH & SOCKET COMBINATION***

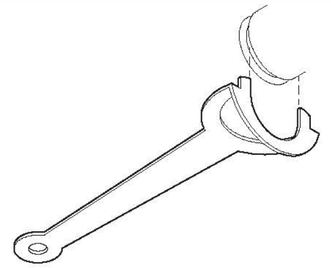


***FIGURE 3***
***PROTECTIVE CAP REMOVAL TOOL***

**Copper sprinkler system piping**
Any time copper piping is used in any part of a fire sprinkler system, the copper piping must be installed in conformance with all applicable standards and requirements for copper piping, including: NFPA 13, 13D, 13R and 25, ASTM B 813, ASTM B 828, and Copper Development Association (CDA). Any soldering in any part of a sprinkler system, either internally or externally, must be done with use of only an ASTM B 813 approved flux. Residual flux must be thoroughly removed from both the interior and exterior surfaces of the piping before installing the sprinkler heads. The use of improper flux, or the failure to thoroughly remove proper flux, may result in corrosion of the sprinkler head or stress cracking, which in turn may cause the sprinkler heads to develop leaks, operate unexpectedly, or not operate properly.

# Installation

The TYCO RAPID RESPONSE Series LFII Residential Flush Horizontal Sidewall Sprinklers (TY2384) must be installed in accordance with this section:

**General Instructions**
The Protective Cap is to remain on the sprinkler during installation until the ceiling installation is complete. The Protective Cap must be removed to place the sprinkler in service.

A leak-tight 1/2 inch NPT sprinkler joint Should be obtained by applying a minimum to maximum torque of 7 to 14 ft.-lbs. (9,5 to 19,0 Nm). Higher levels of torque can distort the sprinkler Inlet with consequent leakage or impairment of the sprinkler.

Do not attempt to compensate for insufficient adjustment in the sprinkler by under- or over-tightening the Sprinkler/ Support Cup Assembly. Re-adjust the position of the sprinkler fitting to suit.

Each sprinkler must be inspected before installation. Do not use any sprinkler that exhibits any deformations or cracks, including cracks on the protective cap.

**Step 1.** Horizontal sidewall sprinklers must be installed only in the horizontal position with their centerline of waterway perpendicular to the backwall and parallel to the ceiling. The top of the deflector is to face towards the ceiling, as depicted in Figure 1B, with the front edge of the deflector parallel to the ceiling.

**Step 2.** Install the sprinkler fitting so that the distance from the face of the fitting to the mounting surface will be nominally 3/4 inches (19,1 mm) as shown in Figure 1A.

**Step 3.** With pipe thread sealant applied to the pipe threads, hand tighten the sprinkler into the sprinkler fitting.

**Step 4.** Wrench tighten the sprinkler using only the Sprinkler Socket or Wrench & Socket Combination (Figure 2). The wrench recess of the socket is to be applied to the sprinkler wrenching area (Figure 1A).

The Sprinkler Wrench must be correctly aligned to slide over the Protective Cap. After the leading edge of the Sprinkler Wrench passes over the flat portion of the Protective Cap, it must be rotated and realigned to engage with the sprinkler wrenching area.

*Conversely to remove the Sprinkler Wrench, sufficiently pull the Sprinkler Wrench so that it disengages from the sprinkler wrenching area, and then rotate the Sprinkler Wrench so that it can pass over the Protective Cap.*

**Step 5.** Use the “backwall tolerance limit” indicator (Figure 1A) on the Protective Cap to check for proper installation depth. The finished wall surface must line up within the 3/16 inch (4,8 mm) range of the “backwall tolerance limit”. Figure 1A illustrates the finished wall surface at the mid-point of the “backwall tolerance limit”. Relocate the sprinkler fitting as necessary. If desired the Protective Cap may also be used to locate the center of the clearance hole. Apply chalk to the center point of the Cap and then gently touch the wall material against the center point of the Cap.

**Step 6.** After the wall has been completed with the 2-1/4 inch (57,2 mm) diameter clearance hole, use the Protective Cap Removal Tool (Figure 3) to remove the Protective Cap and then push on the Escutcheon until its flange comes in contact with the wall.

If the Escutcheon cannot be engaged sufficiently to contact the wall and/or the Escutcheon cannot be engaged per Figure 1C (i.e., 3/16 inch (4,8 mm) to flush with respect to the face of the sprinkler body), relocate the sprinkler fitting.

# Care and Maintenance

The TYCO RAPID RESPONSE Series LFII Residential Flush Horizontal Sidewall Sprinklers (TY2384) must be maintained and serviced in accordance with this section:

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, obtain permission to shut down the affected fire protection system from the proper authorities and notify all personnel who may be affected by this action.

Absence of an Escutcheon Plate may delay the time to sprinkler operation in a fire situation. This outer piece of the escutcheon is used to cover a clearance hole.

The owner must assure that the sprinklers are not used for hanging any objects and that the sprinklers are only cleaned by means of gently dusting with a feather-duster. Otherwise, non-operation in the event of a fire or inadvertent operation may result.

Sprinklers which are found to be leaking or exhibiting visible signs of corrosion must be replaced.

Automatic sprinklers must never be painted, plated, coated, or otherwise altered after leaving the factory. Modified or overheated sprinklers must be replaced.

Care must be exercised to avoid damage to the sprinklers - before, during, and after installation. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like, must be replaced.

The owner is responsible for the inspection, testing, and maintenance of their fire protection system and devices in compliance with this document, as well as with the applicable standards of the National Fire Protection Association (e.g., NFPA 25), in addition to the standards of any other authorities having jurisdiction. Contact the installing contractor or sprinkler manufacturer regarding any questions.

Automatic sprinkler systems are recommended to be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

# Ordering Procedure

Contact your local distributor for availability. When placing an order, indicate the full product name and part number (P/N).

**Sprinkler Assembly**
Specify: Series LFII (TY2384), K=4.2, Residential Flush Horizontal Sidewall Sprinkler with 162°F (72°C) temperature rating, (specify) finish, and P/N (specify).

Signal White (RAL9003). . . . . .P/N 51-124-4-162
Jet Black (RAL9005) . . . . . . . .P/N 51-124-5-162
Chrome. . . . . . . . . . . . . . . . . . .P/N 51-124-9-162

**Escutcheon**
Specify: Escutcheon for Series LFII (TY2384), K=4.2, Residential Flush Horizontal Sidewall Sprinkler with (specify) finish, and P/N (specify).

Signal White (RAL9003). . . . . P/N 56-124-4-001
Jet Black (RAL9005) . . . . . . . P/N 56-124-5-001
Chrome. . . . . . . . . . . . . . . . . . P/N 56-124-9-001

**Accessories**
Specify: Socket for Series LFII Residential Flush Horizontal Sidewall Sprinkler (TY2384), P/N 56-000-4-949.

Specify: Wrench & Socket for Series LFII Residential Flush Horizontal Sidewall Sprinkler (TY2384), P/N 56-000-4-950.

Specify: Protective Cap Removal Tool for Series LFII Residential Flush Horizontal Sidewall Sprinkler (TY2384), P/N 56-000-4-300.

## Viking VK476 Flush Pendent Sprinkler



TECHNICAL DATA

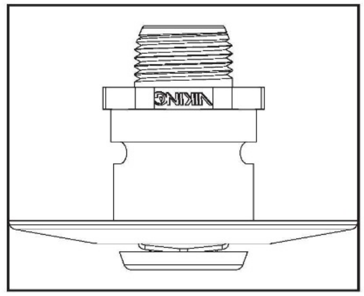
**FREEDOM® RESIDENTIAL FLUSH PENDENT SPRINKLER VK476 (K4.9)**

**The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058**
**Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com**

### 1. DESCRIPTION

Viking Freedom® Residential Flush Pendent Sprinkler VK476 is a small high-sensitivity fusible element residential sprinkler designed for installation on concealed pipe systems where the appearance of a smooth ceiling is desired. The sprinkler orifice design, with a K-Factor of 4.9 (70.6 metric*), allows the sprinkler's efficient use of available water supplies for the hydraulically designed fire-protection system. The operating element and special deflector characteristics meet the challenges of residential sprinkler standards.

The two-piece design of the sprinkler and ceiling ring allows installation and testing of the sprinkler prior to ceiling installation. The ceiling ring allows for up to 5/8" (16 mm) of vertical adjustment and can be removed and re-installed, allowing access above removable ceiling panels without shutting down the sprinkler system and removing the sprinkler.




### 2. LISTINGS AND APPROVALS

c UL us EU **UL Listed (C-UL-US-EU):** Category VKKW

Refer to the Approval Chart and Design Criteria for C-UL-US-EU Listing requirements that must be followed.

### 3. TECHNICAL DATA

**Specifications:**
Available since 2009.
Minimum Operating Pressure: Refer to the Approval Chart.
Maximum Working Pressure: 175 psi (12 bar). Factory tested hydrostatically to 500 psi (34.5 bar).
Thread size: 1/2" (15 mm) NPT
Nominal K-Factor: 4.9 U.S. (70.6 metric*)

* Metric K-factor measurement shown is in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.

Overall Length: 2-1/8" (54 mm)
Covered by the following US Patent No: 6,152,236

**Viking Technical Data may be found on The Viking Corporation's Web site at http://www.vikinggroupinc.com. The Web site may include a more recent edition of this Technical Data Page.**

**Material Standards:**
Sprinkler Body and Inlet: QM Brass
Deflector Assembly: Copper UNS-C51000 and Brass UNS-C36000
Pin Assembly: Stainless Steel UNS-S30200 and C23000
Seat Assembly: Brass UNS-C31400 or UNS-C31600
Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
Fusible Element Assembly: Beryllium Nickel and Eutectic Solder
Element Cover: Copper UNS-C11000
Lever Bar Assembly: Copper Alloy UNS-C72500 and Brass UNS-C36000
Lever Arm: Stainless Steel UNS-S31600
Element Assembly: Copper UNS-C11000 and Nickel Alloy
Ceiling Ring: Cold Rolled Steel UNS-G10080

**Ordering Information:** (Also refer to the current Viking price list.)
Viking Freedom® Residential Flush Pendent Sprinkler VK476 and Ceiling Ring:
Part No. 15630MC/- (includes a 165 °F (74 °C) rated sprinkler with a protective plastic cap covering the unit, and a ceiling ring).
Specify finish of the sprinkler and ceiling ring by adding the appropriate suffix for the finish to the base part number:
Finish Suffix: Wood Beam Finish = G, Painted White = W, Painted Black = B
For example, sprinkler VK476 with a Wood Beam Finish = 15630MC/G.

**Available Finishes And Temperature Ratings:** Refer to Table 1.

**Accessories:** (Also refer to the "Sprinkler Accessories" section of the Viking data book.)

**Sprinkler Wrench**:** Heavy Duty Wrench Part No. 15209W/R (available since 2009)

**Requires a ½" ratchet (not available from Viking).

**Sprinkler Cabinet:** Part No. 01731A, Capacity: five (5) sprinklers (available since 1971)

**Replacement Ceiling Ring** (3" diameter)**:** Base Part No. 16580M/-

| VIKING® | TECHNICAL DATA | FREEDOM® RESIDENTIAL FLUSH PENDENT SPRINKLER VK476 (K4.9) |
|---|---|---|

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

Specify finish of the ceiling ring by adding the appropriate suffix for the finish to the base part number:
Finish Suffix: Wood Beam Finish = G, Painted White = W, Painted Black = B
For example, ceiling ring 16580 with a Wood Beam Finish = 16580M/G.

## 4. INSTALLATION

Refer to appropriate NFPA Installation Standards.

## 5. OPERATION

During fire conditions, when the fusible element reaches its operating temperature, the element cover, fusible element and lever assembly fall away. The deflector is suspended below the ceiling. Water flowing through the sprinkler orifice strikes the deflector, forming a uniform spray pattern over a specific area of coverage determined by the water supply pressure at the sprinkler to extinguish or control the fire.

## 6. INSPECTIONS, TESTS AND MAINTENANCE

Refer to NFPA 25 for Inspection, Testing and Maintenance requirements.

## 7. AVAILABILITY

Viking Sprinkler VK476 is available through a network of domestic and international distributors. See The Viking Corporation web site for the closest distributor or contact The Viking Corporation.

## 8. GUARANTEE

For details of warranty, refer to Viking's current list price schedule or contact Viking directly.

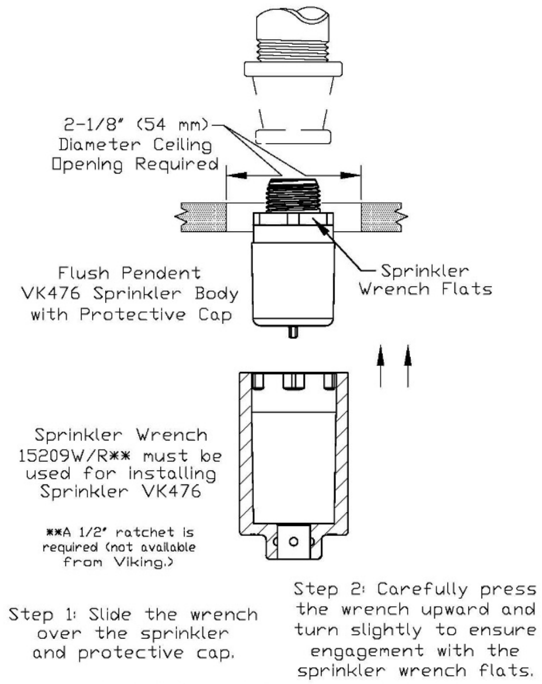



**Figure 1:** **Sprinkler Installation and Correct Use of Wrench**

**TABLE 1: AVAILABLE SPRINKLER TEMPERATURE RATINGS AND FINISHES**

| Sprinkler Temperature Classification | Sprinkler Nominal Temperature Rating[1] | Maximum Ambient Ceiling Temperature[2] | Ceiling Ring Base Part Number[3] |
|---|---|---|---|
| Ordinary | 165 °F (74 °C) | 100 °F (38 °C) | 16580 |
| **Finishes:** Wood Beam Finish, Painted White, or Painted Black | | | |

**Footnotes**

[1] The sprinkler temperature rating is stamped on the sprinkler inlet.
[2] Based on NFPA-13, NFPA 13R, and NFPA 13D. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.
[3] Part number shown is the base part number for replacement ceiling rings. For complete part number, refer to current Viking price list schedule.

VIKING® | TECHNICAL DATA | **FREEDOM® RESIDENTIAL FLUSH PENDENT SPRINKLER VK476 (K4.9)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## Approval Chart
## Viking VK476, 4.9 K-Factor Residential Flush Pendent Sprinkler

**For systems designed to NFPA 13D or NFPA 13R. For systems designed to NFPA 13, refer to the design criteria. For Ceiling types refer to NFPA 13, 13R or 13D 2013 Editions**

| Sprinkler Base Part Number [1] | SIN | NPT Thread Size | | Nominal K-Factor | | Maximum Water Working Pressure | Overall Length | |
|---|---|---|---|---|---|---|---|---|
| | | Inches | mm | U.S. | metric [2] | | Inches | mm |
| 15630 | VK476 | 1/2 | 15 | 4.9 | 70.6 | 175 psi (12 bar) | 2-1/8 | 54 |

| Max. Coverage Area [7] Width X Length Ft. X Ft. (m X m) | Ordinary Temp Rating (165 °F/74 °C) | | Deflector to Ceiling | Installation Type | Listings and Approvals [3] | | | Minimum Spacing Ft. (m) |
|---|---|---|---|---|---|---|---|---|
| | Flow [7] GPM (L/min) | Pressure [7] PSI (bar) | | | cULus EU [4] | NYC | NSF | |
| 16 X 16 (4.9 X 4.9) | 13 (49.2) | 7.0 (0.48) | Refer to Figure 2 | Flush with Ceiling Ring | See Footnote 6 | See Footnote 5 | -- | 8 (2.4) |
| 18 X 18 (5.5 X 5.5) | 17 (64.4) | 12.0 (0.83) | | | | | | |
| 20 X 20 (6.1 X 6.1) | 21 (79.5) | 18.4 (1.27) | | | | | | |

**Footnotes**

[1] Part number shown is the base part number. For complete part number, refer to current Viking price schedule.

[2] Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.

[3] This chart shows the listings and approvals available at the time of printing. Other approvals may be in process. Check with the manufacturer for any additional approvals. Refer also to Design Criteria.

[4] Listed by Underwriter's Laboratories, Inc. for use in the U.S., Canada, and European Union.

[5] Meets New York City requirements, effective July 1, 2008.

[6] Accepted Finishes are: Wood Beam Finish, Painted White, and Painted Black [8].

[7] For areas of coverage smaller than shown, use the "Flow" and "Pressure" for the next larger area listed. Flows and pressures listed are per sprinkler. The distance from sprinklers to walls shall not exceed one-half the sprinkler spacing indicated for the minimum "Flow" and "Pressure" used.

[8] Painted finish consists of Polyester Baked Enamel. Other paint colors are available on request with the same listings as the standard finish colors. Listings and approvals apply for any paint manufacturer. Contact Viking for additional information.

**NOTE:** Custom colors are indicated on a label on the sprinkler body.

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TECHNICAL DATA

**FREEDOM® RESIDENTIAL FLUSH PENDENT SPRINKLER VK476 (K4.9)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## DESIGN CRITERIA

(Also refer to the Approval Chart.)

**UL Listing Requirements (C-UL-US-EU):**

When using Viking Residential Flush Pendent Sprinkler VK476 for systems designed to NFPA 13D or NFPA 13R, apply the listed areas of coverage and minimum water supply requirements shown in the Approval Chart.

For systems designed to NFPA 13: The number of design sprinklers is to be the four contiguous most hydraulically demanding sprinklers. The minimum required discharge from each of the four sprinklers is to be the greater of the following:

- The flow rates given in the Approval Chart for NFPA 13D and NFPA 13R applications for each listed area of coverage, **or**
- Calculated based on a minimum discharge of 0.1 gpm/sq. ft. over the "design area" in accordance with sections 8.5.2.1 or 8.6.2.1.2 of NFPA 13.
- Minimum distance between residential sprinklers: 8 ft. (2.4 m).

**IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to pages RES1-17 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA and any other similar Authorities Having Jurisdiction, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable. Final approval and acceptance of all residential sprinkler installations must be obtained from the Authorities Having Jurisdiction.**

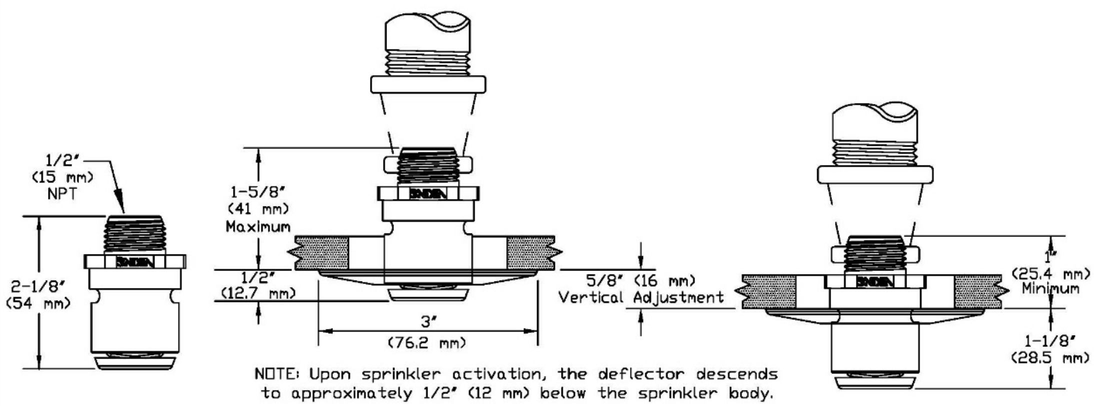


**Figure 2:** Sprinkler Dimensions and Ceiling Ring Installation

Viking VK457 Concealed Pendent Sprinkler



VIKING® | TECHNICAL DATA | **FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9)**

**The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058**
**Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com**

## 1. DESCRIPTION


Viking Freedom® Residential Concealed Pendent Sprinkler VK457 is a small high-sensitivity solder link and lever residential sprinkler designed for installation on concealed pipe systems where the appearance of a smooth ceiling is desired. The orifice design, with a K-Factor of 4.9 (70.6 metric*), allows the sprinkler's efficient use of available water supplies for the hydraulically designed fire-protection system. The operating element and special deflector characteristics meet the challenges of residential sprinkler standards.

The sprinkler is pre-assembled with a threaded adapter for installation with a low-profile small-diameter cover assembly installed flush to the ceiling. The two-piece design allows installation and testing of the sprinkler prior to installation of the cover plate. The "push-on", "thread-off" design of the concealed cover plate assembly allows easy installation of the cover plate after the system has been tested and the ceiling finish has been applied, while also providing up to ½" (12.7 mm) of vertical adjustment. The cover assembly can be removed and reinstalled, allowing temporary removal of ceiling panels without taking the sprinkler system out of service or removing the sprinkler. The Electroless Nickel PTFE (ENT) coating has been investigated for installation in corrosive atmospheres and is C-UL-US-EU Listed as corrosion resistant as indicated in the Approval Charts. The ENT finish is only available for the sprinkler assembly, the cover plate is not plated.

## 2. LISTINGS AND APPROVALS

cULus EU **UL Listed (C-UL-US-EU):** Category VKKW
Refer to the Approval Charts and Design Criteria on for C-UL-US-EU Listing requirements that must be followed.

## 3. TECHNICAL DATA

**Specifications:**
Available since 2008.
Minimum Operating Pressure: Refer to the Approval Chart.
Maximum Working Pressure: 175 psi (12 bar). Factory tested hydrostatically to 500 psi (34.5 bar).
Thread size: 1/2" (15 mm) NPT
Nominal K-Factor: 4.9 U.S. (70.6 metric*)

* Metric K-factor measurement shown is in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.

**Material Standards:**
Sprinkler Body: Brass UNS-C84400 or QM Brass
Deflector: Phosphor Bronze UNS-C51000
Deflector Pins: Stainless Steel UNS-S30200
Button: Brass UNS-C36000
Seat Assembly: Brass UNS-C31600
Compression Screw: Brass UNS-C36000
Fusible Element Assembly: Beryllium Nickel, coated with black acrylic paint
Levers: Stainless Steel UNS-S31600
Lever Bar: Copper Alloy UNS-C72500
Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
Cover Adapter: Cold Rolled Steel UNS-G10080, Finish: Clear Chromate over Zinc Plating
Shipping Cap: Polyethylene

**Viking Technical Data may be found on The Viking Corporation's Web site at http://www.vikinggroupinc.com. The Web site may include a more recent edition of this Technical Data Page.**

**Cover Plate Materials:**
Cover Plate Assembly: Copper UNS-C11000 and Brass UNS-C26800
Spring: Beryllium Nickel
Solder: Eutectic

**Ordering Information:** (Also refer to the current Viking price list.)
Viking Freedom® Residential Concealed Pendent Sprinkler VK457 and Cover Plate Assembly must be ordered separately:
**Sprinkler:** Order Sprinkler VK457 by first adding the appropriate suffix for the sprinkler finish and then the appropriate suffix for the temperature rating to the sprinkler base part number.
Finish Suffix: Brass = A and ENT = JN
Temperature Suffix: 165 °F (74 °C) = C, 205 °F (96 °C) = E
For example, sprinkler VK457 with a Brass finish and a 165 °F (74 °C) temperature rating = Part No. 14694AC.

| VIKING® | TECHNICAL DATA | FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9) |
|---|---|---|

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

**Cover Plate Assembly:** Base Part No. 13504 (2-3/4" diameter), Base Part No. 13642 (3-5/16" diameter), or Base Part No. 15394 (square cover plate, 3-5/16" diameter)
Specify finish and temperature rating of the cover plate assembly by adding the appropriate suffixes for the finish and the cover temperature rating to the base part number:
Finish Suffix: Polished Chrome = F, Brushed Chrome = F-/B, Bright Brass = B, Antique Brass = B-/A, Brushed Brass = B-/B, Brushed Copper = E-/B, Painted White = M-/W, Painted Ivory = M-/I, Painted Black = M-/B
Temperature Suffix: 135 °F/57 °C = A
For example, cover 13504 with a Polished Chrome finish and a 135 °F/57 °C temperature rating = 13504FA.
**Available Finishes And Temperature Ratings:** Refer to Table 1.
**Accessories:** (Also refer to the "Sprinkler Accessories" section of the Viking data book.)
**Sprinkler Wrenches**:**
A. Heavy Duty Part No. 13623W/B (available since 2006), or
B. Head Cabinet Wrench Part No. 13619*** (available since 2006)
C. Optional Concealed Cover Plate Installer Tool Part No. 14412 (available since 2007)
D. Optional Large Concealed Cover Plate Installer Tool Part No. 14867 (available since 2007)
**Requires a ½" ratchet (not available from Viking). ***Also optional for removal of the protective cap. Ideal for sprinkler cabinets.
**Sprinkler Cabinet:** Part No. 01731A (available since 1971)

## 4. INSTALLATION
Refer to appropriate NFPA Installation Standards.

## 5. OPERATION
During fire conditions, when the temperature around the sprinkler approaches its operating temperature, the cover plate detaches, releasing the deflector. Continued heating of the exposed sprinkler causes the fusible element to disengage releasing the sealing assembly. Water flowing through the sprinkler orifice strikes the deflector, forming a uniform spray pattern over a specific area of coverage determined by the water supply pressure at the sprinkler to extinguish or control the fire.

