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Final Report

Whitmore Laboratory Renovation

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Whitmore Laboratory Renovation

Project Overview

- Location: University Park, PA 16802
- Original Construction Date: 1953
- Total Floor Area: 94,000 SF
- Number of Stories: 4
- Construction: May 14 – August 16
- Renovation Cost: $24.5 M
- Delivery Method: Design-Bid-Build

Project Team

- Owner: Pennsylvania state University
- Construction Manager: Barton Malow
- Architecture/Engineering: Stantec
- General Contractor: J.C Orr
- Mechanical Contractor: North Central Mechanical
- Electrical Contractor: Westmoreland Electrical

Mechanical System

- 8 AHU (15000CFM Each)
- Connected to Campus Central Chiller
- Heat Exchanger in the Basement
- Heat Recovery System in the Roof
- Fume Hoods in First and Second Floors

Structural System

- Spread Footing Foundation
- Reinforced Concrete Columns in the Basement
- Reinforced Concrete Slab in the First Floor
- Steel Frame in first, Second and Third Floors

Electrical System

- Source is Campus Grid.
- One Transformer (From 1247KV to 480 V)
- Two Electrical Rooms in the Basement
- All Conduits are EMT
- Fume Hoods in First and Second Floors

Courtesy to Stantec

AKNOWLEDGMENTS

INDUSTR AKNOWLEDGMENT

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PACE Industry Members

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EXECUTIVE SUMMARY

This report is an expansion of the investigation done in the Fall semester. It clearly presents the proposed four analyses that suggest solutions for the Whitmore Laboratory Renovation project. All the analyses share the same theme, which is enhancing the facility performance leading to minimal environmental impact. The topics are carefully selected and ensured that they would make a significant improvement in the project and the facility.

Primarily, the first topic studies the feasibility of installing evacuated-tube solar collector system. the system is intended to supplement the domestic water heating system. A complete system design is developed plus providing the structural support and piping details in the breadths. Potential constructability issues are addressed. The detailed cost estimate shows that the system will payback in 32 years, which leads to conclusion of not installing the suggested system because it is too expensive.

Secondly, it is suggested that the copper pipes in the domestic water distribution system are replaced with Aquatherm pipes. To narrow down the scope of the investigation, it encompasses only the domestic cold water piping system. Constructability, cost estimation and comparison are presented to study the feasibility. The result shows that Aquatherm brings several advantages to the project making it a better option over the copper pipe.

Thirdly, a waste management plan was proposed. The plan uses different resources and techniques compared with the existing plan. The reader should clearly understand the procedure from the provided process map that demonstrates the operation steps. As a result, construction waste produced from the project will be efficiently dealt with ensuring it makes the minimum environmental impact.

Last, a construction lean tool known as First Run Studies is discussed expansively. A background research of the lean tools is included along with an analysis of a case study. Then an implementation guide was developed that is tailored for the fume hood installation activity. As the research proves, the labor productivity rate will increase while waste is reduced.

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BUILDING BACKGROUND

Whitmore Laboratory is 88,721 SF building and three stories above grade plus a ground floor. It is occupied by Elberly College of Science in University Park, PA 16802. The building is a mix of teaching and research labs. As the number of students is increasing, the building will be renovated and upgraded to serve 12oo students properly. The project will include upgrade to the mechanical, electrical roofing systems plus replacing the windows and interior doors. Design-Bid-Build delivery method is used in this project. Whitmore Laboratory renovations will be phased into two phases to allow continuous use of the building. Construction started at the end of July 2015 and will finish at the end of July 2016. Project cost is $24.5 M for both phases. Cost breakdown is as following:

a. Demolition – 361,565

b. Abatement – 822,600

c. Masonry Restoration – 370,000

d. Steel – 502,052

e. Roofing – 294,475

f. Windows – 738,759

g. General Trades – 1,851,384

h. Flooring – 311,580

i. Painting – 170,984

j. Lab Casework & Fume Hoods – 2,079,000

k. Lab Equipment – 72,500

l. Fire Protection – 359,040

m. Mechanical & Plumbing – 7,974,500

n. Electrical – 2,050,000

o. Wheelchair Lifts – 118,000

p. Site work – 475,000

q. Self-Perform, Allowances & Buyout Savings – 1,918,055

r. Contingency, Insurance, Staffing & General Conditions, Fee – 4,076,880

There are many trades involved in the project but not listed in table. Main project parties are listed in the table with links to their website.