## 6. INSPECTIONS, TESTS AND MAINTENANCE
Refer to NFPA 25 for Inspection, Testing and Maintenance requirements.

## 7. AVAILABILITY
Viking Sprinkler Model VK457 is available through a network of domestic and international distributors. See The Viking Corporation web site for the closest distributor or contact The Viking Corporation.

## 8. GUARANTEE
For details of warranty, refer to Viking's current list price schedule or contact Viking directly.

**TABLE 1: AVAILABLE SPRINKLER TEMPERATURE RATINGS AND FINISHES**

| Sprinkler Temperature Classification | Sprinkler Nominal Temperature Rating[1] | Maximum Ambient Ceiling Temperature[2] | Temperature Rating of the Cover Assembly (Required)[3] | Cover Plate Base Part Number[4] | Large Cover Plate Base Part Number[4] | Square Cover Plate Base Part Number[4] |
|---|---|---|---|---|---|---|
| Ordinary | 165 °F (74 °C) | 100 °F (38 °C) | 135 °F (57 °C) | 13504 | 13642 | 15394 |
| Intermediate | 205 °F (96 °C) | 150 °F (38 °C) | 135 °F (57 °C) | 13504 | 13642 | 15394 |

**Sprinkler Finishes:** Brass and ENT

**Cover Plate Finishes:** Polished Chrome, Brushed Chrome, Bright Brass, Antique Brass, Brushed Brass, Brushed Copper, Painted White, Painted Ivory, or Painted Black

**Corrosion Resistant Coatings[5]:** ENT

**Footnotes**

[1] The sprinkler temperature rating is stamped on the deflector.
[2] Based on NFPA-13, NFPA 13R, and NFPA 13D. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.
[3] Maximum ambient temperature for cover assembly is 100 °F (38 °C).
[4] Part number shown is the base part number. For complete part number, refer to current Viking price list schedule.
[5] The corrosion resistant coatings have passed the standard corrosion test required by the approving agencies indicated in the Approval Charts. These tests cannot and do not represent all possible corrosive environments. Prior to installation, verify through the end-user that the coatings are compatible with or suitable for the proposed environment. For automatic sprinklers, the ENT coating is applied to all exposed exterior surfaces, including the waterway. For ENT coated sprinklers, the Belleville spring is exposed.

Form No. F_072607 Rev 15.1

VIKING® | TECHNICAL DATA | **FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## Approval Chart 1
## Viking VK457, 4.9 K-Factor Residential Concealed Pendent Sprinkler

**For systems designed to NFPA 13D or NFPA 13R. For systems designed to NFPA 13, refer to the design criteria. For Ceiling types refer to NFPA 13, 13R or 13D 2013 Editions**

| Sprinkler Base Part Number [1] | SIN | NPT Thread Size | | Nominal K-Factor | | Maximum Water Working Pressure |
|---|---|---|---|---|---|---|
| | | Inches | mm | U.S. | metric [2] | |
| 14694AC - (165 °F/74 °C) 14694AE - (205 °F/96 °C) | VK457 | 1/2 | 15 | 4.9 | 70.6 | 175 psi (12 bar) |

| Max. Coverage Area [6] Width X Length Ft. X Ft. (m X m) | Ordinary Temp Rating (165 °F/74 °C) | | Intermediate Temp Rating (205 °F/96 °C) | | Deflector to Ceiling | Installation Type | Listings and Approvals[3] | | | Minimum Spacing Ft. (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Flow [6] GPM (L/min) | Pressure [6] PSI (bar) | Flow [6] GPM (L/min) | Pressure [6] PSI (bar) | | | cULus EU [4] | NYC | NSF [8] | |
| 12 X 12 (3.7 X 3.7) | 13 (49.2) | 7.0 (0.48) | 13 (49.2) | 7.0 (0.48) | Refer to Figure 2 | Concealed with Cover Plate Assembly | See Footnote 7 and 10 | See Footnote 5 | See Footnote 7 and 10 | 8 (2.4) |
| 14 X 14 (4.3 X 4.3) | 13 (49.2) | 7.0 (0.48) | 14 (53) | 8.1 (0.56) | | | | | | |
| 16 X 16 (4.9 X 4.9) | 13 (49.2) | 7.0 (0.48) | 14 (53) | 8.1 (0.56) | | | | | | |
| 18 X 18 (5.5 X 5.5) | 17 (64.4) | 12.0 (0.83) | 17 (64.4) | 12.0 (0.83) | | | | | | |
| 20 X 20 (6.1 X 6.1) | 20 (75.7) | 16.7 (1.15) | 22 (83.3) | 20.2 (1.39) | | | | | | |

**Footnotes**

[1] Part number shown is the base part number. For complete part number, refer to current Viking price schedule.
[2] Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
[3] This chart shows the listings and approvals available at the time of printing. Other approvals may be in process. Check with the manufacturer for any additional approvals. Refer also to Design Criteria.
[4] Listed by Underwriter's Laboratories, Inc. for use in the U.S., Canada, and European Union.
[5] Meets New York City requirements, effective July 1, 2008.
[6] For areas of coverage smaller than shown, use the "Flow" and "Pressure" for the next larger area listed. Flows and pressures listed are per sprinkler. The distance from sprinklers to walls shall not exceed one-half the sprinkler spacing indicated for the minimum "Flow" and "Pressure" used.
[7] Cover Temperature Rating is 135 °F (57 °C). Cover Part No. 13504[1], 13642[1] (large diameter), or 15394[1] (square cover plate).
[8] UL Classified to: NSF/ANSI Standard 61, Drinking Water System Components (MH48034).
[9] Other paint colors are available on request with the same listings as the standard finish colors. Listings and approvals apply for any paint manufacturer. Contact Viking for additional information. Custom colors are indicated on a label inside the cover assembly. Refer to Figure 3.
[10] Accepted Cover Plate Finishes are: Polished Chrome, Brushed Chrome, Bright Brass, Antique Brass, Brushed Brass, Brushed Copper, Painted White, Painted Ivory, or Painted Black [9].

VIKING® TECHNICAL DATA

**FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## Approval Chart 2
## Viking VK457, 4.9 K-Factor Residential Concealed Pendent Sprinkler

**For systems designed to NFPA 13D or NFPA 13R. For systems designed to NFPA 13, refer to the design criteria. For Ceiling types refer to NFPA 13, 13R or 13D 2013 Editions**

| Sprinkler Base Part Number [1] | SIN | NPT Thread Size | | Nominal K-Factor | | Maximum Water Working Pressure |
|---|---|---|---|---|---|---|
| | | Inches | mm | U.S. | metric [2] | |
| 14694JNC - (165 °F/74 °C) 14694JNE - (205 °F/96 °C) | VK457 | 1/2 | 15 | 4.9 | 70.6 | 175 psi (12 bar) |

| Max. Coverage Area [5] Width X Length Ft. X Ft. (m X m) | Ordinary Temp Rating (165 °F/74 °C) | | Intermediate Temp Rating (205 °F/96 °C) | | Deflector to Ceiling | Installation Type | Listings and Approvals[3] | | | Minimum Spacing Ft. (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Flow [5] GPM (L/min) | Pressure [5] PSI (bar) | Flow [6] GPM (L/min) | Pressure [6] PSI (bar) | | | C-UL-US-EU [4] | NYC | NSF | |
| 12 X 12 (3.7 X 3.7) | 13 (49.2) | 7.0 (0.48) | 13 (49.2) | 7.0 (0.48) | Refer to Figure 2 | Concealed with Cover Plate Assembly | See Footnotes 6, 8, and 9 | -- | -- | 8 (2.4) |
| 14 X 14 (4.3 X 4.3) | 13 (49.2) | 7.0 (0.48) | 14 (53) | 8.1 (0.56) | | | | | | |
| 16 X 16 (4.9 X 4.9) | 13 (49.2) | 7.0 (0.48) | 14 (53) | 8.1 (0.56) | | | | | | |
| 18 X 18 (5.5 X 5.5) | 17 (64.4) | 12.0 (0.83) | 17 (64.4) | 12.0 (0.83) | | | | | | |
| 20 X 20 (6.1 X 6.1) | 20 (75.7) | 16.7 (1.15) | 22 (83.3) | 20.2 (1.39) | | | | | | |

**Footnotes**

[1] Part number shown is the base part number. For complete part number, refer to current Viking price schedule.
[2] Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
[3] This chart shows the listings and approvals available at the time of printing. Other approvals may be in process. Check with the manufacturer for any additional approvals. Refer also to Design Criteria.
[4] Listed by Underwriter's Laboratories, Inc. for use in the U.S. and Canada.
[5] For areas of coverage smaller than shown, use the "Flow" and "Pressure" for the next larger area listed. Flows and pressures listed are per sprinkler. The distance from sprinklers to walls shall not exceed one-half the sprinkler spacing indicated for the minimum "Flow" and "Pressure" used.
[6] Cover Temperature Rating is 135 °F (57 °C). Cover Part No. 13504[1], 13642[1] (large diameter), or 15394[1] (square cover plate).
[7] Other paint colors are available on request with the same listings as the standard finish colors. Listings and approvals apply for any paint manufacturer. Contact Viking for additional information. Custom colors are indicated on a label inside the cover assembly. Refer to Figure 3.
[8] Accepted Cover Plate Finishes are: Polished Chrome, Brushed Chrome, Bright Brass, Antique Brass, Brushed Brass, Brushed Copper, Painted White, Painted Ivory, or Painted Black [7].
[9] C-UL-US-EU Listed as corrosion resistant.

VIKING® | TECHNICAL DATA | FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## DESIGN CRITERIA

(Also refer to the Approval Chart on page 4.)

**UL Listing Requirements (C-UL-US-EU):**

When using Viking Residential Concealed Pendent Sprinkler VK457 for systems designed to NFPA 13D or NFPA 13R, apply the listed areas of coverage and minimum water supply requirements shown in the Approval Charts.

For systems designed to NFPA 13: The number of design sprinklers is to be the four contiguous most hydraulically demanding sprinklers. The minimum required discharge from each of the four sprinklers is to be the greater of the following:

- The flow rates given in the Approval Charts for NFPA 13D and NFPA 13R applications for each listed area of coverage, **or**
- Calculated based on a minimum discharge of 0.1 gpm/sq. ft. over the "design area" in accordance with sections 8.5.2.1 or 8.6.2.1.2 of NFPA 13.
- Minimum distance between residential sprinklers: 8 ft. (2.4 m).

**NOTE: Concealed sprinklers must be installed in neutral or negative pressure plenums only.**

**IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to pages RES1-17 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA and any other similar Authorities Having Jurisdiction, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable. Final approval and acceptance of all residential sprinkler installations must be obtained from the Authorities Having Jurisdiction.**

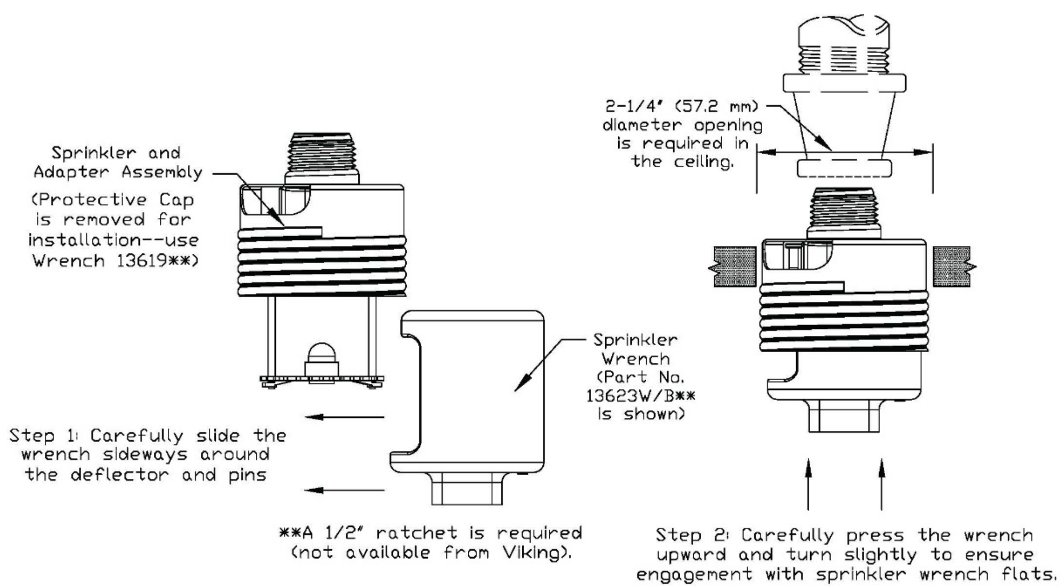


**Figure 1:** Sprinkler Installation and Correct Use of Wrenches

VIKING® TECHNICAL DATA

**FREEDOM® RESIDENTIAL CONCEALED PENDENT SPRINKLER VK457 (K4.9)**

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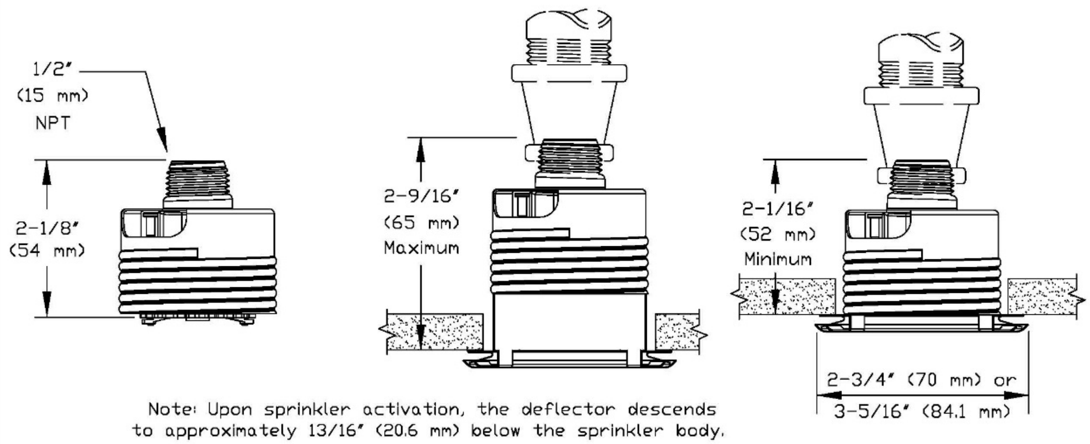


**Figure 2:** Sprinkler Dimensions and Cover Installation


Identification of Custom Paint Color:
All custom color painted cover plates will have an identifying label affixed to the inside of the cover that indicates custom color and will have a representative sample (a paint dot) of the paint on the label.

**Figure 3:** Identification of Custom Paint Color for Concealed Covers

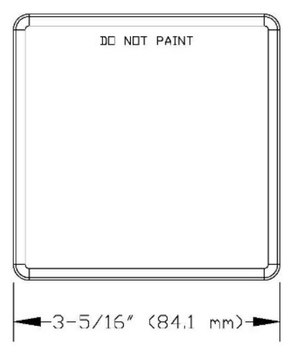


**Figure 4:** Square Cover Assembly 15394

## Viking Waterflow Alarm



VIKING® | TECHNICAL DATA | **WATERFLOW INDICATOR**

**The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058**
**Telephone: 269-945-9501 Technical Services 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com**

### 1. DESCRIPTION

The Waterflow Indicator is a vane-type waterflow switch designed to detect a sustained flow of 10 gpm or more. It is intended for use on wet-pipe sprinkler systems only. The Model VSR has a built-in adjustable pneumatic retard device delays actuation of the electrical switches to reduce the possibility of false alarms caused by one or more transient flow surges. The unit includes two single-pole double-throw snap action switches used to operate local alarms, indicate signals to annunciator panels, trip municipal fire alarm boxes, start fire pumps, or any other function that can be initiated or controlled by the opening or closing of an electrical switch. The device may be installed on the main riser to give a system waterflow signal or on branch feed mains, cross mains, or branch lines to give a waterflow signal by zone or area.

### 2. LISTINGS AND APPROVALS

**Model VSR-S**
- UL Listed - Guide No. USQT.S309
- ULC Listed - Guide No. USQTC.S309
- CSFM Listed - 7770-0328:001
- NYC MEA Accepted - BSA-1033-83

**Model VSR**
- UL Listed - Guide No. USQT.S309
- ULC Listed - Guide No. USQTC.S309
- FM Approved - Waterflow Detectors, Vane Type
- CSFM Listed - 7770-0328:001
- LPCB Approved
- CE Certified - Standard EN-12259-5

**Model VSR-10**
- UL Listed - Guide No. USQT.S309
- ULC Listed - Guide No. USQTC.S309

### 3. TECHNICAL DATA

Viking Technical Data may be found on The Viking Corporation's Web site at http://www.vikinggroupinc.com. The Web site may include a more recent edition of this Technical Data Page.

**Manufactured by:**
Potter Electric Signal Company, LLC
2081 Craig Drive
St. Louis, Missouri 63146

**Specifications:**

**Water Working Pressure:**
Model VSR-S rated for water working service pressure up to 300 psi (20.7 bar) for size 1", 1-1/4", 1-1/2" & 2" (25 mm, 32 mm, 38 mm & 50 mm)
Model VSR rated for water working service pressure up to 450 psi (31 bar) for sizes 2" (50 mm) to 8" (200 mm) - UL
Model VSR-10 rated for water working service pressure up to 300 psi (20.7 bar) for size 10" (250 mm)
**Maximum Surge:** 18 FPS (5.5 m/s)
**Flow Sensitivity Range for Signal:** 4-10 GPM (15-38 LPM) - UL
**Contact Ratings:**
Two single-pole double-throw switches with Form C contacts rated at 10 Amps @ 125/250 VAC, 2.0 Amps @ 0-30 VDC, 10m Amps min. @ 24VDC. Each switch can be wired for open or closed circuit operation. See Figure 8.
**Conduit Entrances:** Two knockouts provided for 1/2" conduit. Individual switch compartments suitable for dissimilar voltages.
Usage: Listed plastic, copper and schedule 40 iron pipe.
VSR-S - Fits pipe sizes 1" (25 mm), 1-1/4" (32 mm), 1-1/2" (38 mm) and 2" (50 mm) Note: 12 paddles are furnished with each unit, one for each pipe size of threaded and sweat TEE, one for 1" (25 mm) CPVC, one for 1" (25 mm) CPVC (Central), one for 1" threaded NIBCO CPVC, and one for 1-1/2" (38 mm) threaded (Japan).

**Material Standards:**
Body: Cast Aluminum
Base: Cast aluminum.
Enclosure: Die-cast, red enamel finish
Cover held in place with tamper-resistant screws

VIKING® TECHNICAL DATA

# WATERFLOW INDICATOR

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

### Ordering Information:

See Table 1.

## 4. INSTALLATION

### VSR-S Model

These devices may be mounted in horizontal or vertical pipe. On horizontal pipe they should be installed on the top side of the pipe where they will be accessible. The units should not be installed within 6" (15 cm) of a valve, drain or fitting that changes the direction of the waterflow. Select the proper paddle for the pipe size and type of TEE used; see Figure 1 for instructions on changing paddle. The unit has a 1" NPT bushing for threading into a non-corrosive TEE. See Figure 2 for proper TEE size, type and installation. Use no more than three wraps of Teflon tape.

Screw the device into the TEE fitting as shown in Figure 2. Care must be taken to properly orient the device for the direction of waterflow. The vane must not rub the inside of the TEE or bind in any way. The stem should move freely when operated by hand. The device can also be used in copper or plastic pipe installations with the proper adapters so that the specified TEE fitting may be installed on the pipe run.

### VSR and VSR-10 Model

These devices may be mounted on horizontal or vertical pipe. On horizontal pipe they should be installed on the top side of the pipe where they will be accessible. The device should not be installed within 6" (15 cm) of a fitting which changes the direction of the waterflow or within 24" (60 cm) of a valve or drain. Drain the system and drill a hole in the pipe using a hole saw in a slow speed drill (see Figure 1). Clean the inside pipe of all growth or other material for a distance equal to the pipe diameter on either side of the hole. Roll the vane so that it may be inserted into the hole; do not bend or crease it. Insert the vane so that the arrow on the saddle points in the direction of the waterflow. Install the saddle strap and tighten nuts alternately to required torque (see Figure 4). The vane must not rub the inside of the pipe or bind in any way.

Place the system back in service and test the waterflow indicator using the system inspector's test valve. If necessary, adjust the pneumatic retard and/or equipment and perform quarterly inspection.

### Adjustments

A. The pneumatic retard is adjustable from 0 to approximately 90 seconds. To increase the time delay, turn the dial to the next higher letter. Normal setting is between 30 and 45 seconds. In no case should the time be set less than 20 seconds nor more than 90 seconds.

B. The flow sensitivity is set at approximately 10 gpm. A small coil spring holds the vane in its normal position against the waterflow. The spring can be adjusted to increase or decrease sensitivity, if necessary, but it must not be over-tightened. Too much tension will decrease the sensitivity of the device. The pneumatic retard must be checked after adjusting the flow sensitivity. All testing and adjusting of the waterflow indicator must be done using the remote inspector's test valve.

## 5. OPERATION

The Waterflow Indicator detects a flow of water exceeding 10 gpm in the piping when the flexible vane is deflected. This motion activates the field-adjustable pneumatic retard device. The pneumatic retard device delays activation of the electrical switches to reduce the possibility of false alarms caused by a single or series of transient flow surges. The retard device instantly resets during a series of surges to prevent a cumulative effect. After a sustained flow, the two switches operate to open or close electrical contacts.

## 6. INSPECTIONS, TESTS AND MAINTENANCE

**WARNING:** Any system maintenance or testing that involves placing a control valve or detection system out of service may eliminate the fire protection of that system. Prior to proceeding, notify all authorities having jurisdiction. Consideration should be given to employment of a fire patrol in the affected area. Ascertain what alarms and equipment are connected to the waterflow indicator and take necessary precautions to protect connected equipment.

### Testing

The frequency of inspection and testing for the Model VSR-S, VSR and VSR-10 and its associated protective monitoring system should be in accordance with applicable NFPA Codes and Standards and/or the authority having jurisdiction (manufacturer recommends quarterly or more frequently.) An inspector's test valve (usually located at the end of the most remote branch line) should always be used for test purposes. If there are no provisions for testing the operation of the flow detection device on the system, application of the VSR-S is not recommended or advisable. A minimum flow of 10 gpm (38 Lpm) is required to activate this device.

### Maintenance

Inspect detectors monthly for leaks. If leaks are found, replace the detector. The VSR-S, VSR and VSR-10 waterflow switch should provide years of trouble-free service. The retard and switch assembly are easily field replaceable. There is no maintenance required, only periodic testing and inspection.