Table A.1 - Main Project Roles

Role	Firm	Link
Owner	Penn State OPP	http://www.opp.psu.edu/
Construction Manger	Barton Malow	http://www.bartonmalow.com/
A/E	Stantec	http://www.stantec.com/
General Contractor	J.C. Orr	http://jcorrpa.com/
Mechanical	North Central Mechanical	www.northcentralmechanicalservices.com/
Electrical	Westmoreland Electrical	http://www.westmorelandelectric.com/
Site Civil A/E	Keller Engineer	http://www.keller-engineers.com/

ARCHITECTURE

Whitmore Laboratory architecture falls under the Federal Style, which is influenced by the Roman architecture. Fluently, the building displays in its façade a great combination of classical symmetric design and modern materials. Following the classical style, every floor has a base, shaft, and an entablature. Moreover, the proportions of façade, Windows, and doors cooperate to perform an artistic monument that mimics ancient Opera houses and Legislatures. The building stands in the western edge of the university central parking lot as shown below. Regarding the building materials, the building integrates glass, aluminum and steel, which signifies the modern aspects such as factories warehouses and the railroads. Besides, the use of steel helps constructing larger and safer structure.

Figure A.1- An Old View of Whitmore Lab [Stantec]

Whitmore Laboratory complies with these codes:

- 2009 Uniform Construction Code – International construction codes
- 2009 International Existing Building Code
- 2009 International Building Code
- 2009 international Fire Code
- 2009 International Energy Conservation Code
- 2009 International Mechanical Code
- 2009 International Plumbing Code
- 2009 ICC/ANSI 117.1
- 2010 NFPA 72-10-National Fire Alarm Code
- 2008 NFPA 72-11 – National Electrical Code
- ASME A17.1 Elevator Code
- 2012 International Building Code, Chapter 11 - Accessibility

ZONING:

Whitmore laboratory complies with Pennsylvania State University's "University Planned District" that was established to promote the university campuses.

- Maximum Building Height: 90 ft.
- Maximum Allowable Floor Area Ratio: 1.00

- Maximum Allowable Impervious Area: 55%
- Minimum Amount of Open Space Required: 45%

BUILDING ENCLOSURE

Whitmore Laboratory façade design goes back to the mid-1900s where the façade consist of Roman brick wall, rectangular windows and three doors as the main entrance to the building. Fiberglass is used as insulation for the enclosure. Aesthetically, the façade rises three stories above ground and holds 21 modules. The windows on the second and third floor are slightly larger than those in the first floor. First floor windows are 6'-4 ¼" x 4'-0 7/8" where the windows on the second and third floor are 9'-5" x 7'-7 5/8".

Exterior windows are being replaced with double glazed aluminum windows with frame of 3 ¾" deep. They have condensation-Resistance Factor (CRF) of 45 and no water leakage tolerance. In addition, the glazing will be 9.00 mm tinted glass rated for 90 mph wind (figure 2).

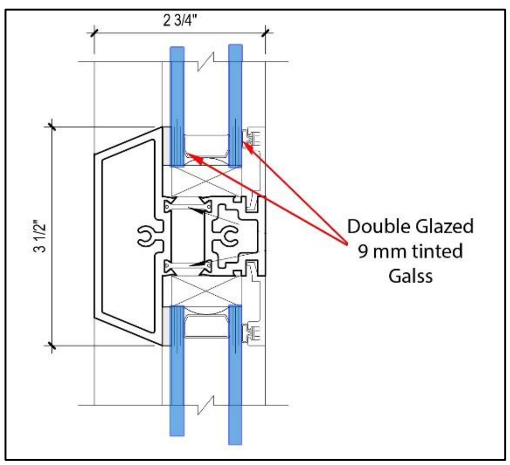

Figure A.2 Double Glazed

Roofing is low-slope roof and comprises several layers as shown on figure 3. Starting from the bottom, the concrete layer provides flat structural support to the layers above. Vapor barrier prevent any moisture from passing to the building. Polisocyanurate tapered insulation provides thermal and acoustical insulation. 1/2"' fiberboard covers the insulation and provides a flat solid surface for the layers above. Base ply with the other plies above it work as a water proof system.