VIKING® TECHNICAL DATA

# WATERFLOW INDICATOR

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
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**Removal**

- To prevent accidental water damage, all control valves should be shut tight and the system completely drained before waterflow detectors are removed or replaced.
- Turn off electrical power to the detector, then disconnect wiring.
- Use a wrench on the flats of the bushing. Turn the switch counterclockwise to disengage the pipe threads.
- Gently lift with your fingers, roll the vane so it will fit through the hole while continuing to lift the waterflow detector.
- Lift detector clear of pipe.

## 7. AVAILABILITY & SERVICE

Viking Waterflow Indicators are available through a network of domestic and international distributors. See the Viking web site or contact The Viking Corporation for closet distributor.

## 8. GUARANTEES

For details of warranty, refer to Viking's current list price schedule or contact Viking directly.

| Nominal Pipe Size | Hole Size | Friction Loss | Part Number | Model |
|---|---|---|---|---|
| Inches | Inches | PSI | | |
| 1" (25 mm) | **See Note 1 below** | 3 | VSRF0100 | VSR-S |
| 1-1/4" (32 mm) | **See Note 1 below** | 3 | VSRF0100 | VSR-S |
| 1-1/2" (38 mm) | **See Note 1 below** | 3 | VSRF0100 | VSR-S |
| 2" (50 mm) | 1-1/4" (32 mm) | 3 | VSRF0200 | VSR-2 |
| 2-1/2" (63.5 mm) | 1-1/4" (32 mm) | 3 | VSRF0250 | VSR-2 1/2 |
| 3" (80 mm) | 2" (50 mm) | 3 | VSRF0300 | VSR-3 |
| 3-1/2" (88.9 mm) | 2" (50 mm) | 3 | VSRF0350 | VSR-3 1/2 |
| 4" (101.6 mm) | 2" (50 mm) | 3 | VSRF0400 | VSR-4 |
| 5" (127 mm) | 2" (50 mm) | 1 | VSRF0500 | VSR-5 |
| 6" (150 mm) | 2" (50 mm) | 1 | VSRF0600 | VSR-6 |
| 8" (200 mm) | 2" (50 mm) | 1 | VSRF0800 | VSR-8 |
| 10" (254 mm) | 2" (50 mm) | 1 | VSRF1000 | VSR-10 |

**Notes:**

[1] 1" through 1-1/2" is installed in a tee in the piping rather than a hole in the piping. The waterflow indicator has a 1" male NPT fitting that screws into a 1" tee. See Figure 3.

**Table 1**

# VIKING® TECHNICAL DATA — WATERFLOW INDICATOR

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## VSR-S MODEL

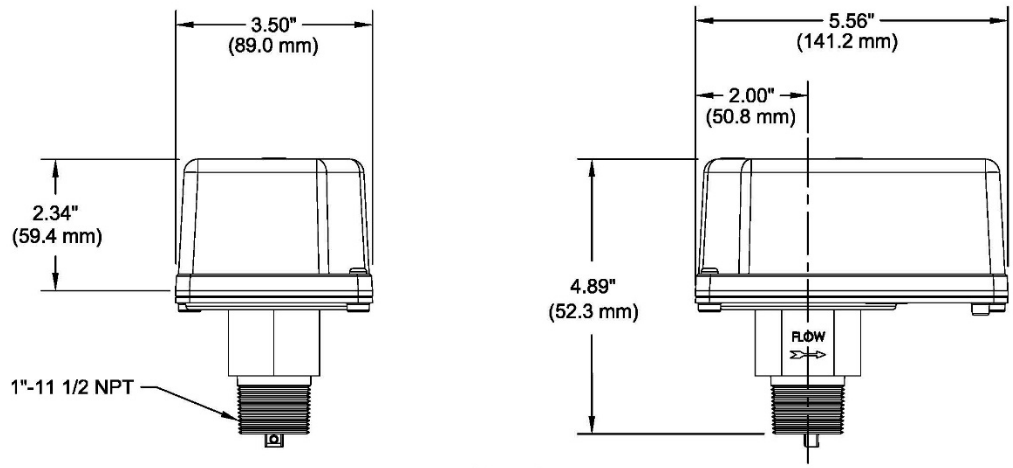



Figure 1

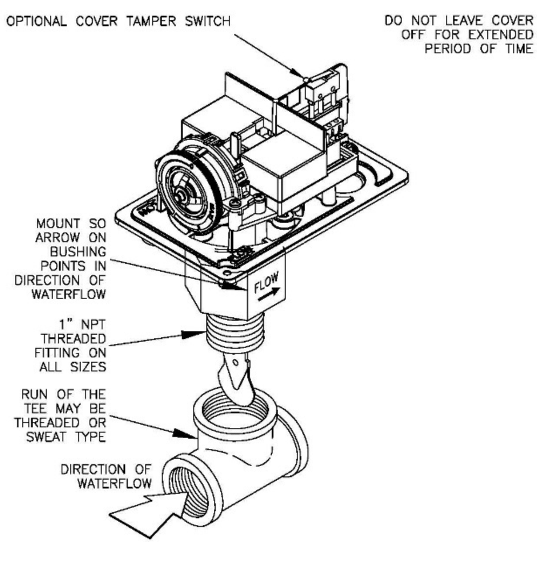
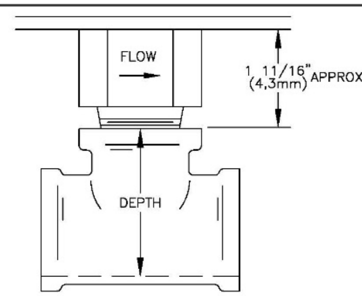



Figure 2




Screw the device into the TEE fitting as shown. Care must be taken to properly orient the device for the direction of the waterflow.

**Important** - The depth to the inside bottom of the TEE should have the following dimensions:

| APPROXIMATE DEPTH REQUIREMENT | | | |
|---|---|---|---|
| TEE SIZE | THREADED | SWEAT | CPVC |
| 1" x 1" x 1" | 2 1/16" | 1 3/4" | 2 7/16" |
| 1 1/4" x 1 1/4" x 1" | 2 7/16" | 2 7/16" | N/A |
| 1 1/2" x 1 1/2" x 1" | 2 11/16" | 2 1/4" | N/A |
| 2" x 2" x1" | 3 3/16" | 2 3/4" | N/A |

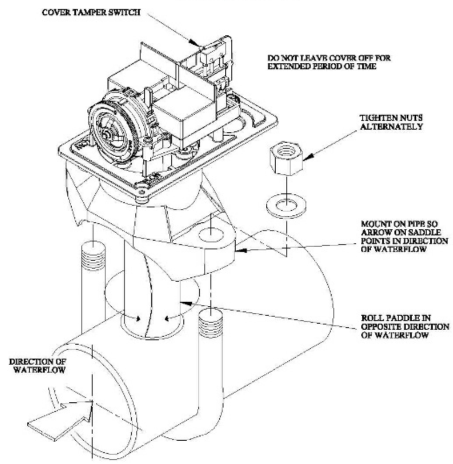
Figure 3

# VIKING® TECHNICAL DATA

## WATERFLOW INDICATOR

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services 877-384-5464 Fax: 269-945-4495 Email: techsvcs@vikingcorp.com

### VSR MODEL




| INSTALLATION REQUIREMENTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | Nominal Pipe Size | | Nominal Pipe O.D. | | Hole Size | | U-Bolt Nuts Torque | |
| | inch | mm | inch | mm | inch | mm | ft-lb | n-m |
| VSR-2 | 2 | DN50 | 2.375 | 60.3 | 1.25 + .125/-.062 | 33.0 ± 2.0 | 20 | 27 |
| VSR-2 1/2 | 2 1/2 | | 2.875 | 73 | | | | |
| VSR-2 1/2 | 2 1/2 | DN65 | 3.000 | 76.1 | | | | |
| VSR-3 | 3 | DN80 | 3.500 | 88.9 | 2.00 ± .125 | 50.8 ± 2.0 | | |
| VSR-3 1/2 | 3 1/2 | | 4.000 | 101.6 | | | | |
| VSR-4 | 4 | DN100 | 4.500 | 114.3 | | | | |
| VSR-5 | 5 | | 5.563 | 141.3 | | | | |
| VSR-6 | 6 | DN150 | 6.625 | 168.3 | | | | |
| VSR-8 | 8 | DN200 | 8.625 | 219.1 | | | | |

Figure 4

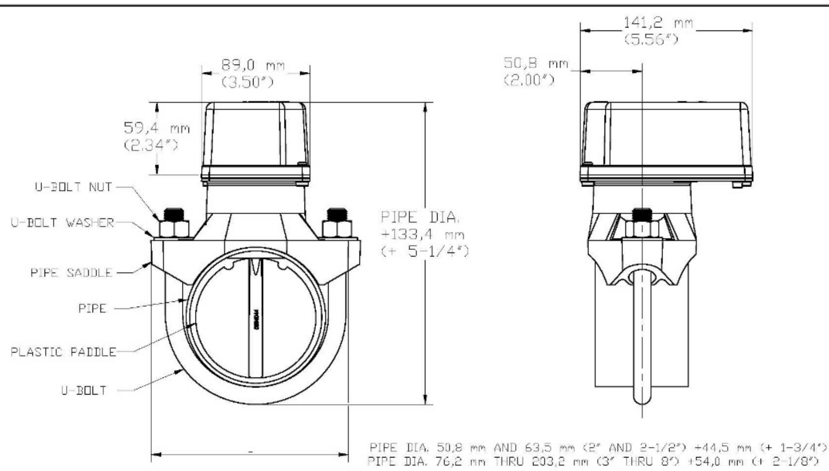
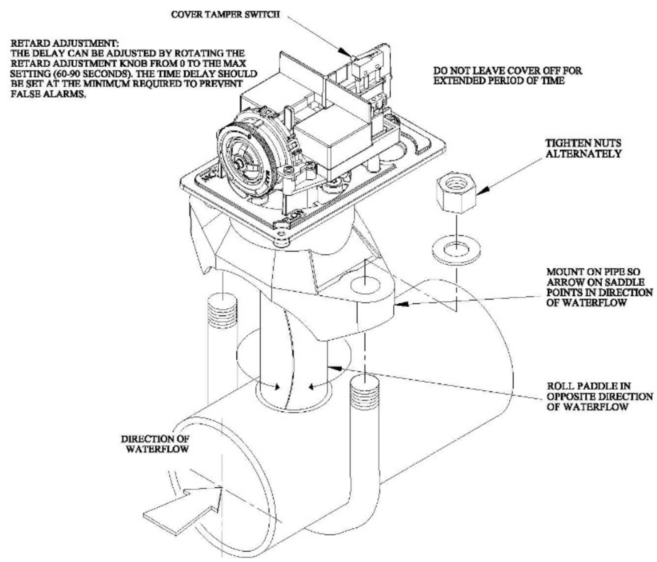



Figure 5

# VIKING® TECHNICAL DATA — WATERFLOW INDICATOR

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

## VSR-10 MODEL




**INSTALLATION REQUIREMENTS**

| Model | Nominal Pipe Size | | Nominal Pipe O.D. | | Hole Size | | U-Bolt Nuts Torque | |
|---|---|---|---|---|---|---|---|---|
| | inch | mm | inch | mm | inch | mm | ft-lb | n-m |
| VSR-10 | 10 | DN250 | 10.750 | 273.0 | 2.00 ± .125 | 50.8 ± 2.0 | 20 | 27 |

Figure 6

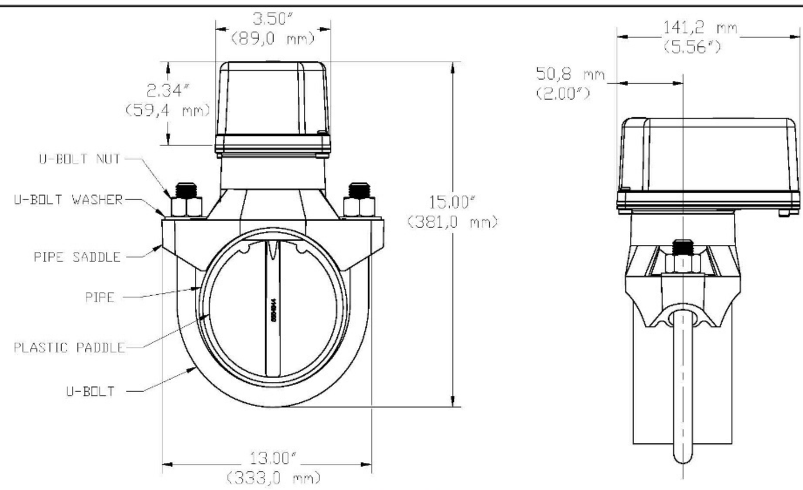



Figure 7

# TECHNICAL DATA

## WATERFLOW INDICATOR

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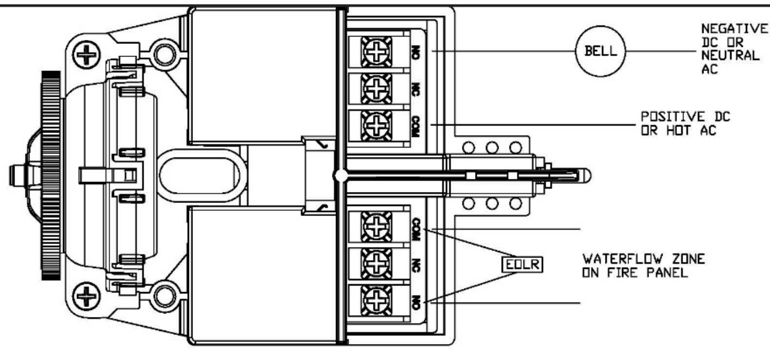


**Figure 8:** Typical Electrical Connections

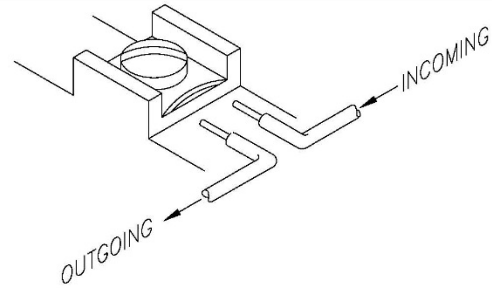


**Figure 9:** Switch Terminal Connections Clamping Plate Terminal

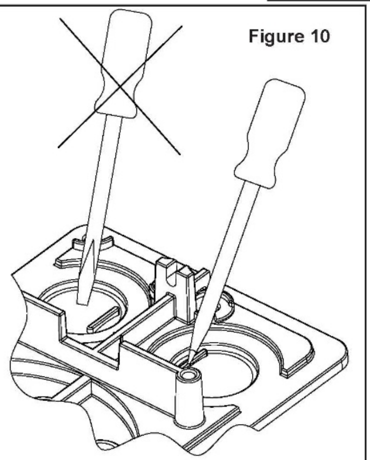

**Figure 10**

To remove knockouts: Place screwdriver at inside edge of knockouts, not in the center.

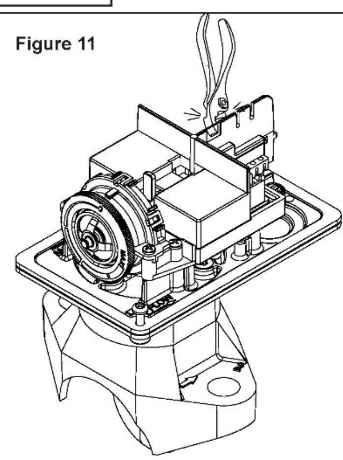

**Figure 11**

Break out thin section of cover when wiring both switches from one conduit entrance.

Plumber's Installation Handbook

PPFA

## INTRODUCTION

This installation *Handbook* is prepared through the voluntary efforts of the members of the Plastic Pipe and Fittings Association. The Plastic Pipe and Fittings Association (PPFA) is the trade association of manufacturers of plastic pipe and fittings, producers of raw materials used in them, and suppliers of related products and services to the plastic pipe and fittings industry. PPFA provides a full range of association services for its members and the industry.

The *Handbook* is organized in sections based on the application or end use for each type of plastic piping, namely, Drain, Waste and Vent (DWV); Water Service Piping; Hot and Cold Water Distribution; and Sewer and Drains.

## PURPOSE and SCOPE

The purpose of the *Handbook* is to provide plumbers and other interested persons with a single publication that describes plastic pipe products and many of the generally accepted installation practices for plastic pipe and fittings currently being utilized in the United States. It does not contain all of the information needed for comprehensive plumbing design and practices using plastic piping. While PPFA has attempted to collect and describe the most widely used, generally accepted installation techniques, there are undoubtedly some that were not included in this *Handbook*. Subsequent editions may add, drop, amend, or revise practices contained herein.

It should be clearly understood that neither PPFA nor its members recommend any single (or even all) installation practice described in this *Handbook* for any specific application or system. Both practical considerations and logic preclude such recommendations because of the wide variety of products and the considerable variation in circumstances surrounding the installation of these products. Accordingly, any plumber or other installer must refer first to the manufacturer's installation instructions and recommendations for the product or products being used. Any inconsistency or discrepancy between those recommendations and instructions and the material in this *Handbook* must be resolved in favor of the manufacturer's installation recommendations or instructions.

We urge you to read and study all information available to you on plastic piping.

Plastic piping is used extensively in the plumbing field for DWV, water service, hot and cold-water distribution systems, sewers, and drains. Learn to recognize and compare the various types of plastic pipe and tubing. The general term "plastic pipe" is no more definitive than saying "metal pipe." Just as you recognize cast iron, galvanized steel, copper, stainless steel, and brass, you will want to become familiar with the different kinds of plastic pipe and the advantages each offers.

Tools designed exclusively for use with plastic piping are available. We suggest that you secure brochures from your suppliers covering these tools. They contribute greatly to the ease and precision of the installation.

Neither PPFA nor its members make any warranties or representations whatsoever, either stated or implied, relative to the fitness of any product, materials, or procedures referred to in this *Handbook* for any particular purpose or use. Many of the products in this *Handbook* are interrelated, and we strongly suggest you read it in its entirety before you begin working with plastic pipe and fittings.

## Plumbing codes & product standards

It is well known that plumbing codes were developed to protect the health and welfare of the communities by preventing contamination of the water supply and providing for the proper disposal of wastewater. These plumbing codes set forth many requirements for acceptable products and usually reference those product standards applicable to them.

Check your plumbing code to determine which materials and products may be used for each application, what product standards apply, and whether there are any special provisions regarding use of the materials. The following chart shows the general categories of piping applications of plastic piping materials covered by national consensus standards. Various manufacturers may exempt certain specific applications from these general applications categories. Thus, reference must be made to a manufacturer's application instructions before installing.

## Plastic Pipe in Fire Resistive Construction

Plastic piping has been used extensively in residential, commercial, and industrial fire-rated construction throughout the US and Canada for decades. The plumbing codes reinforce the fire and building code provisions by requiring that all piping penetrations be made in such a manner as to maintain the integrity of the fire rating of building walls, floors, and ceilings.For additional information, contact PPFA for a copy of the *Plastic Pipe in Fire Resistive Construction* manual.

## Conclusions

Information on the proper methods of installation for all types of plastic piping may not be included in all apprentice-training programs. Just as metals — copper, iron and aluminum — differ, so do the plastics — ABS, PVC, CPVC, PE, PP, PEX, PE-AL-PE, and PEX-AL-PEX. Just as metal alloys — brass, bronze, stainless steel, and cast iron — differ, so also can the plastics differ. Plastic products should be installed with the same care and precision workmanship that has been the standard of the plumber's profession from the beginning. Members of the Plastic Pipe and Fittings Association make installation and technical information on specific products available on their web site.

Remember, plumbing is just one application for plastic pipe. It is also used for chilled water-cooling systems, electrical conduit, environmental/groundwater sampling, buried LP gas piping, high and low head irrigation systems, water and sewer mains, water well casing, telephone duct, liners in high-pressure metal piping, hydronic heating, relining existing sewers, radiant heating, earth-coupled heat pumps, low-temperature heating/cooling systems, and directional drilling installations.

The PPFA Plumber's Installation Handbook was developed by the PPFA Technical Committee using the ballot process. The committee meets in cinjnction with ASTM F 17 sessions and invites comments from all active ASTM F17 members. Comments and suggestions concerning this information should be directed to the Technical Committee through PPFA offices.

| | Plastic Material | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Piping Application | ABS | PE | PVC | CPVC | PP | PEX | SR | Composite pipe PEX-AL-PEX or PE-AL-PE |
| Drain waste & vent (DWV) | X | | X | | | | | |
| Tubular waste | X | | X | | X | | | |
| Water piping | X | X | X | X | | X | | X |
| Hot & cold water distribution | | | | X | | X | | X |
| Outside sewers & drains | X | X | X | | | | X | |
| Septic fields - sub-soil | | X | X | | | | X | |
| Gas piping | | X | X | | | | | |
| Chemical waste piping | X | X | X | X | X | | | |
| Industrial process piping | X | X | X | X | X | | | |
| Fire sprinkler piping | | | X | | X | | | |

## Plumbing codes & product standards

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Check your plumbing code to determine which materials and products may be used for each application, what product standards apply, and whether there are any special provisions regarding use of the materials. The following chart shows the general categories of piping applications of plastic piping materials covered by national consensus standards. Various manufacturers may exempt certain specific applications from these general applications categories. Thus, reference must be made to a manufacturer's application instructions before installing.

## Plastic Pipe in Fire Resistive Construction

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| | Plastic Material | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Piping Application | ABS | PE | PVC | CPVC | PP | PEX | SR | Composite pipe PEX-AL-PEX or PE-AL-PE |
| Drain waste & vent (DWV) | X | | X | | | | | |
| Tubular waste | X | | X | | X | | | |
| Water piping | X | X | X | X | | X | | X |
| Hot & cold water distribution | | | | X | | X | | X |
| Outside sewers & drains | X | X | X | | | | X | |
| Septic fields - sub-soil | | X | X | | | | X | |
| Gas piping | | X | X | | | | | |
| Chemical waste piping | X | X | X | X | X | | | |
| Industrial process piping | X | X | X | X | X | | | |
| Fire sprinkler piping | | | X | | X | | | |

## DWV piping – general

A word of caution is essential: You must check your local plumbing code to be sure that the product you have chosen is approved by your code. Do not assume that every piping product sold by a supplier has been locally approved.

Whether you have chosen ABS-DWV, ABS-DWV cellular core, PVC-DWV or PVC-DWV cellular core piping, you have chosen a widely used product. These products, while made of different plastic materials, are similar in both installation procedures and service abilities.

Mixing ABS and PVC pipe and fittings within the same system is not recommended. However, joining ABS and PVC is possible when connecting building sewers to building drains. Consult your local code official and the product manufacturers for specific instructions.

## DWV piping - storage and handling

Storage on the job site should always be on level support in a shaded area. If shade is not available, a suitable substitute, such as building felt or a tarp, should be used. Fittings should be stored in their shipping cartons or "rough" sorted into cardboard boxes. This will not only protect them from exposure to the sun but will help keep them clean. Pipe and fittings should be kept free of dust, dirt, and oil at all times.

## DWV piping – marking

All PVC and ABS DWV pipe and fittings are marked with their respective ASTM standards for easy identification. In addition to the standards number, other markings will include the manufacturer's name and/or trademark, pipe size, the material (ABS or PVC), DWV, and the mark of a certification organization where required by codes.

Fittings markings vary slightly because of the limitation of space. They will normally be marked with the manufacturer's name and/or trademark, pipe size, the material (ABS or PVC), and the DWV symbol and certification marks.

The ABS-DWV and PVC-DWV markings apply only to Schedule 40 DWV and the 3.25-inch OD (Schedule 30) PVC-DWV piping. (Schedule 40 denotes an outside diameter and wall thickness equal, size for size, to the outside diameter and wall thickness of standard steel pipe.).

## DWV piping - cellular core marking

ASTM F 628, Schedule 40 ABS-DWV pipe with a cellular core has the additional marking "COEX ABS CELLULAR CORE DWV". ASTM F 891, PVC pipe with a cellular core has the additional marking "IPS SCHEDULE 40 SERIES COEX CELLULAR CORE PVC-DWV."