Sustainability Features

Since the building was constructed in the mid-1900s and the current project targets mainly mechanical, electrical and roofing systems, Whitmore Lab will not pursue any LEED Level.

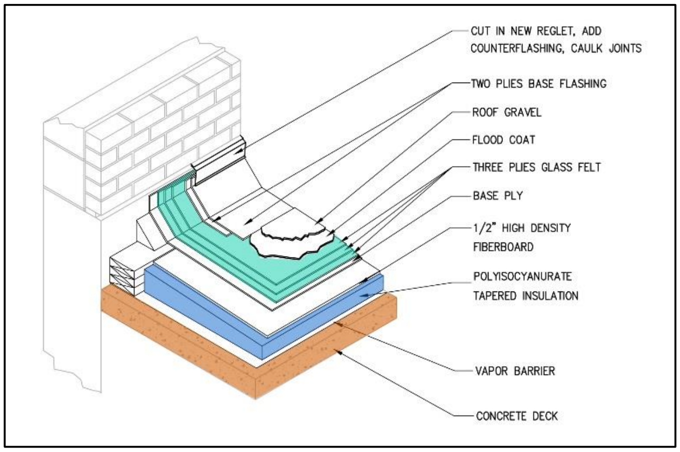

Figure A.3 Roof Layers

However, the roof and equipment upgrade will enhance the power-consumption efficiency. Any use of A/C welders or electrical heater is prohibited during construction to avoid heavy electricity consumption.

PRIMARY ENGINEERING SYSTEMS

CONSTRUCTION

Whitmore Renovation delivery method is Design-Bid-Build. The Design phase started in May 2012 by Stantec and finished in November 2014. Barton Malow (CM) was awarded this project in Fall 2012. Cost estimate was submitted to OPP in July 2013 by Barton Malow. The Construction is phased into two phases; phase one is renovating the west half of the building while phase two is renovating the east half. Construction started from the roof proceeding downwards except for the basement which is renovated first because it houses the mechanical room and the two electrical rooms. A change order was submitted during construction adding the roofing system replacement to the scope. Phase one is expected to finish on December 21, 2015. Phase two starts right away and is expected to finish on August 19, 2016.

Since the renovation is taking place in a three-story building, no cranes are used. However telescopic basket is utilized to reach certain areas where masonry restoration is required. Inside the building, there will be a forklift and hydraulic lift to move and install the fume hoods.

STRUCTURAL SYSTEM

Structural system is designed for a 90 MPH wind, 1.15 seismic importance factor and seismic class B. Type of steel is cold formed metal framing. Foundation is spread footings supporting reinforced concrete columns in the basement. The basement is reinforced concrete columns supporting concrete 12’x12” beams that carry a flat slab. For the first, second and third floor, the structural System is a steel frame with metal decking and concrete slab. Infill steel beams are spaced 10 ft away while the steel beams are spaced in different spans ranging from 12’-14’. The roof is supported by 24” steel joist spanning 42’.

MECHANICAL SYSTEM

The building is air conditioned by 8 Air Handler Unites each has capacity of 15000 CFM with a cooling tower. Mechanical equipment are located in the third floor and to be removed in this project. The new mechanical room is in the basement. The new AHUs will be tied to the campus central chiller that operates at 42 F during the summer and 48 F during the winter. A heat exchanger will be installed in the basement that transfers heat between the campus loop and the building loop. Fume hoods are expected to have a significant effect in the air balance, and HVAC system may be adjusted after installing to ensure minimal air imbalance. In the labs, supply air is 100% outside air. Exhausted air from the fume hoods and the HVAC system will pass through a heat recovery system in the roof to minimize energy consumption. Hallways are always kept wit 10% higher pressure to insure the air moves into the labs but not the opposite.