## DWV piping- coextruded composite marking

ASTM F 1488 pipe is marked with the series (ex. IPS SCHEDULE 40 SERIES) and the designation of the materials, starting with the outermost material (ex. ABS/CELLULAR PVC/ABS). ASTM F 1499 pipe is marked IPS SCH 40 along with the designation of the materials, starting with the outermost material (ex. ABS/PVC). Different combinations of ABS, PVC, and cellular ABS or PVC are permitted by both standards in two or three layers. Cellular core material may only be used in the middle layer of three-layer pipe.

## DWV piping - dual marked PVC marking

Schedule 40 PVC DWV pipe is frequently dual marked for both DWV and potable water pressure pipe (ASTM D 1785 and ASTM D 2665). A dual marked PVC DWV and potable water pressure pipe can be triple marked for use as well casing with the addition of ASTM F 480. None of the other DWV pipes are pressure rated.


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## DWV Piping - ASTM Standards

| Material/Product | ASTM Standard | Title |
|---|---|---|
| ABS | D 2661 | Acrylonitrile-Butadiene-styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings |
| PVC | D 2665 | Poly (Vinyl Chloride)(PVC) Plastic Drain, Waste, and Vent Pipe and Fittings |
| PVC 3.25-inch OD | D 2949 | 3.25" Outside Diameter PVC Drain, Waste, and Vent Pipe and Fittings |
| Cellular Core ABS | F 628 | Acrylonitrile-Butadiene-styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipewith a Cellular Core |
| Cellular core PVC | F 891 | Coextruded Poly (Vinyl Chloride)(PVC) Plastic Pipe with a Cellular Core |
| Coextruded Composite ABS/PVC | F 1488 | Coextruded Composite Pipe |
| Coextruded Composite DWV-PVC/ABS | F 1499 | Coextruded Composite Drain, Waste, and Vent Pipe (DWV) |

## DWV Piping – cutting

Plastic DWV may be cut with pipe cutters, any crosscut saw, or a power saw equipped with a carbide tip blade or an abrasive blade. Special wheels made to cut plastic pipes are available for all standard cutters and lightweight, quick adjusting cutters designed exclusively for plastic piping are available.

A square cut is essential to insure joint integrity with socket fittings. Under no circumstances should you try to offset a solvent cement joint by bias cutting or deflecting the pipe. Use of a power saw on large jobs, or a miter box on small jobs, will insure consistently square cuts. If neither is available, scribe the pipe and cut to the mark. Do not attempt to force your saw. If the cut is not square, face it off with a file. Wipe away all saw and file shavings before applying cement to the pipe or fitting.

Pipe cutters should be sharp and well maintained. Cutters and cutter wheels previously used on metal should NOT be used. They exert excessive pressure, both internally and externally, causing larger shoulders and burrs that must later be removed. Pipe should always be reamed both internally and externally to remove burrs, shoulders, and ragged edges. External burrs can cause faulty joints. Several types of reamers and deburring tools are available for this purpose. Power reamers are available for shops or large projects, but a pocketknife or file can also be used.

## DWV Piping - Joining

### Solvent Cement Joining— General

Plastic PVC and ABS DWV pipe and fittings are generally joined with solvent cements that temporarily soften the joining surfaces. This brief softening period enables the installer to seat the pipe into the interference fit designed in the sockets of plastic fittings. The softened surfaces then fuse together. Joint strength develops as the solvents evaporate. When fully cured, the resulting joint is stronger than the pipe itself.

***You will be referred to these joining instructions several times in this handbook.***

With the exception of the priming step, the instructions for solvent cementing all types of

| Material/Application | ASTM Specification | Title |
|---|---|---|
| ABS-DWV Pipe nd Fittings | D 2235 | Solvent cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings |
| PVC-DWV Pipe and Fittings | D 2564 | Solvent Cemetns for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems |
| PVC Primer* | F 656* | Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings* |

* Some codes require the use of a primer.

PVC and ABS piping are similar.

In addition to these general solvent cement joining guidelines, there are additional guidelines specific to solvent cement joining of PVC and ABS piping.

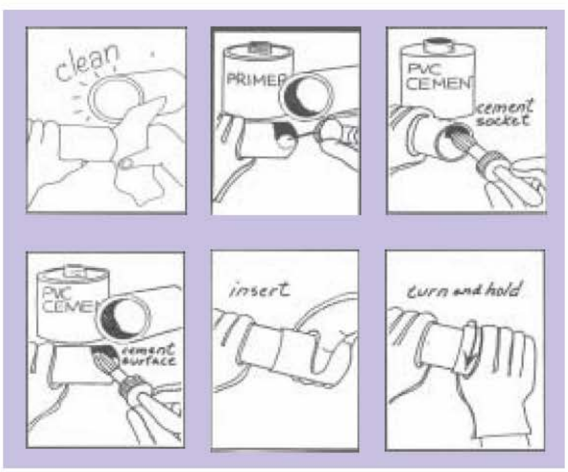
Since ABS and PVC DWV pipes are made from two completely different plastic compounds, each requires a different cement. Look for the correct standard numbers on the manufacturer's label before making the joint. Do not use combination cements, aerosol cements, or other cement types that do not meet these ASTM standards. The applicable ASTM standards of the cements and primers to be utilized with each of these plastic systems are as follows:

The selection of a proper applicator for applying cements and primers is important. Small cans of cement are usually equipped with a dauber affixed to the lid. For larger pipe sizes, natural bristle brushes or rollers should be used. The width of the brush or roller should always be at least ½ the diameter of the pipe being joined to assure sufficient application of the cement. Solvent cements for both ABS and PVC piping are available in 4 oz. to one-gallon cans. **Cement that is lumpy or too thick to flow easily should be discarded. Cans must be sealed when not in use as the cement quickly thickens and hardens. Do not use cements outside the temperature range recommended by the cement manufacturer.**

Before making a solvent cement joint in a plastic DWV system, the pipe and fittings must be clean and free of water, oil, soil or other debris. Also, success is assured only when interference fit exists between pipe and fittings. The pipe should make an interference fit with the fitting socket 1/3 to 2/3 into the socket when dry fitting the pipe.

Fittings to be aligned should be carefully marked for position before applying cement to assure proper alignment in the final assembly. Always use the proper fittings for making changes in direction. Do not place strain on pipe or fittings.

Do not attempt to heat and bend DWV piping.




The curing time required to achieve full joint strength will vary depending on the weather conditions, temperature and humidity, the pipe size, the application technique, the cement being used, and the degree of interference fit between pipe and fitting. All solvent cements do not react and cure the same. Some plastic pipe and fittings applications use solvent cements that require longer or shorter drying periods. Fast-, medium-, and slow-drying cements are available to assist in offsetting weather conditions.



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Select the proper cement for whichever material you are installing and the use conditions (e.g., pipe size and temperature). Check for the material designation (e.g., ABS or PVC), the ASTM number, and for a certifying laboratory seal or mark on the can.

Water testing of DWV systems usually can take place within one hour after the last joint is made. These piping systems shall not be tested with compressed air or other gases unless the procedure being used has been clearly and specifically approved by the manufacturer(s) of the plastic product or system to be tested.

Note: By virtue of their compressibility, compressed air and gases contain large amounts of stored energy which present serious safety hazards should a piping system fail for any reason.

**SAFE HANDLING OF SOLVENT CEMENTS, PRIMERS, AND CLEANERS**

NOTE: Solvent cements, primers, and cleaners MUST be handled properly.

ASTM Standard F 402, *Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners* contains the following directions:

"Avoid prolonged breathing of solvent vapors. When pipe and fittings are being joined in partially enclosed areas, use a ventilating device as to maintain a safe level of vapor concentration with respect to toxicity and flammability in the work area. Select ventilating devices and locate them so as not to provide a source of ignition to flammable vapor mixtures."

KEEP CEMENTS, PRIMERS, AND CLEANERS AWAY FROM ALL SOURCES OF IGNITION, HEAT, SPARKS, AND OPEN FLAME.

Keep containers of cements, primers, and cleaners tightly closed except when the product is being used.

"Most of the solvents used in pipe cements, primers, and cleaners can be considered eye irritants and contact with the eye should be avoided as it may cause eye injury. Proper eye protection and the use of chemical goggles or face shields are advisable where the possibility of splashing exists in handling these products. In case of eye contact, flush with plenty of water for 15 min. and call a physician immediately."

"Avoid contact with the skin. Wear proper gloves impervious to and unaffected by the solvents when contact with the skin is likely. Application of the primers, cleaners, or solvent cements with rags and bare hands is not recommended. Brushes, daubers, and other suitable applicators can be used effectively for applying these products, thus avoiding skin contact. Dispose of used applicators in the same manner as the rags. In the event of contact, remove contaminated clothing immediately and wash skin with soap and water. Wash contaminated clothing before wearing them again."

Additional health and safety information is available on the manufacturer's Material Safety Data Sheet (MSDS).

Dispose of all rags and other materials used for mopping up spills in accordance with regulatory requirements. For additional information, review the MSDS for the product.

## PVC-DWV - solvent cement joining

In addition to the above general solvent cement joining section, the following applies specifically to solvent cement joining of PVC pipes.

In the case of PVC-DWV, some codes require that a colored primer conforming to ASTM Standard F 656 be used prior to the application of PVC cement. CAUTION: DO NOT mix primer with cement in one container. Do not use cements that have gelled. Do not use so much cement or primer inside the joint that it leaves a puddle after assembly. The joining surfaces of both the pipe and the fitting should be wiped with a clean cloth to remove dirt and moisture. Apply the primer to the pipe and the fitting socket. Apply a heavy coat to the pipe and a thinner coat to the fitting socket. Immediately insert the pipe into the fitting socket turning the pipe 1/8 to 1/4 turn in the socket until it bottoms. This will help to obtain an even spread of cement. Be sure to align scribed marks on pipe and fittings at this point. Hold firmly for at least 15 seconds to prevent the pipe from "backing out" of the fitting. Wipe excess cement from the outside of the joint. Allow the joint to set properly vented to the atmosphere. Plastic pipe cements set up very rapidly; consult the cement manufacturer's instructions for curing times and other details. Some local codes may not require the use of primer. Be sure to check the requirements of the local codes and follow the instructions on the can of solvent cement for making the joint.

ABS-DWV - solvent cement joining

In addition to the above general solvent cement joining section, the following applies specifically to solvent cement joining of ABS pipes.

ABS-DWV joints are made in the same manner as PVC-DWV joints except that a primer is not used. The pipe and fitting surfaces must be clean and dry.

Cement should be applied smoothly and evenly. Apply a moderate coat in the socket and a heavy coat on the pipe. Excess cement is undesirable and should be wiped off; however, an insufficient amount can lead to a joint leak. The correct amount will give you an unbroken bead of cement all around the pipe against the fitting socket.

As soon as the parts are pushed together, the cement begins to set. Do not try to realign the pipe or fittings after setting begins. If you catch an error at this time, pull the pipe completely free and reapply cement as before. Should you turn the fitting after the setting has begun, the joint could be destroyed.

## DWV piping installation - lay out

All plastic DWV fittings are of the drainage type and have built-in "Pitch" or "Fall". The skilled plumber will find it easy to layout, cut, and install plastic piping. **Unlike some piping, errors shall not be fixed by bending, with heat or a hammer.**

Do not take measurements with dry pipe inserted part way into the dry fitting sockets. Rather, measure to the full depth of the socket (right up to the 45-degree chamfer). Close tolerances between the pipe and fittings will stop the dry pipe from going to the full depth of the socket (if driven or forced in dry, it is very difficult to remove). Solvent cement lubricates and softens the pipe to permit "bottoming out" to the full depth every time. Thus, dry piece assemblies can "take up" as much as a quarter of an inch per fitting when finally assembled. This could cause errors on essential or critical measurements.

## DWV piping installation – prefabrication

Plastic DWV lends itself to prefabrication as well if not better than any other material available because light weight and its strong joints permits the use of larger assemblies, thus reducing field joints to a minimum. Use jigs to assure accuracy and to speed up the job. A power saw with an adjustable stop will facilitate rapid cutting of pipe to proper lengths.

Shop-fabricated assemblies can be moved to the field soon after the last joint is made, or they can be stacked for future use.

CAUTION: Always check the dimensions of the first assembly carefully before proceeding with additional units.

## DWV piping installation - supports

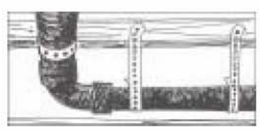
Plastic DWV should be supported as required by the code and in the same manner as any other piping system.

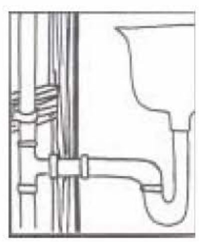
Split ring hangers, ordinary plumbers tape, or band iron may be used. Avoid wire that may cut or compress pipe and tight clamps or straps that prevent pipe from moving with expansion/contraction.

All branch lines to fixtures should be supported as near the fixture outlet as possible to maintain alignment. Fittings that will serve fixture outlets or trap arms should be anchored firmly so that they do not shift when the final connection is made. Follow natural alignment, avoid stress, and allow for thermal expansion of the piping.

Horizontal piping, through four-inch size, should be supported every four feet or as required by the local plumbing code. Supports should be added at changes of direction and large fittings to reduce stresses.

All DWV stacks should be supported at the base. Ensure that stacks do not touch sheet rock or panel walls to avoid setting up an echo chamber effect. DWV piping in walls or ceilings adjacent to living rooms or family rooms should be packed in insulation or wrapped to minimize water flow noises. Avoid binding pipe against wood supports that can lead to expansion noises.



## DWV piping installation - transition connections

Schedule 40 Plastic DWV pipe should never be threaded because the wall thickness is reduced significantly by the process. Factory molded male threaded adapters that solvent cement to the pipe should be used where a threaded joint is required.

Codes require transition from one material to another only through use of approved adapters or joints. Your supplier should have a selection of plastic adapters. In addition, some codes approve clamped, flexible connectors or hubless couplings as adapters between cast iron and plastic piping.

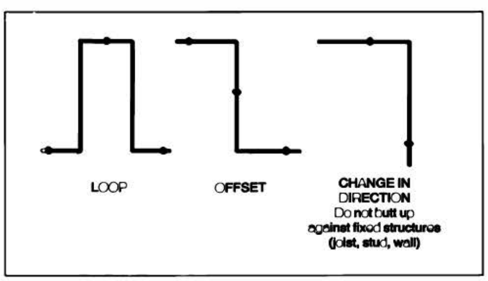
Some thread sealants may have an adverse effect on some plastics. Use only thread tape or thread sealants formulated for plastic piping. Thread sealants or plumber's putty are not necessary on P-trap union joints or slip joints since the threads do not provide the seal.

Joints between plastic pipe and cast iron hubs can be made with caulked lead wool. Although the plastic pipe can be set directly into a CI HUB, a plastic hub adapter is recommended. The hub adapter has a bead on the end of the spigot. This bead provides a seat at the bottom of the hub to retain the oakum in the joint. The joint should be filled with oakum as for metal pipe, and the lead wool caulked in the usual manner.

## DWV piping installation - expansion / contraction

Allow for thermal expansion and movement in all piping installations. Determination of the amount of expansion or contraction should be based upon the difference between the temperature at the time of installation and the seasonal extremes in temperature. The linear expansion rate for ABS is approximately 5/8-in. for each 10º F temperature change for each 100-ft. of piping. The linear expansion rate for PVC is approximately 3/8-in. for each 10º F temperature change for each 100-ft. of piping. Regardless of pipe size, the linear rate remains the same.

The mechanical properties of ABS and PVC piping are such that more thermal stress can be absorbed than by other types of piping. This means expansion and contraction may have a minor effect on ABS and PVC piping once the building is completed and put in use, provided installation versus service temperatures and proper alignment are considered. With precise installation practices, the following methods can be employed to control expansion and contraction:




The use of properly designed offsets with piping properly guided through floors. Depending on operating temperatures encountered, offsets can be utilized as often as every other floor and as seldom as one per building.

The use of guides (in most instances, proper sleeve sizing and alignment) at every other floor, with anchors at the alternate floors for applications involving small temperature changes. As a general rule, this method can be employed in buildings of five stories or less.

Clamped flexible connectors or hubless couplings, where permitted by the plumbing code, have been used satisfactorily. For example, placed in risers between floors of tall buildings, expansion and contraction compensation has been achieved by leaving a 1/8-in. to 3/8-in. gap between the ends of the pipe within the flexible connector. This has been the standard method of installation in Europe for many years, where the "push-on" joining system is in universal use.

The use of expansion joints if approved by the plumbing code, properly adjusted to compensate for installation versus service temperatures, properly guided and properly anchored. Refer to expansion joint manufacturer's installation instructions.

temperatures, generally do not require special provisions.

Support but do not rigidly restrain piping at branches or changes in direction. Do not anchor pipes rigidly in walls, except where controlling the direction of expansion/ contraction. Holes through construction must be adequately sized to allow for free movement, except where otherwise designed for fire penetration protection. Hangers and straps must not compress, distort, cut, or abrade the piping and must allow free movement. Piping and joints must be properly installed, so as not to cause stress and strain.

## DWV piping installation - concrete slab on grade

When DWV piping is to be encased in concrete, it should be filled with water and anchored to prevent floating and misalignment during the concrete pour. All openings should be capped or sealed against possible entry of concrete. The system should be checked immediately after pouring in order to correct any damage or misalignment before the concrete sets.

## DWV piping installation - underground

For underground line installations, whether in a building drain, branch lines, or a sewer, good installation practices should be followed.

Grade all trench bottoms free of stone and pockets and for continuous, uniform support fill holes or depressions with clean, well-tamped material. Do not set pipe on bricks, concrete or wood blocks. Install pipe on proper grade with full, continuous support. Backfill along sides of pipe with selected fill free of stones, clods, or frozen lumps. Tamp backfill carefully to protect pipe alignment. Then backfill on top of pipe with selected fill (free of rock, stone, cement, and other hard materials) to a depth of 12 inches. The trench can then be backfilled in a conventional manner.

## DWV piping installation - freezing

When it is necessary to protect traps and fixtures from freezing, do not use alcohol or petroleum products. Use only approved plastic pipe antifreeze packaged for this purpose or one of the following solutions:

- Sixty percent, by weight, of glycerin in water.
- Twenty-two percent, by weight, of magnesium chloride in water.
- Strong saturated solutions of common table salt (sodium chloride).

## DWV Piping – other considerations

## Air admittance valves (AAVs) - general

The air admittance valve is a product that simplifies drainage and waste venting in commercial and residential applications. It is a one-way valve designed to allow air to enter the plumbing drainage system when negative pressures develop in the piping system. The device closes by gravity and seals the vent terminal at zero differential pressure (no flow conditions) and under positive internal pressures. The purpose of an air admittance valve is to provide a method of allowing air to enter the plumbing drainage system without the use of a vent extended to open air and to prevent sewer gases from escaping into a building.

## Installating air admittance valves

The AAV comes with an adapter that allows solvent welding on 1-1/2" or 2" pipes. The adapter meets the dimensional requirements of pertinent ASTM standards and is suitable for installation on PVC or ABS pipes. Apply Teflon ® tape to threads on valve before joining. Do not use pipe dope.

The AAV must be installed in a vertical plumb position after rough in. It shall be installed a minimum of 4" (102 mm) above the horizontal branch of the drain or fixture drain being vented and in accessible locations which permit free movement of air into the valve. For example, under a sink or lavatory, in attic spaces, in a plumbing case, in a false ceiling or wall by using a recess box.

When installed in an attic, the AAV must be a minimum of 6" above insulation material.

For installation in areas with temperature range from -40º F and +150º F a minimum of one open pipe vent shall extend to the open air for every building plumbing drainage system.

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# Water Service Piping

## Water Service Piping - general

A word of caution is essential: You must check your local plumbing code to be sure that the product you have chosen is approved by your code. Do not assume that every piping product sold by a supplier has been locally approved.

Plastic water piping usage has been increasing since the 1950's in this country and around the world. This can be attributed to code acceptance, and excellent performance along with economics.

"Water Service Piping," as used in this section, refers to the cold-water service line from the water meter, water main, water well, or street right-of-way to the house or building. It is not intended to cover either water mains or the distribution piping within the building.

Plastic water service piping is available in PE (polyethylene), PVC (polyvinyl chloride), PEX (cross-linked polyethylene), CPVC (chlorinated poly vinyl chloride) and PE-AL-PE composite. Depending on the type of material and product selected, the available pressure ratings range from 80 psi to over 315 psi. Actual pressures encountered are usually between 35 psi and 125 psi. However, population growth and extensions of municipal water systems tend to require constantly increasing pressures. The pipes selected should have some allowances for increases in pressure. Many plumbing codes and water utilities require a minimum of 160 psi pressure rated pipe for water service piping connected to municipal water systems.

PVC and CPVC pipe are referred to as "rigid" and are shipped in straight lengths. Smaller sizes of CPVC are also available in coils. PE, PEX, and composite pipe are referred to as "flexible" and are normally shipped in coils.

Because there are several kinds of plastic piping designed for and suitable for water service piping, a variety of joining methods are used. For additional information regarding the joining of specific materials, please see the *Handbook* or the manufacturer's instructions for that specific material.

*The installer must exercise care in selecting the proper material for the application. All plastic piping is economical. Local codes, availability, and local practices typically govern the choice of piping material and product standard.*

## Water Service Piping - storage and handling

Flexible piping (PE, PEX, and composite) is normally shipped in coils that are available in 100-foot increments. Coils can be stacked up to ten high without crushing or damaging. Coils should never be allowed to be exposed to fire or excessive heat. During installation, do not drag the piping over rough terrain and avoid contact with sharp objects that could gouge or cut the piping.

Rigid piping (ABS, PVC, and CPVC) is normally available in 10' and 20' lengths. CPVC is also available in 50' and 100' coils.

Most plastic pipe should be stored inside or under cover. However, some materials such as UV stabilized PE do not require inside storage. See manufacturer's instructions for details.

## Water Service Piping - marking

Markings on plastic water pipe should comply with the requirements of the respective standard under which the particular piping is manufactured. Generally, the standards require that the pipe marking be spaced at intervals of not more than 24 inches on some pipes and 5 feet on other pipes. Water piping standards require marking only on one side of the pipe.

Most standards require that the markings include:

1. Manufacturer's name or trademark and production code
2. The ASTM pipe, fitting, or system standard number
3. Type of plastic material and its ASTM designation
4. Nominal pipe (or tube) size
5. Schedule (40, 80, 120) or SDR
6. Pressure ratings at 73 °F (or other temperature)
7. The seal or mark of the laboratory that evaluates the product for use in potable water systems
8. For ASTM D 2239 Pipe Test Category marking required

## Water Service Piping – ASTM Standards

### PE (Polyethylene) Piping - ASTM Standards

| Product | ASTM Specification | Title |
|---|---|---|
| Pipe and Tubing | D 2239 | Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter |
| Pipe and Tubing | D 2447 | Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside diameter |
| Pipe and Tubing | D 2737 | Polyethylene (PE) Plastic Tubing |
| Insert Fittings | D 2609 | Plastic Insert fittings for Polyethylene (PE) Plastic Pipe |
| Butt Fusion fittings | D 3261 | Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipeand Tibing |
| Electrofusion Fittings | F 1055 | Electrofusion Type Polyethylene fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing |

### PE-AL-PE Composite - ASTM Standards

| Product | ASTM Specification | Title |
|---|---|---|
| Pipe | F 1282 | PE-AL-PE Composite Pressure Pipe |

### PEX (Cross-linked Polyethylene) Piping - ASTM Standards

| Product | ASTM Specification | Title |
|---|---|---|
| Pipe and Tubing | F 876 | Crosslinked Polyethylene (PEX) Tubing |
| Pipe and Tubing | F 877 | Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution sSstems |
| Insert fittings | F 1807 | Metal Insert fittings Using a Copper Crimp Ring for SDR9 Crosslinked Polyethylene (PEX) Tubing |
| Insert fittings | F 1960 | Cold Expansion Fittings with PEX Reinforcing rings for Use with Crosslinked Polyethylene (PEX) Tubing |

* ***Some codes require the use of a primer***

### PVC (Polyvinyl Chloride) Piping ASTM Standards

| Product | ASTM Specification | Title |
|---|---|---|
| Pipe (1120, 1220, 2120) | D 1785 | Poly (Vinyl Chloride) (PVC) Schedules 40, 80 and 120 |
| Pipe (PVC 1120, 1220, 2120) | D 2241 | Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series) |
| Fittings | D 2464 | ThreadedPoly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80 |
| Fittings | D 2466 | Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40 |
| Fittings | D 2467 | Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80 |
| Solvent Cement | F 493 | Solvent Cement Systems for Poly (Vinyl Chloride) (PVC) Plastic Piping systems |
| Primer* | F 656* | Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and fittings* |

### CPVC (Chlorinated Polyvinyl Chloride) ASTM Standards

| Product | ASTM Specifications | Title |
|---|---|---|
| Pipe and Fittings | D 2846 | Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems |
| Fittings | F437 | Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe fittings, Schedule 80 |
| Fittings | F439 | Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80a |
| Pipe | F 441 | Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80 |
| Solvent Cement | F 493 | Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings |
| Primer* | F 656* | Primers for Use in Solvent Cement Joints of Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings* |

### Water Service Piping – Cutting

### Cutting PE, PEX & PE-AL-PE

A plastic tubing cutter is recommended for a square, clean cut. Many tool manufacturers now feature inexpensive cutters specifically designed for cutting plastic piping. Do not use cutters previously used on metal piping.

### Cutting PVC and CPVC

A plastic pipe cutter or a power cut-off saw should be used for a clean, square cut. If a wheel type cutter is used, remove the ridge created by the wheel and provide a chamfer with a tool or a file. If other cutters are not available, cuts can be made with a handsaw or hack saw. Use a miter box or scribe and cut to the mark for a square cut. Never depend on "eye-balling" for a square cut.

### Joining PE, or PEX or PE-AL-PE

PE piping is joined by heat fusion or mechanical fittings. PEX and PE-AL-PE piping are generally joined with mechanical fittings. *However, none of this piping can be joined by solvent cementing.*

Connecting to a corporation stop or curb stop is simple and easy with flexible plastic piping. It can be done with compression fittings, insert fittings using clamps, or a stab-type fitting.

First, affirm that the fitting is recommended by the manufacturer for connecting PE, PEX or PE-AL-PE water piping. Care must be used to match the sizing of the fittings to the pipe or tubing you are using. This is best done by matching the sizing on the pipe print line with the fitting's label. In using insert or compression fittings, consult the installation instructions of the particular manufacturer whose fittings you are using. Stab-type mechanical fittings designed for PE and PEX water piping are of a one-piece design that simplifies installation.

Compression type mechanical connectors include insert fittings with crimp or band-type rings, nut-follower style, flanged bolted and stab-type fittings. Insert fitting joints utilize insert fittings with male barbed ends. Insert crimp/band type or nut-type mechanical couplings with rigidly positioned stiffeners that extend beyond the clamp or coupling nut should not be used unless provisions are made to prevent the creation of a stress riser at the end of the stiffener.

Heat fusion uses a combination of heat and force resulting in two melted surfaces flowing together to produce a joint. Commonly available fusion machines provide the means for truing pipe ends, holding them in alignment, heating them, and applying the correct force to produce a satisfactory joint.

Once the joint has cooled to ambient temperature, it can be handled in the same manner as the pipe.

### Joining PVC or CPVC

Rigid, PVC and CPVC pipe and fittings for water service lines are solvent cemented employing the techniques described in the Solvent Cement Joining section of this *Handbook*. All systems require care during assembly to assure leak-free joints.

Plastic threaded fittings are only intended to be attached to other plastic threaded fittings. Systems that involve transitions from metal to plastic require careful attention. Several styles of adapters have been specially developed to provide leak-free transitions to metal piping. Some of these include: plastic/metal unions, reinforced female threaded adapters, and flanges. When assembling metal and plastic threads, the preferred method is plastic male threads to metal female threads.

If transitions from metal to plastic are exposed to fluctuations in temperature, then cyclic heating and cooling may result in dripping links. In this situation, do not use plastic male threads to metal female threads. Instead use plastic/metal unions, plastic to metal transition fittings, or plastic to metal flanges.

Before assuming that a fitting is appropriate for use as a metal to plastic transition fitting, be sure to check with the specific manufacturer for suitability. Once contacted, manufacturers can also give advice on how their transition products will behave under different operating conditions (e.g., some products might be better suited to large swings in temperature than others).

The recommended tightness for plastic pipe threads is two turns past finger-tight; over tightening may result in split fittings. Do not use pipe wrenches or other tools, which would damage plastic pipe and fittings. When gauging plastic threads, they are within the permissible tolerance if not more than 1-1/2 turns large or small.

When making threaded connections, conventional joint sealers such as solder flux, linseed oil based products, putty, and other unknown mixtures shall not be used. Use only Teflon® tape or recommended thread sealants based on specific manufacturers' recommendations.

**See the Solvent Cement Joining section on pages 4-6 of this Handbook for specifics on joining and safe handling of solvent cements, primers and cleaners.**

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## Water Service Piping - installation

### General installation

This section addresses the various methods of installing plastic water service piping and should be used in conjunction with the more detailed, material specific guidelines below. Specific installation guides are available from the manufacturers of particular products.

Compression type mechanical connectors may have several internal parts and should be used only as recommended by the manufacturer for plastic water piping applications. Compression type mechanical connectors include insert fittings with crimp or band-type rings, nut-follower style, flanged bolted and stab-type fittings. Crimp or nut-type mechanical couplings with rigidly positioned stiffeners that extend beyond the clamp or coupling nut should not be used unless provisions are made to prevent the creation of a stress riser at the end of the stiffener. All stiffeners should be "nosed" or rounded at the end and all sharp edges or burrs must be removed. Bridging or support sleeves are one method of preventing undue stresses on the plastic pipe at the end of the stiffener. Stab-type mechanical water fittings with self-contained insert stiffeners are designed to mitigate any stress risers when properly installed on PE and PEX piping.

The installer should also make sure that the fitting and pipe are both based on the same dimensioning system, (i.e., Outside Diameter Control or Inside Diameter Control and IPS or tubing sizes). The best way to assure correct dimensioning is to match the print line on the pipe to the fitting label.

Full knowledge of installation procedures is important. For more details, see ASTM D 2774, Standard Practice for Underground Installation of Thermoplastic Pressure Pipe. Additional information regarding the design, installation, and operation of plastic piping is available from the Plastic Pipe and Fittings Association as well as other sources within the industry.

When installing or repairing water service lines, cleanliness helps prevent contamination that must be corrected by disinfection.

When disinfecting new or repaired water mains, services, and distribution systems, the methods and procedures found in ANSI/ AWWA C 651 and the manufacturer's instructions are recommended. NOTE: Do not exceed the piping manufacturer's disinfection instructions without consulting the manufacturer.

### Installating PE, PEX and PE-AL-PE

*In addition to the above general installation guidelines, the following guidelines are specific to these Water Service Piping products.*

Piping should be installed on trench bottoms that provide continuous support and are uniform and free from rocks, stones, or other debris. Initial backfill around the piping should be clean fill, and should be well tamped to provide adequate piping support. Ditches should be well tamped to prevent settling.

*Ditches may be curved to avoid obstructions, but the radius of curvature should not be smaller than that recommended by the manufacturer to avoid pinching or crimping the piping.*

*Plastic water service piping expands and contracts more than metal piping, so the piping should never be pulled tight or stretched for connection. Allow an extra 6 inches per 100 feet for expansion and contraction by snaking the piping from side to side in the trench. This is easily accomplished with flexible piping.*

*CAUTION: Depth of burial should always be at* least 12 inches below the local frost depth and in all cases at least 18 inches below the surface to protect the piping from traffic loads. While PE and PEX plastic piping are not as subject to damage by freezing as metals, they are somewhat more difficult to thaw once they are frozen. Never use an open flame to thaw plastic piping. Thawing can be accomplished by using thermostatic controlled (160º F) electric heat tapes, by using hot air, or by disconnecting the line and flushing with hot water. This will usually clear the stoppage.

## Water Service Piping -helpful hints for PE, PEX and PE-AL-PE

REMEMBER, you can avoid problems by:

1. Protecting the piping from damage before installation.
2. Inspecting piping for cuts and damage before installation and rejecting damaged piping.
3. Never permitting rocks and sharp objects to bed against piping.
4. Never "reverse bend" coiled piping.
5.I nstalling piping without placing stress on fittings.
6. Never permitting plastic piping to be kinked or installed under strain at a metal fitting.
7. Snaking the piping in the ditch to allow for temperature differences.
8. Flushing the line free of dirt before the final connection.

9. Filling the line with water and pressure testing before back filling. Test to t he pressure required by the code or to 150% of working pressure.

### Installing PVC and CPVC

In addition to the above general installation guidelines, the following guidelines are specific to PVC and CPVC Water Service Piping.

Most of the trenching, testing, and freeze protection procedures outlined in the previous section on flexible plastic water service materials also apply to rigid piping.

Snaking the line to provide for expansion and contraction is somewhat more difficult than with flexible piping and requires a little more effort, but even rigid pipe has enough "yield" to accomplish this.

After the main portions of the line have been run and the "set" of the joints is assured, stakes can be placed along the piping between the couplings to accomplish the desired snaking. Never place a stake at a coupling. This may cause stress or strain that could damage the joint. After measuring and fitting the last piece of the line, the stakes can be pulled up for reuse. Never run a plastic water service line perfectly straight and tight. Damage or pull out could result when expansion or contraction takes place.

The rigid piping should be laid on a trench bottom free of rocks or sharp objects. Since rigid piping will involve more joints that could be damaged, the service line should be installed in a protective "envelope" of fine soil and at least 6 inches of cover should be provided before backfilling with mechanical equipment.

Leave line pressure in the service line while backfilling. If any leak occurs, it will be easy to find. This will save the labor of digging out more of the line. Should a leak occur, review your joint assembly and installation practices carefully. Allow the repaired joint to cure for the required time period, or you may find yourself repairing it again.

*Too often, careless backfilling results from assigning the job to someone else. Remember that the responsibility for the service line is yours. Supervise the installation until it is completed to your satisfaction.*

### *Water Service Piping - Helpful Hints for PVC and CPVC*

REMEMBER: You can avoid problems if you:

1.Wipe all parts clean and dry before assembly.

2. If required by code and/or manufacturer's instructions use a primer with PVC rigid piping.

3. Use the proper cement for the type of pipe you are joining.

4. Exercise care with each joint to reduce the possibility of leaks.
5. Allow sufficient drying or curing time before testing. This will depend on the weather, type of material, humidity, pipe size, and type of cement. Joint strength increases with time. Check manufacturer's recommendations.
6. Pressure test with water as required by code or at 150% of the working pressure. Apply pressure long enough to detect leaks but no longer than 24 hours. Do not test with compressed air or gas.

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# Hot & Cold Water Distribution Piping

### Hot and Cold Water Distribution - General

A word of caution is essential: You must check your local plumbing code to be sure that the product you have chosen is approved by your code. Do not assume that every piping product sold by a supplier has been locally approved.

### Hot and Cold Water Distribution Piping – General Properties

The plastic industry offers three complete systems for hot and cold-water distribution systems: CPVC (chlorinated polyvinyl chloride), a rigid system; PEX (cross-linked polyethylene), a flexible system; and PEX-AL-PEX or PE-AL-PE (composite) flexible systems. They are approved by most model, state, or local codes. However, we do recommend that the installer verify this approval and the code requirements before beginning installation. For clarity, these systems are dealt with separately.

Plastic water pipe and tube is more resistant to freezing than metal pipe. However, in the event of freezing, blow torches or open flames must never be used for thawing. Use a low temperature hot air gun, circulate warm air with a fan, or thaw by disconnecting the line and flushing with warm water. Afterwards, test the system with water at the pressure required by the code or at 150% of the working pressure.

**NOTE: Polybutylene (PB) piping is no longer available in the USA for water distribution piping. There is a special section at the end of this chapter offering polybutylene-specific guide material**.

### CPVC Properties

CPVC CTS (copper tube size) pipe and fittings, introduced in 1960, are manufactured to conform to ASTM D 2846. CPVC solvent cement conforming to ASTM F 493 is used to join the pipe and fittings. CPVC piping is tan in color, is made with the same OD as copper water tubing and has proven its ability to do its designated job. It resists corrosion, reduces sweating, has adequate impact strength, has smooth walls that give low flow resistance, is lightweight, and is easy to install.

Cost considerations and corrosion problems with metal systems have led many plumbing contractors to turn to this field-proven product. They have found it to be excellent for domestic hot and cold water distribution systems and for circulating hot water systems.

### PEX Properties

PEX tubing can be used in potable water distribution systems. PEX tubing is also widely used for heat transfer applications – both low-temperature (radiant floor heating, snow removal, and ice rinks), as well as distribution piping for temperatures up to 200° F (hot water baseboard, convectors, radiators, etc.).

### *PEX-AL-PEX or PE-AL-PE Properties*

Composite pipe has an aluminum tube laminated between two layers of plastic-PE or PEX. It is made to tube dimensions and is sold in coils. The PE-AL-PE (ASTM F 1282) is dark blue in color and is used for cold water. The PEX-AL-PEX (ASTM F 1281) is orange, light blue or black in color and is used for hydronic heating and hot water. The pipe is supplied with fittings and accessories that complete the system.

### *Hot and Cold Water Distribution Piping - Storage and Handling*

CPVC CTS piping is available in 10' or 20' lengths and 50' and 100' coils. It should be stored inside or under cover to prevent an accumulation of dirt. Short-term exposure to direct sunlight (not to exceed 30 days total time) can be tolerated during construction. Pipe should be stored straight with continuous support over its entire length. Handle carefully to ensure that the pipe stays clean, ends are unchipped and square and abrasion is avoided.

PEX piping and composite piping (PE-AL-PE or PEX-AL-PEX) are normally shipped in coils that are in 100' increments. Coils can be stacked up to ten high without crushing or damaging. Coils should never be allowed to be exposed to fire or excessive heat. During installation, do not drag the piping over rough terrain and avoid contact with sharp objects that could gouge or cut the piping.

Most plastic pipe should be stored inside or under cover. However, some UV stabilized piping products do not require inside storage. See manufacturer's instructions for details.

### *Hot and Cold Water Distribution Piping - Marking General*

Markings on plastic water pipe should comply with the requirements of the respective standard under which the particular piping is manufactured. Generally, the standards require that the pipe marking be spaced at intervals of not more than 24 inches on some pipes and 5 feet on other pipes. Water piping standards require marking only on one side of the pipe.

## Marking CPVC

***In addition to the general requirements, the following are CPVC specific requirements.***

CPVC pipe is required by ASTM D 2846 to be permanently marked on one side of the pipe at intervals not exceeding five feet.

This marking shall include the following:

1. Manufacturer's name or trademark
2. ASTM Designation D 2846
3. Material Designation Code (CPVC 4120) or 23447
4. Pressure Rating – 100psi @ 180° F
5. Nominal Size
6. Standard Dimension Ratio-SDR 11
7. The seal or mark of the third party certifier that evaluates the product for use in potable water systems and for conformance with the D 2846 Standard. Fittings markings should include at least (1), (2), (3), and (7) of the above information. Transition fittings must be marked with (1), (3), and (7) of the above information.

## Marking PEX

***In addition to the general requirements, the following are PEX specific requirements.***

PEX tubing must be labeled as follows:

1. The manufacturer's name or trademark.
2. The standard to which it conforms (ASTM F 876, F 877 or both).
3. The tube size and CTS.
4. Material designation code (PEX0006).
5. Pressure/temperature rating(s).
6. SDR9
7. If the tubing is for potable water, a laboratory seal or mark attesting to suitability for potable water.
8. ASTM Standard designation for the fitting system for which the tubing has been approved for use.

## Marking PE-AL-PE or PEX-AL-PEX

In addition to the general requirements, the following are composite pipe specific requirements:

1. The manufacturer's name or trademark
2. The standard to which it conforms (ASTM F 1281 or F 1282)
3. The tube size in metric (mm) or inch sizes (1216 ~1/2"; 1620 ~ 5/8"; 2025 ~¾"; 2532~1")
4. The material designation (PEX-AL-PEX or (PE-AL-PE)
5. Pressure temperature rating (PEX-AL-PEX) 200 psi @ 73°F & 125 psi @ 180°F
6. Pressure temperature rating (PE-AL-PE) 200 psi @ 73° F & 160 psi @ 140° F
7. A laboratory seal or mark attesting to suitability for potable water and conformance with the standard marked on the pipe.

## Hot and Cold Water Distribution Piping - Cutting

### Cutting CPVC

A plastic pipe cutter or power cut-off saw should be used for a clean, square cut. If a wheel-type tubing cutter is used, remove the ridge created by the wheel and provide a chamfer with the appropriate tool or file. If other cutters are not available, cuts can be made with a handsaw or hack saw. Use a miter box or scribe and cut to the mark for a square cut. Never depend on "eye-balling" for a square cut.

### Cutting PEX & PEX-AL-PEX or PE-AL-PE

A plastic pipe cutter or a power cut-off saw should be used for a clean, square cut. If neither is available, cut with a handsaw or hack saw. Use a miter box or scribe and cut to the mark for a square cut. Never depend on "eye-balling" for a square cut.

## Hot and Cold Water Distribution Piping – Joining

### Joining CPVC

CPVC pipe and fittings are joined with CPVC cements. The solvent cement process can be a one- or a two-step process. The one-step cement does not require the use of a primer or cleaner; this cement is yellow in color. The two-step process does require the use of a primer or cleaner; this cement is orange in color. Both types of cements are manufactured under the ASTMF 493 Standard and will be marked with that number. The label on the can will indicate color and whether a primer is required. The label may also refer to D 2846.

See the Solvent Cement Joining section in this Handbook on pages 4-6 for specific solvent cementing instructions.

Use only CPVC cement and follow the cement manufacturer's recommendations in selecting and using the primers and cements. All other conditions of cementing CPVC are identical to those of PVC DWV and PVC water piping, including safe handling of solvent cements, primers, and cleaners. Make sure that the local code allows the use of one step cement before using it.

### Joining PEX

A full line of directional and transition fittings is available. The joint can be formed by various methods including mechanical compression, insert fittings using a copper crimp ring (ASTM F 1807), cold expansion

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fittings using a PEX reinforcing ring (ASTM F 1960), and mechanical stab joints.

In manifold systems, one-piece PEX tubing is installed between the centrally located manifold and the fixture connection, thus the only joints are at the ends of the tube. Only a few additional joints are needed to complete the supply line to the header.

### Joining PEX-AL-PEX or PE-AL-PE

A full line of directional and transitional fittings is available. Two types of joints are available, mechanical compression and crimp ring. Metal fittings are the norm. In manifold systems, a single piece of the tube is installed between the manifold and the fixture so the only joints are at these two accessible locations

### Hot and Cold Water Distribution Piping – Installation

### Installing CPVC

The installer is cautioned to:

1. Read and follow the manufacturer's recommendations.
2. Wipe joint surfaces clean and dry.
3. Use a primer before cementing with orange cement. Alternatively, use the yellow cement without a primer if local plumbing codes permit.
4. Use only CPVC solvent cement.
5. Hold the pipe and fitting joint together for at least 15 seconds after assembly.
6. Never bind piping.
7. Allow joints to cure, flush out the system, and pressure test with water as required by code.

A CPVC Hot & Cold Water Piping Installation Manual containing more information on the use of CPVC, is available from PPFA.

### Installing CPVC – metal connections

Adapters (transition fittings) from metal piping to CPVC are available. These fittings come in the form of unions, compression fittings, and reinforced male and female threaded adapters. When water temperatures exceed 150° F, use brass threaded transition fittings only. Use the manufacturer's recommended fittings for transition to other piping materials and follow instructions for proper installation. When making threaded connections with CPVC fittings, conventional joint sealers, solder flux, or other components should never be used on plastic threads. Use only recommended thread sealants or Teflon® tape. When threaded plastic fittings are used, make sure they are not over-tightened.

Common pipe wrenches will bite or score plastic fittings. Flat, smooth-surfaced adjustable wrenches, open-end wrenches, or smooth pliers should be used to tighten fittings.

When connecting CPVC to inlets and outlets at the top of a gas water heater, provide at least twelve (12) inches of metal nipple or appliance connector so that the CPVC cannot be damaged by the buildup of excessive radiant heat from the flue. CPVC piping should not be in contact with, or close to, heat-producing sources such as flues or steam pipes. Some high-efficiency, direct-vent gas water heaters eliminate the radiant heat from the flue and the CPVC pipe connections can be made with brass threaded CPVC transition fittings.

### *Installing CPVC - Supports*

For 180° F service, CPVC should be supported at three feet maximum spacing for sizes one-inch and smaller, and at four feet maximum spacing for larger sizes. For 73° F service, the support spacing can be increased by 50 percent. It should be strapped or hung in a manner that will permit movement caused by expansion and contraction. Do not fasten tightly to studs or joists. Hangers should have a smooth surface to prevent cutting or abrading the piping.

### *Installing CPVC - Expansion and Contraction*

The linear thermal expansion rate for CPVC is approximately 7/16 inch for each 10º F temperature change for each 100 feet of pipe or tubing. When installing long runs of piping allow 1/16 to 3/32-inch longitudinal clearance per foot of run to accommodate thermal expansion. Proper design includes offsets of 12 inches or more at intervals as required on vertical risers, if they are restrained by horizontal branches. Piping should not be anchored rigidly to a support, but it should be secured with broad, smooth hangers providing for a degree of movement. Refer also to manufacturer's literature and the local plumbing code. CPVC is approved for underslab installations, with joints, in all model-plumbing codes.

### Installing CPVC - freezing

Like other plastic water pipe and tube, CPVC is more resistant to damage by freezing than are metals. However, in the event of freezing, blow torches or open flames must never be used for thawing. Use a low temperature hot air gun, circulate warm air with a fan, or thaw

by disconnecting the line and flushing with warm or hot water. After flushing, test all systems with water at the pressure required by the code or at 150% of the working pressure.

### Installing PEX or PEX-AL-PEX

The installer is cautioned to read the manufacturer's installation instructions for proper installation practices. In all cases, normal workmanship is required if a long-term satisfactory installation is to be achieved. Do not use tubing that has been cut, severely scuffed, kinked, or crushed. Cut and replace damaged sections.

The tubing must be placed so that it will not be exposed to sources of high heat. Keep the tubing at least 6-inches horizontally and 12-inches vertically from fluorescent and incandescent light fixtures, heating appliances, and furnace or water heater flue vents.

PEX tubing should not be directly connected to gas or electric water heaters. Use a minimum of 18-inch length of metallic pipe for each connection. However the PEX-AL-PEX tube can be connected directly to both types of water heaters.

When making transition fittings to copper or brass pipe or fittings by soldering or brazing, do the soldering first, and allow the joint to cool before making the connection to the tubing. Do not expose the tubing to an open flame as damage can result.

### Installing PEX – Supports

PEX tubing is usually supported on the face of, or by holes through, joists or studs. Otherwise, support horizontal piping above ground every 32 inches using hangers wide enough to avoid deforming the tubing at the point of support. Sharp edges must be avoided. Typical clevis hangers or one-hole or two-hole clamps ranging from about 3/8 inches to 1 inch are usually suitable. Clamp tubing firmly, but not so tightly that it cannot move as it expands and contracts.

PEX piping run vertically should be supported mid-story and at every floor level and again when making significant changes in direction.

### Installing PE-AL-PE and PEX-AL-PEX-Supports

This tubing comes in coils but when it is uncoiled there is no spring-back. The tube can be bent by hand and the minimum radius is 5 X Diameter. For 1" tube, use a bending tool. Although the maximum support spacing for this tubing is 8' 2", the plumbing code may require closer support spacing. Plastics clamps are recommended and clamps should be provided at changes in directions.

### Installing PEX – expansion and contraction

PEX piping will expand and contract about 1 inch for every 100 feet of length for each 10° F change in temperature. For tubing sizes 1 inch and smaller, this length change is accommodated by snaking tubing around obstacles and by normal slack that is present in laying flexible pipe. For those cases where significant temperature variation is expected, piping dimensional change can be accommodated at changes in direction or with offsets or loops.