LIGHTING/ELECTRICAL SYSTEM

The building is fully fed from campus grid and power is transformed from 1247 KV to 480 V by one transformer located outside the building. The main switchgear will be replaced to satisfy the new building loads. All the conduits will be replaced with new EMT and flexible metal. Two electrical rooms are located in the basement and conduits branching out through building in EMT conduits. All conduits run in the plenum.

All light fixture are recessed troffer LED except for the few existing fixtures. Efficacy of the light fixtures ranges from 91-81 lumen/W. Light control is dim for all rooms except the storage and the mechanical room.

ADDITIONAL ENGINEERING AND ENGINEERING SUPPORT SYSTEMS

FIRE PROTECTION

Fire protection system is automatic wet-pipe sprinklers and standpipe. The system is fed from a 6” pipe coming from Muller building. All pipes are installed with seismic resistant to avoid any structural load being transferred to the pipes. Sprinkler heads are selected based on the room use and layout; and there are different types of sprinkler heads in the building: FlexHead, Concealed pendant, Horizontal sidewall, and Dry sidewall. In addition, fire extinguishers will be placed and labeled in cabinets in different locations in the building. Doors will be protected by powder paint with two coats. Existing beams will be cleaned and painted in areas where fire protection has vanished.

TRANSPORTATION

Whitmore Laboratory has an entrance in all four sides of the building. The main entrance is located in the west side. Two stairs wells in the building, one in the north side and the other in the south side. One elevator located towards the south side conveys to four floors. The building also has a wheelchair lift in the first floor that transports to and from the elevated floor in the first floor.

TELECOMMUNICATION

Whitmore Laboratory is covered by Penn State wireless network (psu). Offices in the third floor are provided with telephones for the department faculty and staff.

LAB CASEWORK AND FUME HOODS

Coordination must be established with the mechanical, electrical and plumbing subcontractors, before installing the casework or fume hoods. Pipe unistruts are installed before screwing the racks of the casework on the floor.

Fume hoods will be assembled in the factory to the greatest possible extents but not greater than 35” x 79” to fit into a door opening. All accessories associated with the fume hood are pre-mounted in factory. Other services such as: wiring, plumbing and in-fume ducting are completed in the shop prior to delivery. All fume hoods are fed by a #12 AWG 3-wire, 20-amp, 120V and connected to junction box in the plenum just to the right of each fume hood.

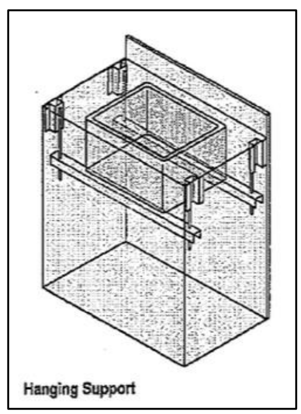

Figure A.3- Aluminum Channel supporting the Sink [CD]

The racks of the casework provide the structural support to the casework. First, the aluminum racks are screwed to the floor and then cabinets and drawers are fitted in and secured in place. Next, the counter tops are placed and screwed from below to be attached to the racks. After that, the sinks are installed and supported by a hanging aluminum channel (figure 5). When all the parts of the casework are fixed, the services (power, plumbing and ducting) are connected to the building services. Besides, wall mounted cabinets are above the countertop and to the defined height. Finally, Epoxy is applied to the specified areas and left to dry.

ANALYSIS I: INSTALLING EVACUATED-TUBE SOLAR COLLECTOR

ANALYSIS SUMMARY

An average multipurpose lab in Penn State consumes 198.44 kBTU/SQFT[1]. That is about double what one square foot consumes in a classroom building. In attempt to reduce the high energy demand in the Whitmore Laboratory, this analysis studies a potential renewable resource to offset some of the energy demand. Theoretically, the building can incorporate wind turbines, geothermal wells or a solar system. However, wind turbines are not suitable in an educational zone basically because they produce loud noise. Similarly, geothermal does not work the best for this geographical area as the lower layers of the soil are porous and do not provide sufficient contact area. The last option is installing a solar system, which is investigated in this report.

Photovoltaic array, flat solar collector panels or evacuated-tube solar collector (ETC) are the most valid possibilities in this particular project. This has been analyzed thoroughly and it was concluded an evacuated-tube solar collector would be the best option. The study examined the feasibility of integrating an ETC system in the existing domestic water heating system. Therefore, a complete design of the system was completed in this analysis including: system type, area boundaries, rows spacing, tilt angle, orientation and the number of tubes required. In addition, the mechanical breadth explains how this system would be joined with the existing water heating system. Equally, the structural breadth examines the existing roof structural frame from its integrity standpoint. The ETC system factored load summed up to 3.7 psf which can be supported by the existing roof frame and eventually the downstream structural members. Wind and snow loads are considered also in the design and accounted for.

As a result, the system will cover 50% of the roof area bearing in mind that includes the 3 feet spacing between rows. The actual area covered by the tubes is 23.5% of the roof. That is expected to produce on annual average of 1342 MBTU and will cost $384,500. It was concluded the system is not feasible since it has a payback period of 32 years.

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[1] Mike Prinkey, Senior Energy Program Engineer at OPP

PROBLEM IDENTIFICATION

The HVAC system in the building is required by code to supply 100% fresh air since it is serving a laboratory building. The building having 117 fume hoods with face velocity of 75 exhausts a tremendous amount of air. That air is replaced with fresh air from the outside. Heating up that amount of outside air requires a significant amount of energy. Besides, a considerable amount of hot water is used in the labs. The peak use of the building happens during the working hours (8:00 AM - 5:00 PM) when most classes take place.

BACKGROUND RESEARCH

Nowadays, many buildings integrate some type of renewable resources in the HVAC or domestic water systems. For instance: wind turbines, geothermal wells, photovoltaic panels and evacuated-tube solar collector (ETC). Above all, ETC is selected for this project among all others because of the following reasons:

1. ETC performance relies on the intensity of the sunlight rather than the temperature which makes it functional all year long.
2. 1 SQFT of ETC produces energy equivalent to that produced by a 6.25 SQFT of photovoltaic[2].
3. The Payback period for ETC is relatively short compared with other renewable energy systems.
4. Reduces electricity consumption which leads to emission reduction.

Evacuated-tube collector absorbs the sunlight (electromagnetic waves) and convert it thermal energy that can be used to heat the built-environment including: domestic and commercial hot water, space heating, Jacuzzi heating and sometimes used for air conditioning. The most common application is heating the domestic hot water in residential and commercial buildings.

The size of an evacuated tube set varies in dimensions and number of tubes. That being said the specifications of the system varies from manufacturer to other. In this section, we are

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[2] http://www.asse-plumbing.org/chapters/%5CNOH%20SolarWtrHtg%20Pres.pdf

going to discuss the products made by APRICUS due to the quality of the products and the availability of information. Figure 1.2 shows a set of 20 tubes while there are other sized including 10, 22 and 30.

The ETC consists of 4 principal parts:

1. Evacuated Tube (ET)

The evacuated tube is a double glass tube with an evacuated space between the two layers to form insulation against heat loss. The function of the tube to let the energy from the sunlight in and trap inside the tube converting it to a form of thermal energy which then is absorbed

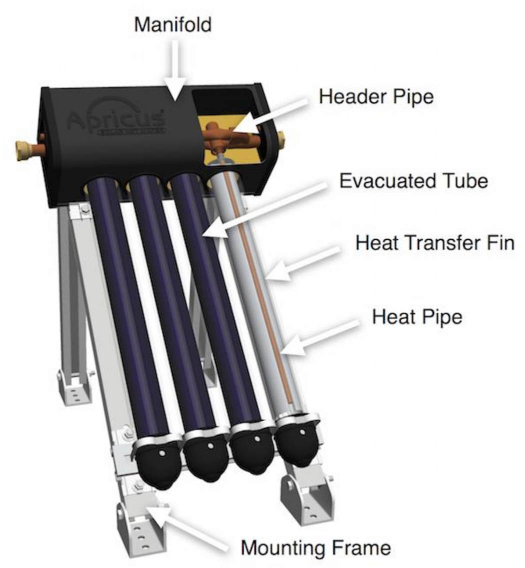


Figure 1.1- Solar collector components [5]

Figure 1.2- 20-tube solar collectors [5]

by the heat pipe.