### Installing PE-AL-PE and PEX-AL-PEX-expansion and contraction

This tubing has a coefficient of linear expansion similar to copper tubing. Therefore no special provisions are needed to compensate for the temperature changes that typically occur in hot and cold water distribution systems.

### Installing PEX - freezing

Like other plastic water pipe and tube, PEX is more resistant to damage by freezing than are metals. However, in the event of freezing, blow torches or open flames must never be used for thawing. Use a low temperature hot air gun, circulate warm air with a fan, or thaw by disconnecting the line and flushing with warm or hot water. After flushing, test all systems with water at the pressure required by the code or at 150% of the working pressure.

### PB (PolybutyleneGuidelines

Polybutylene (PB) is no longer offered for use in North America. The pipe was sold primarily in coils from 1970-1995. You may encounter some in structures built or remodeled during that time frame. The majority of product would be gray in color and be found in single-family structures, apartments, and mobile homes.

PB piping was made to the following ASTM Standards for these applications:

- ASTM D 3309 -Hot & Cold Water Distribution- This was copper tube size (CTS) piping mostly coiled but also available in straight lengths. It was gray in color. This PB piping was also used for fire sprinkler systems, and for radiant slab heating systems. PB piping was used in many mobile homes and in some pre-fabricated housing.
- ASTM D 2513 -Natural Gas- This was CTS size PB piping (gold or black) used for underground

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distribution or service lines and was installed by some gas companies.

- ASTM D 2666 - Water Service Lines. This was CTS size PB piping (black or blue) used for lines from the water main to the meter and to the building. ASTM D 2662, ID controlled PB pipe, was also used for water service lines.
- ASTM D 2666 and D 2662 - Almost all PB water service lines were made to the D 2666 specification, in black or blue grades. They were used in main to meter or meter to house applications.

# Storm and Sanitary Sewers and Drains

### Storm and Sanitary Sewers and Drains-General

***A word of caution is essential: You must check your local plumbing code to be sure that the product you have chosen is approved by your code. Do not assume that every piping product sold by a supplier has been locally approved.***

Storm and sanitary sewer pipes are covered by ASTM standards D 2729, D 2751, D 3034, F 789 and F 891. While these products are now acceptable in most areas, the user still must check the local code.

This section will deal with house and building sewers on private property, outside buildings. For the sake of brevity, only normal depth and installation will be discussed. In addition to plastic piping for sanitary sewers, the plastic industry makes lighter wall piping suitable for clear water drainage and foundation drains. (Note: for storm water and roof drains within the building, most codes will also permit the use of the approved DWV products).

For those who do septic tank work, perforated drainpipes made from SR (styrene rubber), PE (polyethylene), and PVC (polyvinyl chloride) are available. Again, we caution the installer to refer to his local plumbing code to determine which materials and which products are approved for use.

*Each of the noted standards includes both the pipe and the fittings designed to be used in the system. Mixing the pipe meeting one standard with fittings meeting another standard is not recommended. Note that DWV piping and sewer/drain piping use different outside diameters for each pipe size. Check the markings on both pipe and fittings.*

### Storm and Sanitary Sewers and Drains - Marking

Sewer and drain piping is identified in a similar manner as DWV piping. See

DWV Piping - Marking section on page 8 of the *Handbook*, for typical marking requirements.

## Storm and Sanitary Sewers and Drains- ASTM Standards

### ASTM Standards for ABS and PVC Storm and Sanitary Sewer Pipe and Drain Piping

| Material/Application | ASTM Specification | title |
|---|---|---|
| ABS Drains | D 2751 | Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings |
| PVC Type PSM Sewer | D 3034 | Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings |
| PVC Type PS-46 Sewer | F 789 | Type PS-46 and Type PS-115 Poly (Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings |
| PVC Coex Sewer | F 891 | Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core |
| PVC Drain | D 2729 | Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings |

### ASTM Standards for PE and PP Sewer Pipe and Drain Piping

| Material/Application | ASTM Specification | Title |
|---|---|---|
| PE Corr Drain | F 405 | Corrugated Polyethylene (PE) Pipe and fittings |
| PE & PP Drain | F 1412 | Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems |

## Storm and Sanitary Sewers and Drains – Cutting

### Cutting ABS and PVC

A plastic pipe cutter or a power cut-off saw should be used for a clean, square cut. If neither is available, cuts can be made with a hand saw or hack saw. Either a miter box or scribing and cutting to the mark should be used for a square cut. Never depend on "eye-balling" for a square cut.

### *Cutting PE and PP*

*A plastic tubing cutter is recommended for a square, clean cut. Many tool manufacturers now feature inexpensive cutters specifically designed for cutting plastic piping. Do not use cutters previously used on metal piping.*

## Storm and Sanitary Sewers and Drains – Joining

### Joining ABS and PVC

*Plastic sewers may be joined either by solvent cementing or with elastomeric seal joints. Consult the DWV solvent cementing portion of this Handbook on page 11 for specifics on solvent cement joining and safe handling of solvent cements, primers and cleaners.*

### Joining PE and PP

PE and PP Plastic sewers may be joined either by heat fusion or with elastomeric seal joints. Consult the heat fusion joining portion of this *Handbook* for specifics on heat fusion joining.

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## Storm and Sanitary Sewers and Drains - Installation

All the model-plumbing codes include sections on installing sewer piping. Consult your local code and follow it. In the absence of local code provisions, use the following steps. Excavate to the desired grade. Be sure trench is safe — shore sides when in doubt. Use a transit or level line to obtain proper grade. Cut down high spots, fill holes or depressions, and tamp thoroughly. Remove all rocks or other sharp objects. If necessary in rough soil conditions, excavate to a greater depth than required and then backfill with select fill material to proper level and grade.

Where trenching conditions are difficult due to rock, water, gumbo soil, or other unstable conditions, the sewer pipe must be supported throughout its full length using treated timber, concrete pad, sand, or properly selected backfill material. Lay the pipe in a straight line. Use a level or transit to set the pipe to grade. Use proper fittings for all turns. Do not try to bend piping.

Be sure the pipe has full support. Encase the pipe in a protective "envelope" by filling along the sides with earth or fill free from large rocks. Tamp side fill material as it is placed. As with all underground installations, proper tamping will minimize deflection, is consistent with the pipe manufacturer's recommendations, and the plumbing codes.

Cover the entire pipe with clean earth or backfill to a depth of at least 12 inches, tamping along both sides but not over the pipe as you fill. The trench can now be filled either by hand or mechanically. All sewer pipe fittings should be of the drainage pattern. All materials, regardless of smoothness, are subject to stoppage. Cleaning rods, whether manual or automatic, will not execute sharp or short radius turns. Avoid future problems by providing full radius turns at every change in direction.

These are the fundamental requirements for every sewer or drain trench.

*Molded plastic adapters and rubber ring doughnuts are available for connections during the tests. A water exfiltration test can be used making connections either size by size or* one material to another. Do not use concrete cement or unauthorized joining material for making plastic pipe sewer joints. Use the proper connections only.

While drains are not generally considered the same as sewers, they also can encounter stoppage, flooding, and back flow due to poor installation. The same installation procedures should be followed when laying drains as when laying sewers.

## Storm and Sanitary Sewers and Drains - Other Considerations

## Storm and Sanitary Sewers and Drains - Testing

Where testing of the sewer service is required, it may be preferable to do it before covering the joints so that they can be checked for leaks. Soil can be placed over the pipe between the joints for protection during the tests. A water test is recommended. These piping systems shall not be tested with compressed air or other gases unless the procedure being used has been clearly and specifically approved by the manufacturer(s) of the plastic piping to be tested.

Note: By virtue of their compressibility, compressed air and gases contain large amounts of stored energy which present serious safety hazards should a piping system rupture for any reason.

Note: Ground water infiltration has become a major problem in sanitary sewer systems, because it overloads the sewer mains and the sewage treatment plant. In addition, leaking joints allow root penetration that can result in blockage. Ensure a watertight installation. Plastic piping joints – both solvent cemented and gasketed – are easy to make and remain watertight.

# Polyethylene Pipe Insulation

## General

Tundra Plus & Tundra Seal Plus Polyelfin/Polyethylene Pipe Insulation is low density, polymer-based and easy-to-apply tubing products that are available in a wide variety of sizes in semi-slit and self-sealing designs. The self-sealing design has a yellow release liner that is both easy to see and peel. These chemically inert pipe insulations are specially formulated to retard heat gain and their closed-cell structures allow them to function as efficient insulators.

## Key Features

- Low density
- Easy-to-apply
- Available in Self-Seal or Semi-Slit
- Best for indoor applications such as plumbing, hot water heater lines or in-floor radiant heat
- Best applications where temperature does not exceed 82°C or below -68°C
- Reduces Heat Loss
- Resists Freezing
- Reduces Condensation
- Reduces Plumbing Noise

## Uses

Tundra Plus & Tundra Seal Plus Polyethylene Pipe Insulation are widely used to reduce unwanted heat loss or heat gain, control condensation, decrease plumbing noise and maximize energy savings. They can be used on hot and cold water lines, refrigeration lines, air conditioning lines; line set tubing, condenser coils, and connection and distribution lines.

These tubing products boast a broad range of other insulating applications and can be used as protective covers where necessary. Tundra Plus & Tundra Seal Plus Polyethylene Pipe Insulation meets all specifications for both home and industrial applications where the operating temperature is between -90°F and 180°F (-68°C and 82°C).

Tundra Plus & Tundra Seal Plus Polyethylene Pipe Insulation have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, as tested by ASTM E 84 "Surface Burning Characteristics of Building Materials."

**Note:** Numerical flammability ratings alone may not define the performance under actual fire conditions. They are provided only for use in the selection of products to ensure the specified limits are met.

Tundra Seal Plus is available in both black and white, and is available in a variety of wall thicknesses—from 3/8" to 1", and ID's of 3/8" to 4½"

Can be used for underground applications.

## Specifications

| Physical Properties | TUNDRA | Test Method |
|---|---|---|
| Material | Closed Cell Polyolefin | — |
| Colour | Charcoal or White | — |
| Upper Use Limit | 180° F (82° C) constant | — |
| Lower Use Limit | -90° F (-68° C) | — |
| Density | 1.5 lbs/ft³ | ASTM D 1622 |
| Ozone Resistance | Good | ASTM D 1171 |
| Thermal Conductivity (K) | at 75° F (24° C) Mean Temp | ASTM C 177 or C 518 |
| BTU-in/hr-ft² -°F (W/m-K) | 0.230 (0.033) | — |
| Water Absorption | 0.02% by Volume | ASTM E 96 |
| Flame Speed | Less than 25 | ASTM E 84; CAN/ ULC-S102.2-M88 |
| Smoke Classification | Less than 50 | ASTM E 84; CAN/ ULC-S102.2-M88 |

## Tundra Plus & Tundra Seal Plus Pipe Insulation

Sizes, Wall Thicknesses, Quantities and R Values

| | | | | 3/8″ Wall | | | 1/2″ Wall | | | 3/4″ Wall | | | 1″ Wall | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal ID | Metric (mm) | Nom Copper | Iron Pipe | Pcs/Ctn | Ft/Ctn | R Value | Pcs/Ctn | Ft/Ctn | R Value | Pcs/Ctn | Ft/Ctn | R Value | Pcs/Ctn | Ft/Ctn | R Value |
| 3/8 | 9.5 | 1/4 | — | 100 | 600 | 2.687 | 74 | 444 | 3.844 | — | — | — | — | — | — |
| 1/2 | 12.5 | 3/8 | 1/4 | 80 | 480 | 2.490 | 60 | 360 | 3.582 | 34 | 204 | 6.027 | — | — | — |
| 5/8 | 15.9 | 1/2 | 3/8 | 68 | 408 | 2.357 | 51 | 306 | 3.375 | 30 | 180 | 5.653 | 18 | 108 | 8.189 |
| 3/4 | 19.1 | 5/8 | — | 60 | 360 | 2.680 | 45 | 270 | 3.223 | 28 | 168 | 5.374 | 17 | 102 | 7.767 |
| 7/8 | 22.2 | 3/4 | 1/2 | 50 | 300 | 2.187 | 40 | 240 | 3.107 | 26 | 156 | 5.155 | 15 | 90 | 7.435 |
| 1 1/8 | 27.6 | 1 | 3/4 | 40 | 240 | 2.082 | 30 | 180 | 4.835 | 17 | 102 | 4.835 | 15 | 90 | 6.941 |
| 1 3/8 | 34.9 | 1 1/4 | 1 | 32 | 192 | 2.011 | 25 | 150 | 2.822 | 15 | 90 | 4.610 | 12 | 72 | 6.588 |
| 1 5/8 | 41.3 | 1 1/2 | 1 1/4 | 22 | 132 | 1.959 | 20 | 120 | 2.737 | 14 | 84 | 4.42 | 10 | 60 | 6.323 |
| 1 7/8 | 47.9 | — | 1 1/2 | 18 | 108 | 1.920 | 15 | 90 | 2.672 | 11 | 66 | 4.313 | 9 | 54 | 6.115 |
| 2 1/8 | 54.0 | 2 | — | 15 | 90 | 1.889 | 14 | 84 | 2.620 | 9 | 54 | 4.209 | 8 | 48 | 5.948 |
| 2 3/8 | 59.9 | — | 2 | 15 | 90 | 1.864 | 11 | 66 | 2.578 | 9 | 54 | 4.124 | 7 | 42 | 5.810 |
| 2 5/8 | 66.3 | 2 1/2 | — | 12 | 72 | 1.844 | 10 | 60 | 2.544 | 8 | 48 | 4.053 | 6 | 36 | 5.695 |
| 2 7/8 | 72.6 | — | 2 1/2 | 10 | 60 | 1.827 | 9 | 54 | 2.514 | 7 | 42 | 3.993 | 6 | 36 | 5.596 |
| 3 1/8 | 79.4 | 3 | — | 9 | 54 | 1.812 | 8 | 48 | 2.490 | 6 | 36 | 3.942 | 12 | 72 | 5.512 |
| 3 1/2 | 83.9 | — | 3 | — | — | — | 7 | 42 | 2.459 | 12 | 72 | 3.877 | 12 | 72 | 5.404 |
| 3 5/8 | 32.1 | 3 1/2 | — | — | — | — | 7 | 42 | 2.449 | — | — | — | 12 | 72 | 5.373 |
| 4 | 101.6 | — | 3 1/2 | — | — | — | 6 | 36 | 2.425 | — | — | — | — | — | — |
| 4 1/8 | 104.8 | 4 | — | — | — | — | 5 | 30 | 2.418 | — | — | — | 9 | 54 | 5.264 |
| 4 1/2 | 114.3 | — | 4 | — | — | — | 5 | 30 | 2.399 | — | — | — | 8 | 48 | 5.196 |

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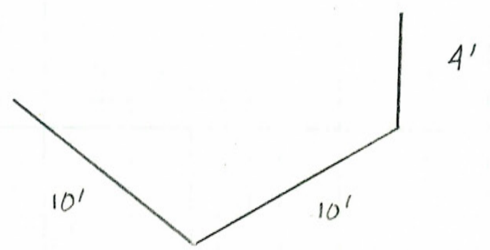
# APPENDIX E - Calculations

## Supply Pressure Drop Calculation

Hand calcs for Revit Pressure Drop 11/24

- Schematic / Given




- $T = 70\,^{\circ}F$
- $l = 24'$
- $d = 1/12'$
- $P_1 = 50\text{psi}$
- $z_1 = 0'$
- $z_2 = 4'$
- $\rho = 1.9348$
- $\varepsilon = 0.000006$
- $V = 6.19\ \text{ft/sec}$

- Bernoullis

$$\left(\frac{P_1}{\rho g} + \cancel{\frac{V_1}{2g}}^{0} + z_1\right) - \left(\frac{P_2}{\rho g} + \cancel{\frac{V_2}{2g}}^{0} + z_2\right) = h_{l_{maj}} + h_{l_{min}}$$

$$\frac{P_1}{\rho g} + z_1 - \frac{P_2}{\rho g} - z_2 = f\left(\frac{l}{d}\right)\left(\frac{V^2}{2g}\right) + 2K\left(\frac{V^2}{2g}\right)$$

$$\frac{P_1 - P_2}{\rho g} + (z_1 - z_2) = f\left(\frac{l}{d}\right)\left(\frac{V^2}{2g}\right) + 2K\left(\frac{V^2}{2g}\right)$$

$$\frac{P_1 - P_2}{\rho g} + (z_1 - z_2) = f\left(\frac{l}{d}\right)\left(\frac{V^2}{2g}\right) + 2K\left(\frac{V^2}{2g}\right)$$

$$\frac{(7200 - P_2)\ \frac{lb}{ft^2}}{62.3\ \frac{lb}{ft^3}} + 4\text{ft} = f\left(\frac{l}{d}\right)\left(\frac{V^2}{2g}\right) + 2K\left(\frac{V^2}{2g}\right)$$

$$Re = \frac{\rho V d}{\mu} = \frac{(1.9348\ \text{slugs/ft}^3)(6.19\ \text{ft/sec})(1/12\ \text{ft})}{2.034 \times 10^{-5}\ \frac{lbf\,s}{ft^2}}$$

$$= 49067.56801$$

$$= \underbrace{49{,}067.57}_{> 2300 \text{ so turbulent}}$$

$$Re = \frac{ud}{\nu} = \frac{(6.19\ \text{ft/s})(1/12\ \text{ft})}{1.052\ (\text{ft}^2/\text{s}) \times 10^{-5}}$$

$$= 49033.58682$$

$$= \underbrace{49{,}033.59}_{> 2300 \text{ so turbulent}}$$

Hand calcs for Revit pressure Drop 11/24

- Bernoullis continued

  - from moody chart, $f = 0.015$

$$f = \frac{h}{\left(\frac{l}{d}\right)\left(\frac{V^2}{2g}\right)}$$

  - Revit uses the colebrook equation for the Friction factor

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon}{3.7D} + \frac{2.51}{Re\sqrt{f}}\right) \Big\} \text{ for transitional \& turbulent flow}$$

$$f = \frac{64}{Re_e} \Big\} \text{ for laminar flow}$$

  - we have turbulent flow
    - solve using wolfram Alpha

$$\frac{1}{\sqrt{F}} = -2\log\left[0.00019459 + \frac{0.000051154}{F^{.5}}\right]$$

$$1 = -2\log\left[0.00019459 + \frac{0.000051154}{F^{.5}}\right]\sqrt{F}$$

      - solution

$$f = 0.00510041$$
$$= \underline{0.0051}$$

-plug into Bernoullis

$$\frac{7200 - P_2}{62.3}\,ft - 4ft = 0.0051\left(\frac{24ft}{1/12\,ft}\right)\left(\frac{(6.19ft/s)^2}{64.4ft/s^2}\right) + 2 \cdot 1.5\left(\frac{(6.19ft/s)^2}{64.4\frac{ft}{s}}\right)$$

Major head = 0.87389 ft
= 0.874 ft

Minor head = 2 · 0.89246 ft
= 1.78491 ft
= 1.785 ft

$$\left[\frac{7200 - P_2}{62.3}\right]ft = 6.658801491\ ft$$

$$P_2 = 47.11914 \Rightarrow 47.12\ psi$$

Datum / Date: 11/24/14

# Hand calcs for Revit pressure Drop

11/24

- Pressure Drop

$$P_1 - P_2 = \Delta P$$

$$\Delta P_h = 50\,psi - 47.11914\,psi$$

$$\Delta P_h = 2.880856\,psi$$

$$\Delta P_h = 2.88\,psi$$

- check

Revit $\Rightarrow \Delta P_r = 3.00\,psi$

- percent ~~Error~~ Difference

$$\frac{\Delta P_r - \Delta P_h}{\Delta P_r} = \frac{\text{difference b/w revit \& hand}}{\text{revit}}$$

$$= \frac{3.00 - 2.88}{3.00}$$

$$= \frac{0.12}{3.00}$$

$$= \boxed{4\ \%\ \text{error}}$$

- Might be Different B/C Revit Might take into account the fact that the flow isn't fully developed
- Entry issues

## Fire Protection Prescriptive Pipe Sizing Calculation – First Iteration Design

Datum / Date:

Perscriptive Pipe Sizing

supplied equation: $P_t = P_{sup} - PL_{svc} - PL_m - PL_d - PL_e - P_{sp}$

$P_t$: friction loss pressure offset

$P_{sup}$: pressure available from water supply source

$PL_{svc}$: pressure loss in water service pipe

$PL_m$: pressure loss in water meter

$PL_d$: pressure loss in devices other than the water meter

$PL_e$: pressure loss with changes in elevation

$P_{sp}$: maximum pressure required by a sprinkler

Find $P_t$ and then determine maximum pipe run from NFPA 13D Tables 10.4.9.2 (h)

$P_{sup} = 50$ psi (standard domestic water supply)

$PL_{svc} = 4.2$ psi from Table 10.4.9.2(a), 1 in Water Service line, 14 gpm
assumed to be gpm at water line for two sprinklers

$PL_m = 2$ psi from Table 10.4.3 (a), 1 in meter with flow < 18 gpm

$PL_e = 4.4$ psi from Table 10.4.9.2(b) for 10 ft in elevation

$PL_{sp} = 7$ psi from Viking VK476 data sheet at 13 gpm flow

$$PL_d = \underbrace{2\text{ psi}}_{1''\text{ tee-branch}} + \underbrace{3(0.5\text{ psi})}_{1''\text{ tee-straight}} + \underbrace{2(1\text{ psi})}_{1''\text{ Elbow}} + \underbrace{9\text{ psi}}_{\frac{1}{2}''\text{ elbow}} + \underbrace{2\text{ psi}}_{\frac{1}{2}''\text{ connector}} + \underbrace{0.5\text{ psi}}_{\frac{3}{4}''\text{ connector}}$$

$PL_d = 17$ psi

Plug into supplied equation and solve for $P_t$

$P_t = 50\text{psi} - 4.2\text{ psi} - 2\text{ psi} - 4.4\text{ psi} - 7\text{ psi} - 17\text{ psi}$

$P_t = 15.4$ psi

From Table 10.4.9.2(h), the allowable length of pipe from service valve to furthest sprinkler for 1" PEX Piping is:

$\boxed{128\text{ ft}}$

The actual length from service valve to the furthest sprinkler is 57 feet so the line size is adequate.

## Fire Protection Hazen-Williams Pressure Loss Calculation – First Iteration Design

Datum / Date:

# Fire Sprinkler Pressure Loss

Hazen-Williams equation

$$P = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$$

Q: flow rate in gpm
C: Hazen-Williams constant
d: pipe diameter in inches
P: pressure loss from friction in $\frac{psi}{ft}$

For PEX : $C \simeq 140$

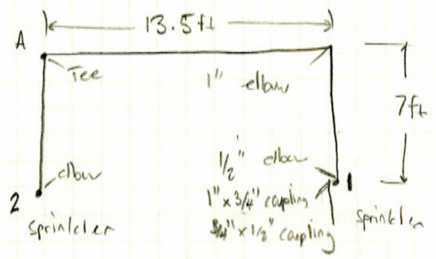
Pipe will either be 3/4" or 1", start with 3/4" to see if the can get away with it.