2. Heat pipe (HP)

Heat pipes are basically copper vacuumed pipes with both ends closed. They provide a medium that transfers heat from the glass evacuated tubes to the manifold. Copper was chosen because of its high thermal conductivity property (385 W/m K).

3. Manifold

Manifold is an insulated housing enclosing the copper header pipes. The header comprises a copper cap that has two pipes countering around it to provide the maximum contact surface while maintain a dry connection. The heat pipes plug in the caps tightly to minimize heat loss between the caps and the heat pipes.

4. Mounting Frame

The structural support for the collectors is provided by the mounting frame which is made of aluminum alloy. It features installation adjustable angle and a range of attachment options.

COLLECTOR OPERATION

ETC operation is very similar to the conventional water heater. The system has two loops: external loop and internal loop. The external loop is a closed cycle that starts from the collector and passes through the solar tank delivering the hot water where the heat is exchanged between the external loop and the water in the tank. The internal loop feeds the solar tank with cold water and draws the hot water to a boost tank that makes up any deficiencies in the solar tank. It is worth mentioning that the boost tank is the same as the regular water heater. In short, the solar collector system is a helper of the actual water heater in the building.

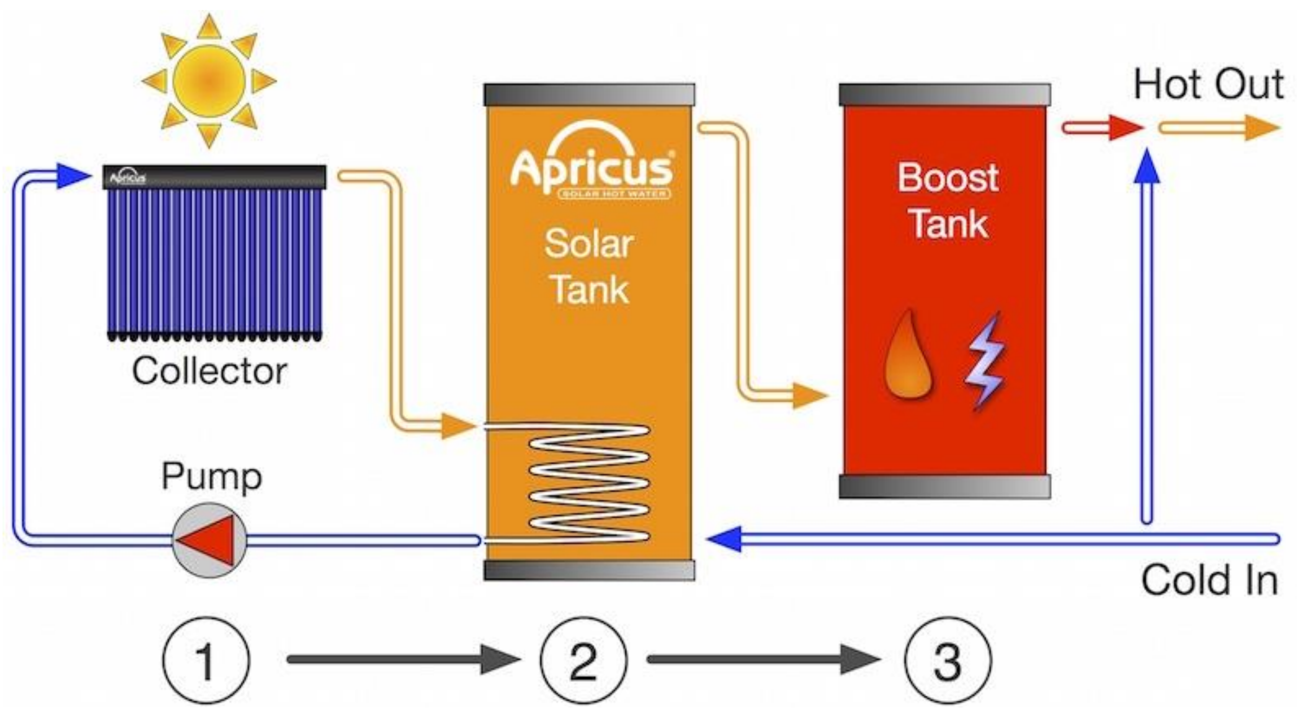


Figure 1.3- ETC schematic diagram [5]

COLLECTOR MOUNTING

The ETC is attached to racks where the racks can be fixed to the building structure in a variety of options including: roof, wall, ground or custom built structure. It is important to consider the type of the building envelope to determine if the screws will affect the waterproofing or vapor retardant layers.

DESIGN ADVANTAGES

1. Evacuated Tube and Heat Pipe

The assembly of the evacuated tube and heat pipe are put together in a patented design that is unique in the market. The conventional evacuated tube assembly heats up the centrally located heat pipe by transferring heat to it rough the transferring fins which meanwhile reflects out the sunlight reducing the efficiency of the system. Unlike the conventional way, Apricus designed the heat pipe to be placed against the inner glass wall to create direct contact. The aluminum transferring fins are another layer positioned against the inner glass wall and secured in place by a spring clips. That is to counter act any metal softening or deformation under high heat conditions.

Apricus brand is selected for this proposal because it have many advantages including:

2. Innovative Design

In the other designs of solar collectors, the heat pipe is centered at the evacuated tube with heat transfer fins conveying the energy from the evacuated glass to the heat pipe. In fact, the heat transfer fins reflects the sunlight out. So, Apricus decides to keep physical contact between the heat pipe and the inner glass wall to ensure the maximum heat absorption. Aluminum heat transfer fins are spread around the evacuated tube from the inside and supported by clips to guarantee tight contact with the glass as the aluminum soften with high heat and over time. Figure 1.4 and figure 1.5 illustrate the components of an Apricus ETC pipe.

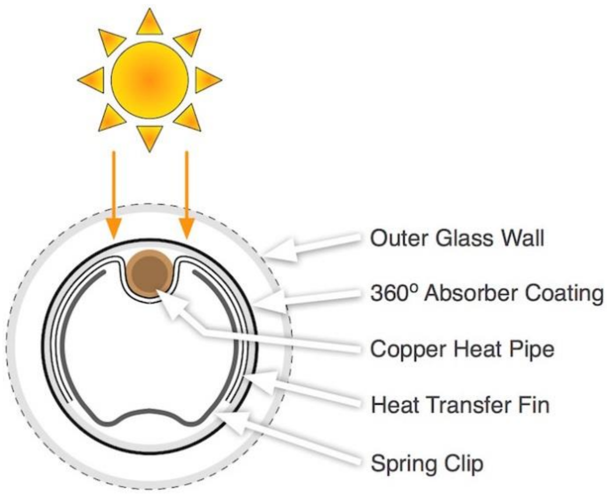
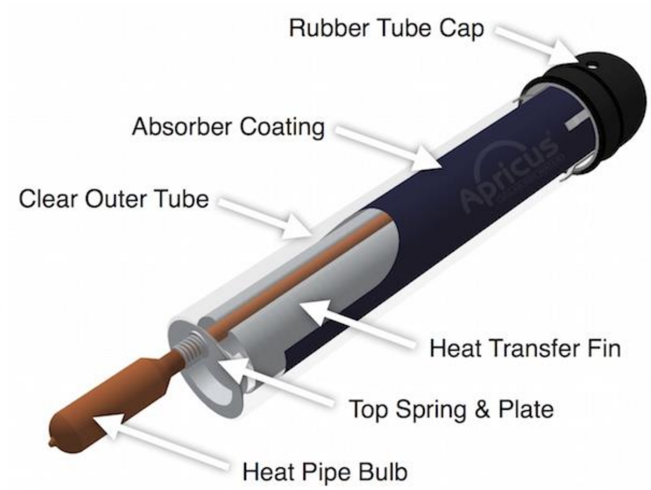


Figure 1.4- ETC cross section [5]



ET and HP componenets [5]

3. Passive Tracking

The round shape of the collectors allow them to passively track the sun without installing mechanical device. Despite the path of the sun during the day, this design optimizes the exposure area from 7am to 5pm. According to Apricus, evacuated-tube solar collectors absorb at least 20% more energy than flat absorber.