$d = \frac{3}{4}$ in

$Q = 13$ gpm

$$P = \frac{4.52\,(13\,gpm)^{1.85}}{(140)^{1.85}(0.75\,in)^{4.87}}$$

$P = 0.226 \; \frac{psi}{ft}$




$P_{loss} = (0.226 \frac{psi}{ft})(20.5\,ft)$

$P_{loss} = 4.633$ psi up to point A from friction

Note all fitting pressure losses are from Sharkbite documentation

$P_{loss_{1\to A}} = 4.633\,psi + 2(2.2\,psi) + 0.5$

pressure loss from elbows    p. loss from tee

$P_{loss_{1\to A}} = 12.533$ psi - total pressure loss up to point A from point 1

$P_A = 7_{psi} + 12.533$ psi

$P_A = 19.533$ psi    pressure at point A for $P_1 = 7$ psi

$P_2 = 19.533 - 2.5\,psi - 0.5\,psi$

$P_2 = 16.033$

$Q_2 = K\sqrt{P_2}$    $K = 4.9$ from Viking VK476 data sheet

$Q_2 = 4.9\sqrt{16.033}$

$Q_2 = 19.62$ gpm

41

Datum / Date:

iterate $P_2$ calculation using assumed 19.5 gpm flow

$P_2 = 19.533 - 6\ psi - 1.2\ psi$

$P_2 = 12.333\ psi$

$Q_2 = 4.9\sqrt{12.333\ psi}$

$Q_2 = 17.21\ gpm$

iterate once more, select 18 gpm flow rate

$P_2 = 19.533 - 4.6\ psi - 1\ psi$

$P_2 = 13.933\ psi$

$Q_2 = 4.9\sqrt{13.933\ psi}$

$Q_2 = 18.32\ gpm$

so, $Q_2 \simeq 18.2$ at sprinkler 2. Once again apply Hazen-Williams equation for the rest of the line

$$p = \frac{4.52\,(18.2\ gpm)^{1.85}}{(140)^{1.85}\,(0.75\ in)^{4.87}}$$

$p = 0.421\ \frac{psi}{ft}$

$P_{loss_{2\text{-}endf}} = \left(0.421\ \frac{psi}{ft}\right)(44\ ft)$

$P_{loss_{2\text{-}endf}} = 18.52\ psi$

$P_{loss_{2\text{-}end}} = 18.52\ psi + 3(1.1\ psi) + 5\ psi$

elbow @ 18.2 gpm — Tee @ ~18.5 gpm

$P_{loss_{2\text{-}end}} = 2\ psi$

Tee @ ~18.5 gpm

$P_{loss_{total}} = 24.21\ psi + 12.533\ psi + 4.4\ psi + 5\ psi + 7\ psi$ — sprinkler

(elevation loss, determined from Table 10.4.9.2(b) of NFPA 13D

Datum / Date:

$P_{loss} = 53.143$ psi

Since the supply pressure is 50 psi a pressure loss of 53 psi means that the 3/4" pipe size will not work for the sprinkler system. Now the calculations will be re-run using a 1" pipe

$$p = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$$

$$p = \frac{4.52\,(13\text{ gpm})^{1.85}}{(140)^{1.85}\,(1\text{ in})^{4.87}}$$

$$p = 0.0557\ \frac{\text{psi}}{\text{ft}}$$

$$P_{Aloss_{major}} = \left(0.0557\ \frac{\text{psi}}{\text{ft}}\right)(20.5\text{ ft})$$

$$P_{Aloss_{major}} = 1.142\text{ psi}$$

add minor losses from fittings estimated from sharkbite engineering documentation pressure loss vs. flow chart for 1" fittings.

$$P_{loss1-2A} = 1.142\text{ psi} + \underbrace{1\text{ psi}}_{1''\text{ elbow}} + \underbrace{0.5\text{ psi}}_{1''\text{ tee-straight}} + \underbrace{9\text{ psi}}_{1/2''\text{ elbow}} + \underbrace{2\text{ psi}}_{1/2''\text{ connector}} + \underbrace{0.5\text{ psi}}_{3/4''\text{ connector}}$$

$$P_{loss1-2A} = 14.142\text{ psi}$$

$$Q_A = 4.9\sqrt{\underbrace{7}_{\text{minor losses from elbow and Tee fitting}} + 14.142\text{ psi}}$$

$$Q_A = 22.53\text{ gpm}$$

$$p = \frac{4.52\,(22.53\text{ gpm})^{1.85}}{(140)^{1.85}\,(1\text{ in})^{4.87}}$$

$$p = 0.154\ \frac{\text{psi}}{\text{ft}}$$

$$P_{loss} = \left(0.154\ \frac{\text{psi}}{\text{ft}}\right)(44\text{ ft})$$

$$P_{loss_{2-end}} = 6.776\text{ psi}$$

43

Datum / Date:

$$P_{loss} = 14.142\ psi + 6.776\ psi + \underbrace{4.4\ psi}_{\text{elevation loss}} + \underbrace{2(7\ psi)}_{\text{sprinklers}} + \underbrace{2(2\ psi)}_{\text{1'' elbows}} + \underbrace{2(0.1\ psi)}_{\text{1'' tee-straight}}$$

$$P_{loss} = 43.518\ psi$$

$P_{loss} < P_{supply}$ so sprinklers will be supplied with adequate pressure.

## NFPA 13D Calculation Worksheet (for 10.4.9.2)

### Preliminary Information

Sprinkler model (SIN #): TY2384

Listed area: 16×16 Listed flow: 20 gpm Listed pressure: 22.7 psi

Total demand flow: 40 gpm (twice listed flow)

### Calculation

Step 1 – Water pressure in street or from pump at demand flow: 50 psi

do not include for competition layout

Step 2 – Pressure loss in water service pipe [Table 10.4.9.2(a)]: 9.1 psi [1¼" line]

Step 3 – Pressure loss from meter [Table 10.4.3(a)]: 4 psi [1.5 in]

Step 4 – Pressure loss from pressure reducing valves, backflow preventers, water softeners, and water filters (obtain from manufacturer): 5.0 psi

Step 5 – Pressure loss due to elevation [use elevation change in feet between the place where pressure in Step 1 was measured and the highest sprinkler in the home with Table ~~8.4.10.1(e)~~ 10.4.9.2(b)]: 4.4 psi [10 ft]

Step 6 – Required pressure at remote sprinkler (see preliminary data): 22.7 psi

Step 7 – Calculate available pressure by subtracting the pressure in Steps ~~2, 3~~, 4, 5, and 6 from the pressure in Step 1: 17.9

per assumptions

Step 8 – Check which table you are using for the pipe in the system:

- ☐ Table 8.4.10.1(d) for ¾-in. Type M copper tube
- ☐ Table 8.4.10.1(e) for 1-in. Type M copper tube
- ☐ Table 8.4.10.1(f) for ¾-in. CPVC pipe
- ☑ Table 8.4.10.1(g) for 1-in. CPVC pipe
- ☐ Table 8.4.10.1(h) for ¾-in. PEX tube
- ☐ Table 8.4.10.1(i) for 1-in. PEX tube

Using table checked above and pressure from Step 7, maximum pipe length: 61 ft

### Summary

Are all sprinklers within length of Step 8? ☑ Yes ☐ No 57 ft actual length

## Fire Protection NFPA 13D Prescriptive Pipe Sizing Calculation – Final Design

### NFPA 13D Calculation Worksheet (for 10.4.9.2)

**Preliminary Information**

Sprinkler model (SIN #): VK457

Listed area: 16’ x 16’   Listed flow: 13 gpm   Listed pressure: 7.0 psi

Total demand flow: 26 gpm (twice listed flow)

**Calculation**

Step 1 – Water pressure in street or from pump at demand flow: 60 psi

Step 2 – Pressure loss in water service pipe (Table 10.4.9.2 (a)): 13.2 psi

*Note that for the competition configuration this pressure loss will not be present

Step 3 – Pressure loss from meter (Table 10.4.3 (a)): 3 psi

*Note that for the competition configuration there in no water meter

Step 4 – Pressure loss from pressure reducing valves, backflow preventers, water softeners, and water filters (obtain from manufacturer): 8 psi

Step 5 – Pressure loss due to elevation [use elevation change in feet between the place where pressure in Step 1 was measured and the highest sprinkler in the home with Table 10.4.9.2 (b): 4.4 psi

Step 6 – Required pressure at remote sprinkler (see preliminary data): 7.0 psi

Step 7 – Calculate available pressure by subtracting the pressure in Steps 2,3,4,5, and 6 from the pressure in Step 1: 24.4 psi

Step 8 – Check which table you are using for the pipe in the system:

☑ Table 8.4.10.1(i) for 1-in. PEX tube

Using table checked above and pressure from step 7, maximum pipe length: 57 ft

**Summary**

Are all sprinklers within length of Step 8? ☑ Yes ☐ No   Actual Furthest Length: 53 ft

For sprinkler design detailed in sheets F-102 and F-501. Note that for competition the water meter and water service pipe pressure losses are not present so for this condition the maximum pipe length will be 95 ft, more than adequate.

## Cold Water Supply Line Sizing Calculation

Hand calcs for line sizing of cold water supply

1) sketch main lines etc.
 – see diagram.

2) table 13

3)

| | 1 | | 2 | |
|---|---|---|---|---|
| | w/ out garden hose | | w/ garden hose. | our unit |
| total | FU | 6.5 | FU | 7.5 |
| | GPM | 7 | GPM | 12 |

$\Rightarrow$ expected 7 GPM (Fig 10) $\Rightarrow$ 12 GPM

4) line length = 41.896 Ft.

5) $\Delta P = (P_s - 0.434H - P_f - P_m)100/L$

- $\Delta P$: avg pressure drop per 100 Ft of equivalent pipe psi
- $P_s$: pressure in street main [50psi]
- $H$: hight of highest fixture above street main [4Ft]
- $P_f$: min pressure req to operate wp fixture [10psi]
- $P_m$: pressure drop through water meter [0]
- $L$: length [41.896Ft]

$$\Delta P = [50psi - 0.434(4ft) - [10psi] - 0]\frac{100}{41.896ft}$$

$$\Delta P = 91.33$$

we can have a maximum of 91.33 psi lost per 100 Ft and still have enough pressure to make it to furthest fixture.

$\therefore$ $\frac{3}{4}$ in works fine for case 1 & case 2.

## Water Hammer Calculation

hand calcs for water hammer

- All PEX pipe used has a pressure rating of 160 psi

$\Delta p_h = \rho c_s V / g_c$ — 32.2 ft/s²

fluid flow vel

pressure rise caused by hammer

62.4

speed of sound in water $c_s = 4720$ fps

$\Delta p_h = 62.4(4720 \text{ fps}) \frac{8.735 \text{ fps}}{32.2 \text{ ft/s}^2}$

$\Delta p_h = 79{,}901.62 \frac{lb}{ft^2}$

$\Delta p_h = 554.87$ psi $\}$ $\frac{3}{4}$ in main

$\Delta p_h = 312.12$ psi $\}$ 1 in main

## Time to Receive Hot Water Calculation

Time to Redieve hot water calculation

$\pi R^2 \leftarrow \frac{\pi D^2}{4} l \leftarrow$ volume of pipe.

Bathroom sink

$l_{3/4}$ pipe = 25.35 ft $\Rightarrow \underbrace{\pi\left(\frac{(.75/12)^2}{4}\right)}_{.023 \frac{gal}{ft}} l = .58305$ gal

$l_{1/2}$ pipe = 5 ft $\Rightarrow \underbrace{\pi\left(\frac{(.5/12)^2}{4}\right)}_{.010 \frac{gal}{ft}} l = .05$ gal

= 0.63305

Shower

$l_{3/4}$ pipe = 28.10 ft $\Rightarrow$

$l_{1/2}$ pipe = 6 ft $\Rightarrow$

laundry

$l_{3/4}$ pipe = 34.47 ft $\Rightarrow$

$l_{1/2}$ pipe = 4 ft $\Rightarrow$

Kitchen sink

$l_{3/4}$ pipe = 47.85 ft $\Rightarrow$

$l_{1/2}$ pipe = 3.5 ft $\Rightarrow$

Dishwasher

$l_{3/4}$ pipe = 47.85 ft $\Rightarrow$

$l_{1/2}$ pipe = 3.5 ft $\Rightarrow$

Note

- length calcs from Revit model
- volume calcs from pipe specs

# Thermal conductivity of pipe.

- Given

$T_H = 120\,°F = 322.039\ K$ } fluid temp

$T_{outside} = \underbrace{59\,°F}_{} = 288.15\ K$ } Ambient temp

Low temp during oct in Irvine
– According to accuweather.com

$D_{pipe} = .75\,in = 0.01905\ m$

$R_{value} = 3.6 = \frac{\Delta t}{\Delta Q}$

$t_{insul} = 0.5\,in = 0.0127\ m$

insul thermal conductivity $= k = \frac{t_{insul}}{R} = \frac{.5}{3.6} = 0.1389\ \frac{Btu\ in}{hr\ Ft\ °F}$

$\Rightarrow \left[\frac{W}{m\,°K}\right] = k \cdot .14$

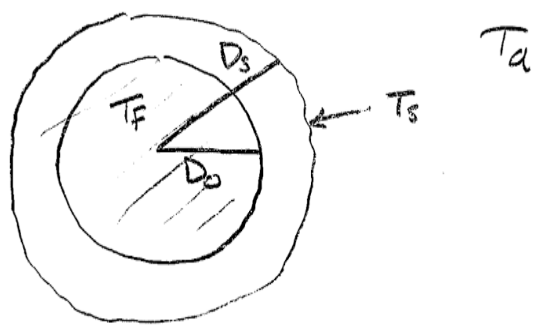
$= \underline{\underline{0.01944}}$

- equations

$$q = \frac{\pi(T_F - T_a)}{\frac{\ln\left(\frac{D_s}{D_o}\right)}{2k} + \frac{1}{h_s D_s}}$$

$$T_s = T_F - q\,\frac{\ln\left(\frac{D_s}{D_o}\right)}{2\pi k}$$

$$h_s = 13.79 + 0.03232\Delta T - 40.86 D_s + 0.0001119\Delta T^2 + 79.3 D_s^2 - 0.01388\Delta T D_s$$




$$q = 4.5033\ W/m$$

## Pipe Sizing Hand Calculation by Velocity

Pipe sizing hand calc. by velocity

$$d = \sqrt{\frac{Q_w}{3600v} \frac{4}{\pi}} \qquad \Delta P = \frac{\frac{1}{144} \mu \cdot l V^2 \rho}{2d/156}$$

$$V = \frac{0.134\, Q_w}{3600\pi \left(\frac{d}{24}\right)^2}$$ ← gal/hr

inner dia [in]

$$= \frac{0.134\,(720)}{3600\pi \left(\frac{3/4}{24}\right)^2}$$

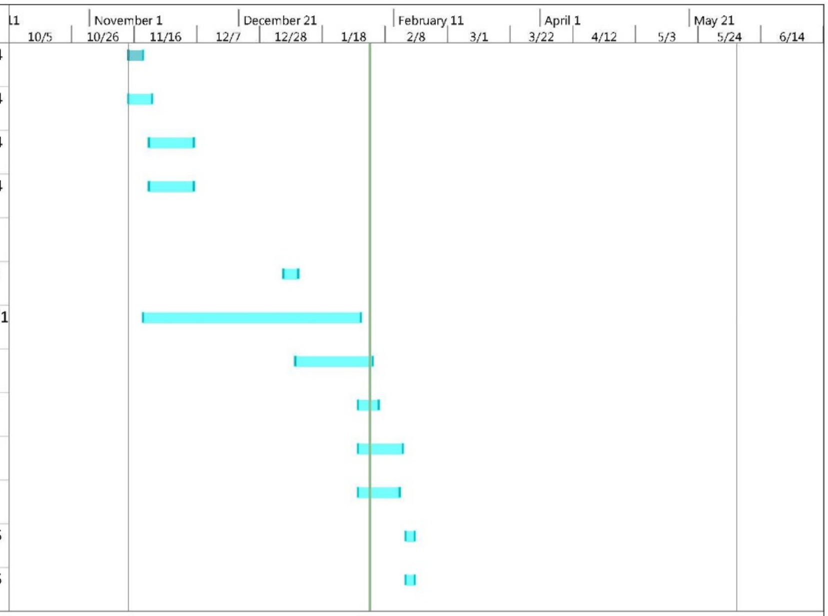
$$V = 8.735 \text{ fps.}$$

$$= \frac{0.134\,(720)}{3600\pi \left(\frac{1}{24}\right)^2}$$

$$= 4.914 \text{ fps}$$

# APPENDIX F – Gantt Chart

| ID | Task Name | Start |
|---|---|---|
| 1 | Preliminary Design Report | Fri 11/14/14 |
| 2 | Preliminary Design Review | Fri 11/14/14 |
| 3 | Fire Sprinkler System | Fri 11/21/14 |
| 4 | Gray and Black Return Design | Fri 11/21/14 |
| 5 | Minimum Pressure Calculations | Fri 12/5/14 |
| 6 | Sprinkler Coverage Simulation | Mon 1/5/15 |
| 7 | Detailed Analysis | Wed 11/19/1 |
| 8 | Final Design Report | Fri 1/9/15 |
| 9 | Final Design Review | Fri 1/30/15 |
| 10 | Order Materials | Fri 1/30/15 |
| 11 | 95% Construction Documents | Fri 1/30/15 |
| 12 | Supply Pump Test | Sun 2/15/15 |
| 13 | Waste Pump Test | Sun 2/15/15 |

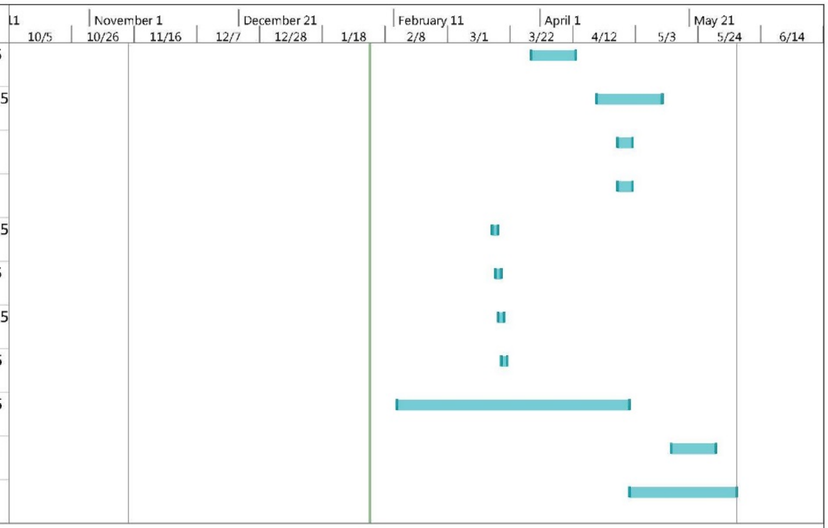



Project: GanttChart_Updated.m
Date: Tue 2/3/15

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

Page 1

| ID | Task Name | Start |
|---|---|---|
| 14 | Building subfloor system | Sun 3/29/15 |
| 15 | Fire Sprinklers | Mon 4/20/15 |
| 16 | Sprinkler Line Flow-Rate Test | Mon 4/27/15 |
| 17 | Sprinkler Line Pressure Test | Mon 4/27/15 |
| 18 | Visual Inspection | Mon 3/16/15 |
| 19 | Leak Test | Tue 3/17/15 |
| 20 | Run Test | Wed 3/18/15 |
| 21 | Appliance Flow-Rate Test | Thu 3/19/15 |
| 22 | Testing | Thu 2/12/15 |
| 23 | Senior Project Expo | Fri 5/15/15 |
| 24 | Final Project Report | Fri 5/1/15 |

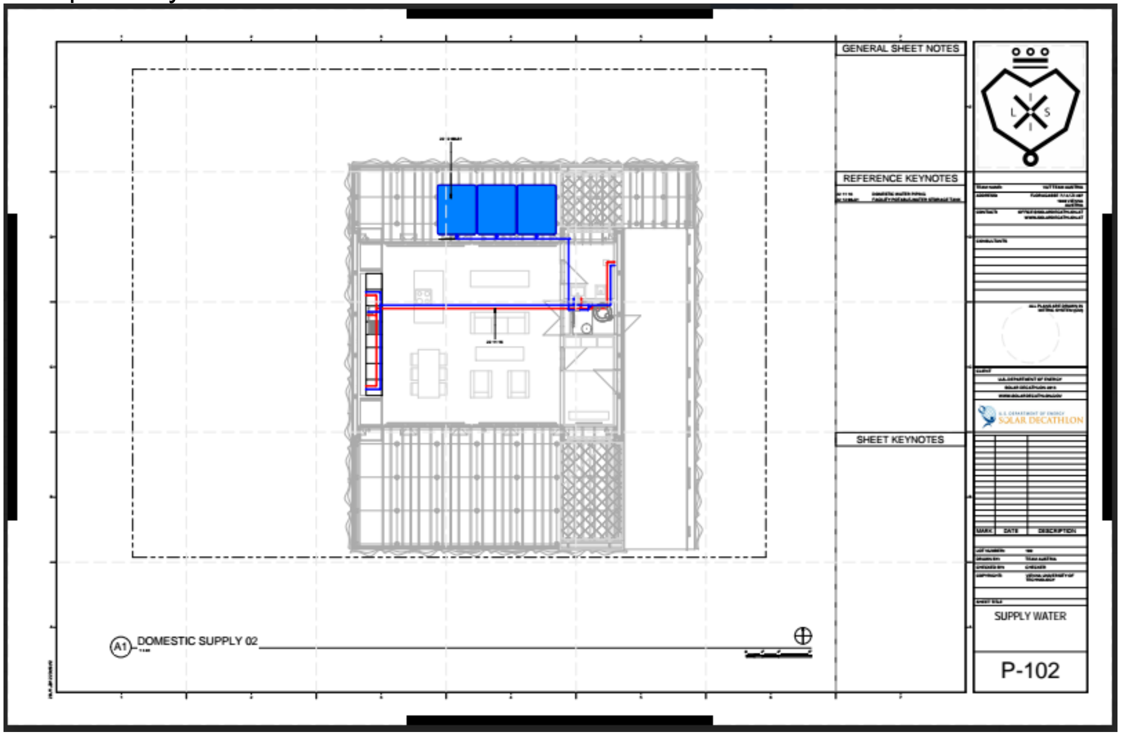



Project: GanttChart_Updated.m
Date: Tue 2/3/15

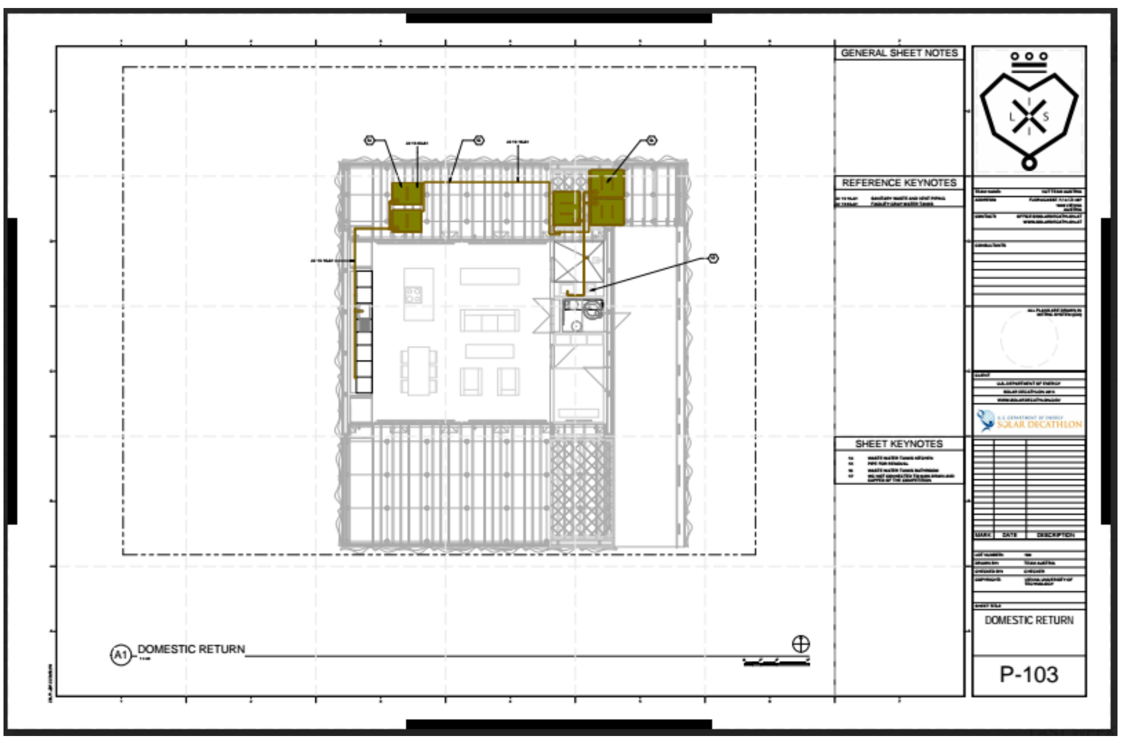
| | | |
|---|---|---|
| Task | Inactive Summary | External Tasks |
| Split | Manual Task | External Milestone |
| Milestone | Duration-only | Deadline |
| Summary | Manual Summary Rollup | Progress |
| Project Summary | Manual Summary | Manual Progress |
| Inactive Task | Start-only | |
| Inactive Milestone | Finish-only | |

# APPENDIX G – Reference Construction Documents

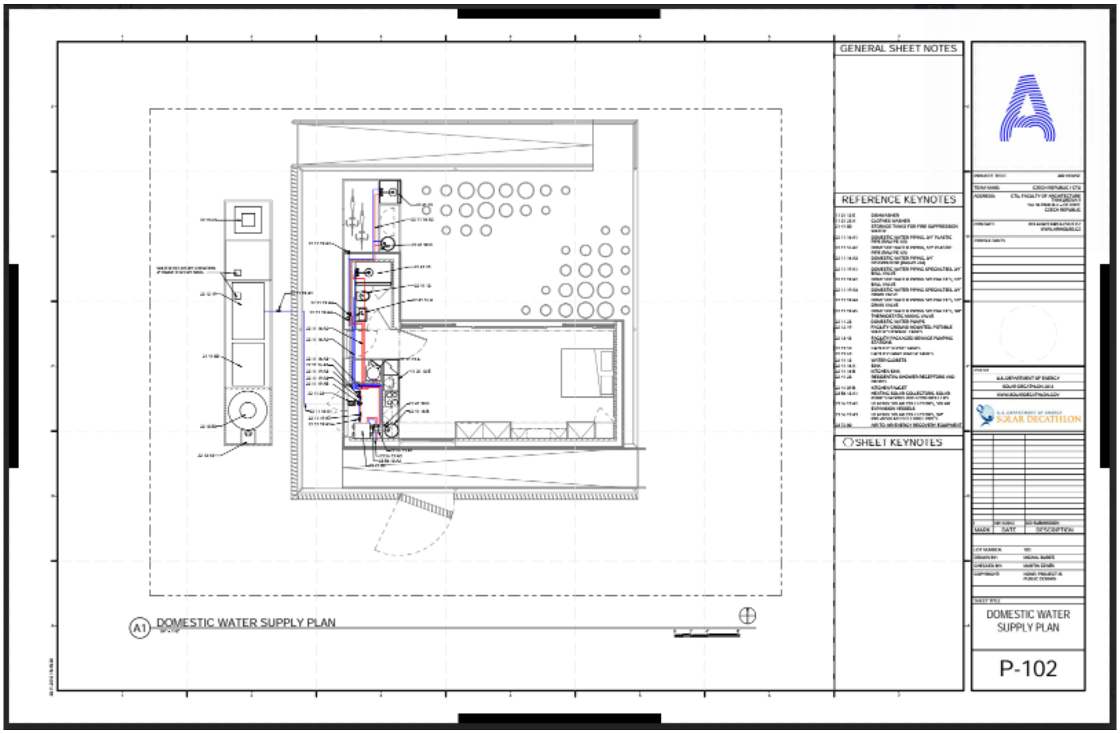
Plumbing plans and diagrams for Team Austria, Czech Technical University, and Team Las Vegas respectively.



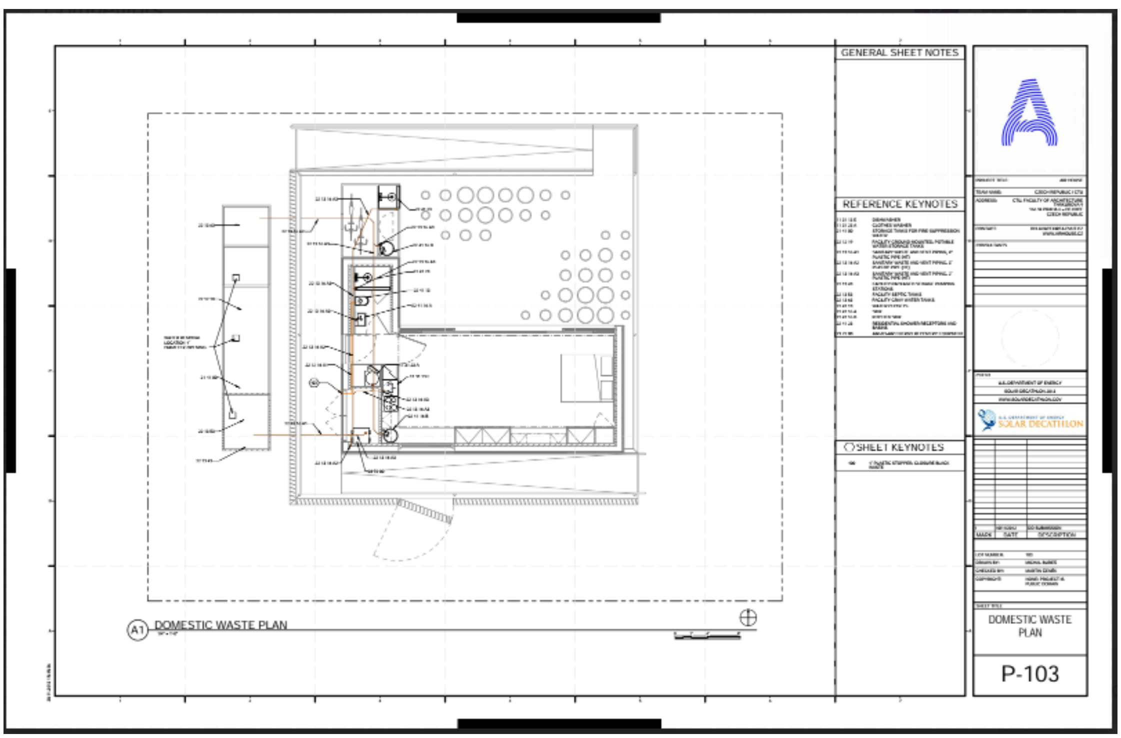

Team Austria (Vienna University of Technology): Domestic Supply Diagram



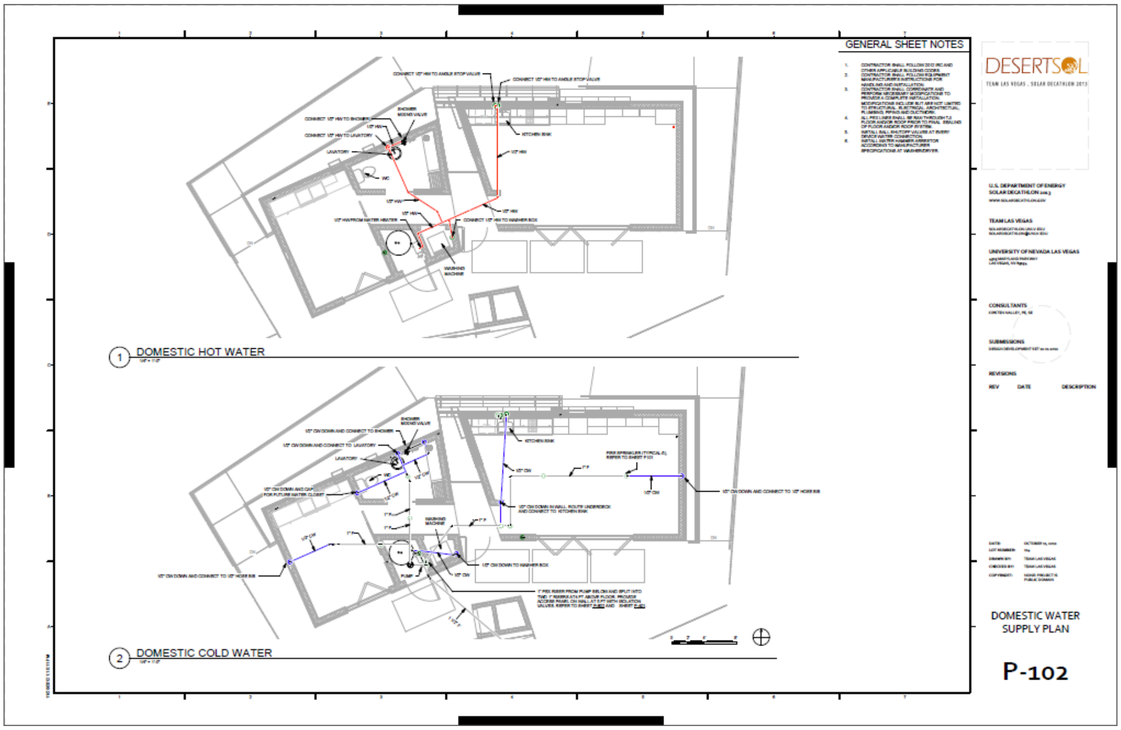

Team Austria (Vienna University of Technology): Domestic Return Diagram



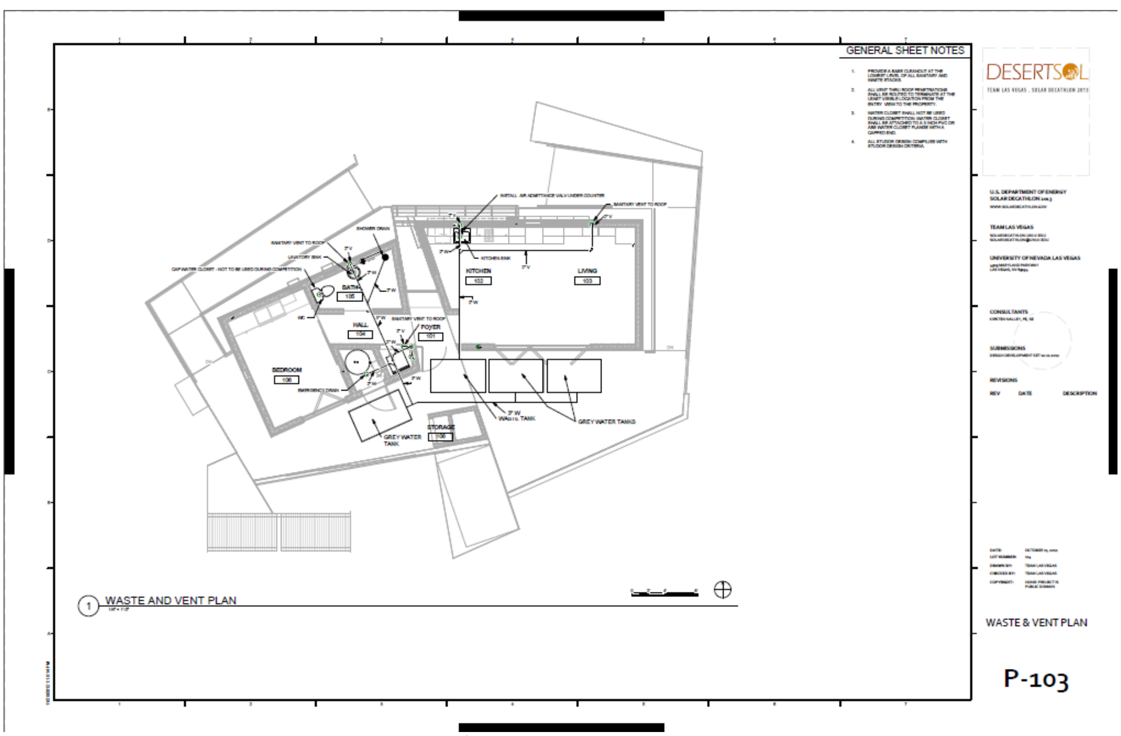

Czech Technical University: Domestic Supply Diagram




Czech Technical University: Domestic Return Diagram




Team Las Vegas (University of Nevada, Las Vegas): Domestic Supply Diagram




Team Las Vegas (University of Nevada, Las Vegas): Domestic Return Diagram

# APPENDIX H – Short Form Specification Sheets

## Fire Suppression System

SECTION 21 00 00
FIRE SUPPRESSION

PART 1 GENERAL

1.1 SUMMARY

A. Provide fire suppression systems.

B. Maintain fire alarm system in operation during construction.

C. Coordinate with Owner's room uses to provide adequate system for all contract areas.

D. Coordinate location of fire protection systems to avoid interference with location of designated lighting fixture locations. Notify Owner prior to construction of conflicts, which cannot be resolved.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.

C. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Provide complete sprinkler coverage per NFPA 13D.

C. Sprinklers utilizing non-metal parts in the sealing portion of the sprinkler are strictly prohibited. Residential concealed sprinklers shall have a ½" NPT, a nominal K Factor of 4.9, and shall be cULus Listed with an operating temperature of 165°F.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fire Suppression Systems:
1. Manufacturers, Piping, Valves and Fittings: Sharkbite, Apollo
2. Manufacturers, Fire Suppression Sprinklers: Viking
3. Manufacturers, Alarms, Meters and Gages: Viking, Everbilt
4. Application: Water-based system.
5. Application: Sprinkler system.
6. Sustainable Design: Optimize energy performance.
7. Sustainable Design: Energy efficient equipment and fixtures.
8. Sustainable Design: Commissioning.
9. Type: Fire-suppression sprinkler systems.

a. Wet-pipe.
   1) Sharkbite Model U880W300 (1” Pex piping)
b. Residential concealed pendent sprinkler head.
   1) Viking SIN VK457 (Base Part Number 14694A-X)
   2) Viking Model 135D4MA/W (White cover plate)

10. Components: Sole Sources
    a. Waterflow alarm.
       1) Viking Model VSRF0100
    b. Ball valves, check valves, and drain valves.
       1) Apollo Model 4ALF-105-A2F (1” Double check valve assembly)
       2) Sharkbite Model 22463LF (1” Ball valve)
       3) Sharkbite Model 22306-0000LF (1” Ball valve with drain)
    c. Piping, fittings, and joints.
       1) Sharkbite Model UC260LFA (1” Elbow)
       2) Sharkbite Model UC374LFA (1” Tee)
       3) Sharkbite Model UCF168U (1” PEX x 1/2” FNPT Elbow)
       4) Sharkbite Model UC140LFA (1” Male thread adapter)
11. Components: Suitable for service.
    a. Pipe hangers and supports.
    b. Meters and gauges

## PART 3 EXECUTION

### 3.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and building code requirements.

B. Fire sprinklers installed in the residential occupancy shall be of a listed residential type. Residential sprinklers shall be installed in conformance with the manufacturer's installation guidelines and the applicable installation standard. Sprinklers shall be of all brass frame construction with a fusible link type operating element and a metal Belleville spring seal, coated on both sides with Teflon film.

C. The concealed pendent sprinkler shall be installed with an adapter and a push-on, thread-off cover assembly, with 1/2" of adjustment, and a 2-3/4” or 3-5/16” diameter.

D. The residential concealed sprinkler will have a white finish cover plate.

E. Wet type fire sprinkler systems shall be equipped with the means to provide an alarm when a waterflow condition exists. This shall be accomplished through the provision of a vane or paddle type waterflow switch affixed to the system riser. Water vane type switch shall be labeled as to the correct orientation of flow when mounted on system piping. If drilling of the system riser is necessary to mount flow switch, the drilled out disc shall be retrieved and attached to the mounting u-bolt of the flow switch. The vane type flow switch shall be equipped with an adjustable delay of audible alarm initiation and be UL Listed and Factory Mutual Approved for its intended use. Adjustment range shall be from 0 to 90 seconds.

F. Using the PEX plastic tubing cutters to cut the tubing to length, making sure that you have a good square cut. Slide the correct size Sharkbite® clamp or crimp ring over the tube approximately 2" past the end of the tubing. Push the tubing onto the Sharkbite® barbed fitting until it touches the fitting shoulder. Position the clamp or crimp ring 1/8"-1/4" from the end of the tube. When making clamp connections, position the open jaws of the Clamp Tool over the raised tabs of the Clamp ring and squeeze. Verify the connection is secure by visually checking the clamp tab. Make Crimp connections by placing the jaws of the Crimp

Tool over the copper crimp ring and squeezing until the jaws close completely. Verify that the connection is secure using the go/no-go gauge.

G. The tube shall be inserted into the SharkBite® push-fit fitting in the first stage through a release collar and then through a stainless steel grab ring. The grab ring has teeth that open out and grip onto the tube. At the second stage the tube shall be pushed through an O-ring protector which aligns the tube. A specially formulated EPDM O-ring shall be compressed between the wall of the fitting and the tube before the end of the tube reaches the tube stop. Only when the tube has passed through the O-ring and reached the tube stop shall a secure joint be created. The fitting shall be a SharkBite® push-fit fitting.

H. System shall be plumbed using SharkBite® Tubing cross-linked polyethylene pipe and all joints shall be made using SharkBite® push-fit fittings or brass Cash Acme barbed fittings with clamps. Tubing and fittings shall be installed as outlined in the SharkBite® PEX installation manual.

I. Center ceiling-mounted elements in center of ceiling tiles as applicable.

J. Clearly label all valves and components.

K. Restore damaged finishes. Test all systems for proper operation in accordance with NFPA 13, 14, and 20. Clean and protect work from damage.

L. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

# Plumbing Piping

SECTION 22 00 00
PLUMBING

PART 4 GENERAL

4.1 SUMMARY

A. Provide plumbing systems.

4.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

4.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Coordinate with Owner's room uses to provide adequate system for all contract areas.

C. Coordinate location of plumbing systems to avoid interference with location of structure and other building systems. Notify Owner prior to construction of conflicts, which cannot be resolved.

PART 5 PRODUCTS

5.1 MATERIALS

A. Plumbing Systems:
1. Manufacturers, Piping, Valves and Fittings: Sharkbite, VPC, JM Eagle
2. Type: Plumbing pipes and pumps.
    a. Sharkbite Model U880B100
    b. Sharkbite Model U870B100
    c. Sharkbite Model U860I100
    d. Sharkbite Model U870R100
    e. Sharkbite Model U860I100
    f. JM Eagle Model 57737
    g. VPC Model 1202
3. Components: Suitable for service.
    a. Piping.

PART 6 EXECUTION

6.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and building code requirements.

B. Support piping properly. Pitch to drain points. Install with pipe expansion loops, mechanical

expansion joints, and anchors.

C. Install shutoff valves on each piece of equipment on both hot and cold water supply.

D. Clearly label all valves and components.

E. Sterilize water distribution system. Flush and test all systems for proper operation. Adjust system to prevent water hammer.

F. Restore damaged finishes. Clean and protect work from damage.

G. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

## Plumbing Insulation

SECTION 22 07 00
PLUMBING INSULATION

PART 7 GENERAL

7.1 SUMMARY

A. Provide insulation for plumbing piping and equipment.

7.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

7.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 8 PRODUCTS

8.1 PRODUCTS

A. Plumbing Insulation:
1. Manufacturers: Armacell, Pratt Retail Specialties
2. Application: Secure insulation and protection of PEX piping.
3. Sustainable Design: Utility efficient equipment and fixtures.
4. Sustainable Design: Commissioning.
5. Insulation Materials: Type suitable for service.
6. Fire Performance: Type suitable for service.
7. Vapor Barrier: Type suitable for service.

PART 9 EXECUTION

9.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and code requirements. Provide proper clearances for servicing.

B. Restore damaged finishes. Clean and protect work from damage.

END OF SECTION

## Plumbing ABS Fixtures

SECTION 22 41 16
PLUMBING FIXTURES

PART 10 GENERAL

10.1 SUMMARY

A. Provide plumbing fixtures and trim.

10.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

10.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Standards:
1. Materials, Products, and Installation: ASME B31.9.
2. Plastic Piping Components: NSF 14.

C. Compliance: ANSI A117.1 and local regulations.

D. Accessibility Requirements: ADAAG and local requirements.

PART 11 PRODUCTS

11.1 MATERIALS

A. Plumbing Fixtures:
1. Manufacturers: Oatey, Nibco
2. Application: Return of water from various appliances within the house in question. Secure and safe connection of sections of ABS piping.
3. Sustainable Design: Utility efficient equipment and fixtures.
4. Sustainable Design: Commissioning.
5. Plumbing Fixtures:
   a. Water Closets: Suitable for service required.
   b. Lavatories: Suitable for service required.
   c. Sinks: Suitable for service required.
   d. Service Sinks: Suitable for service required.
   e. Showers: Enclosure material, receptor material, shower door, fittings.
   f. Toilet Seats: Compatible with water closet.
   g. Flushometers: Water closet and urinal types.
   h. Commercial/Residential Faucets: Cast-brass and cast-brass underbody faucets.
   i. Residential/Light Commercial Faucets: Nonmetal underbody faucets.
   j. Bath/Shower Pressure Balance Faucets: Single-lever type.
   k. Bath/Shower Thermostatic Mixing Valve Faucets: Single-lever type.
   l. Shower Receptors: Terrazzo or molded stone type.

m. Sensor-Operated Faucets and Devices: Automatic operating units.
n. Fittings, Except Faucets: Supplies, stops, traps, wastes, and escutcheons.
o. Supports: ASME A112.6.1M.
p. Hot Water Dispensers: ASSE 1023 instant on-off control.
q. Disposers: Continuous feed type food waste disposer, UL 430.
r. Water Filters: Replaceable cartridge type.

## PART 12 EXECUTION

### 12.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and code requirements. Provide proper clearances for servicing.

B. Support piping properly. Pitch to drain points. Install with pipe expansion loops, mechanical expansion joints, and anchors.

C. Maintain indicated fire ratings of walls, partitions, ceilings and floors at penetrations. Seal with firestopping to maintain fire rating.

D. Clearly label and tag all components.

E. Test and balance all systems for proper operation.

F. Restore damaged finishes. Clean and protect work from damage.

G. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

## Plumbing PEX Fixtures

SECTION 22 41 16
PLUMBING FIXTURES

PART 13 GENERAL

13.1 SUMMARY

A. Provide plumbing fixtures and trim.

13.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

13.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Standards:
1. Materials, Products, and Installation: ASME B31.9.
2. Plastic Piping Components: NSF 14.

C. Compliance: ANSI A117.1 and local regulations.

D. Accessibility Requirements: ADAAG and local requirements.

PART 14 PRODUCTS

14.1 MATERIALS

A. Plumbing Fixtures:
1. Manufacturers: Sharkbite, Homewerks Worldwide
2. Application: Supply of water to various appliances within the house in question. Secure and safe connection of sections of PEX piping.
3. Sustainable Design: Utility efficient equipment and fixtures.
4. Sustainable Design: Commissioning.
5. Plumbing Fixtures:
    a. Water Closets: Suitable for service required.
    b. Lavatories: Suitable for service required.
    c. Sinks: Suitable for service required.
    d. Service Sinks: Suitable for service required.
    e. Showers: Enclosure material, receptor material, shower door, fittings.
    f. Toilet Seats: Compatible with water closet.
    g. Flushometers: Water closet and urinal types.
    h. Commercial/Residential Faucets: Cast-brass and cast-brass underbody faucets.
    i. Residential/Light Commercial Faucets: Nonmetal underbody faucets.
    j. Bath/Shower Pressure Balance Faucets: Single-lever type.
    k. Bath/Shower Thermostatic Mixing Valve Faucets: Single-lever type.
    l. Shower Receptors: Terrazzo or molded stone type.

m. Sensor-Operated Faucets and Devices: Automatic operating units.
n. Fittings, Except Faucets: Supplies, stops, traps, wastes, and escutcheons.
o. Supports: ASME A112.6.1M.
p. Hot Water Dispensers: ASSE 1023 instant on-off control.
q. Disposers: Continuous feed type food waste disposer, UL 430.
r. Water Filters: Replaceable cartridge type.

## PART 15 EXECUTION

### 15.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and code requirements. Provide proper clearances for servicing.

B. Support piping properly. Pitch to drain points. Install with pipe expansion loops, mechanical expansion joints, and anchors.

C. Maintain indicated fire ratings of walls, partitions, ceilings and floors at penetrations. Seal with firestopping to maintain fire rating.

D. Clearly label and tag all components.

E. Test and balance all systems for proper operation.

F. Restore damaged finishes. Clean and protect work from damage.

G. Instruct Owner's personnel in proper operation of systems.

END OF SECTION