In order to increase the efficiency of the ETC system, the collectors should be oriented due south. However, orienting the collectors East or West will reduce the efficiency by 16% only (as tested in Sydney) which is an advantage counted for the system. That offers a great degree of flexibility. Not to mention, the reduction may vary from location to another

4. Headers Design

When designing the header, there are several considerations that should be taken into account. First, the fluctuation in operating temperature from day to night which leads to relatively large copper expansion and contraction. Second, the high operating pressure. Due to the combination of the two factors, great amount of stress will develop in the brazed connection points. To tackle this problem, the header was designed to have dry connections avoiding leakage problems. The copper cap of the heat pipe is surrounded by two copper pipes that contour around the cap. That sums up to 4 brazed connections in total per header as opposed to 60 brazed connections in other designs. Figure 1.6 shows the header design.

5. Manifold Casing

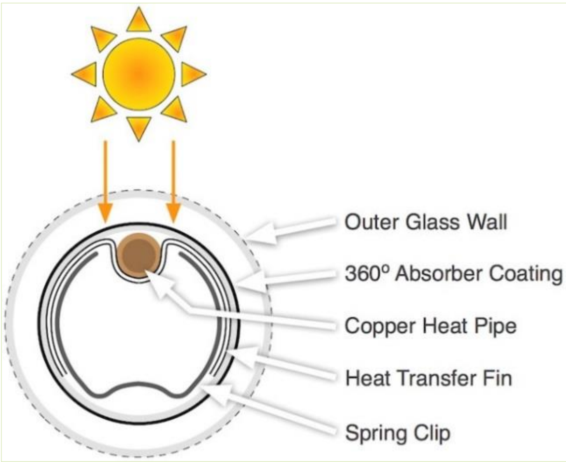


Figure 1.6- Header design [5]

Figure 1.7 Header design [5]

Aluminum is used for the casing to provide strong lightweight housing that protects the header. A layer of matte black (polyvinylidene fluoride) PVDF coating is added for protection against ultra violet waves. For insulation, backed glass wool is installed. Meanwhile, it provides structural shell protecting the header. That also reduces the use of metal making it lightweight as the heaviest manifold, ETC-30, is 20.24 lbs. an installer will appreciate that because it easier and safer to install.

6. Weatherability

The system being installed outdoor, its components have to be robust against extreme weather conditions and UV light. The design of the ETC considered these conditions, hence silicon is used for the caps of the evacuated tubes and rubber is used for header seals and manifold finishing. As opposed to plastic, silicon is heat resistant where it can resist up to 392 F and can withstand damage caused by ultra violet light.

POTENTIAL SOLUTIONS

A typical system of solar water heater incorporates ET Collectors, storage tank, pump, piping, valves and controller. There are many factors need to be considered in order to design the system including; owner purpose, location, climate, limitations and existing water heating system. Based on the analysis of the different attributes, the piping configuration of the system can be determined. The following demonstrates the possible alternatives of ETC system types.

The ETC system design procedure for the Whitmore Laboratory will be presented after listing the different alternatives in order to deliver a clear demonstration to the reader.

ACTIVE VS PASSIVE FLOW

ETC is referred at as either passive or active relying on the way of water flow through the solar collector. Passive system depends on thermosiphoning action which makes water circulate slowly through the collector. Active system integrates a pump to control water circulation. In this proposal, the focus is going to be on the active system because that is the most common practice.

PLUMBING CATEGORIES

The solar thermal system can be plumbed using one of the three categories:

- Direct; the potable water is passed through the collector
- Indirect (aka closed loop); heat transfer liquid is circulated in a close loop.
- Drainback; the heat transfer liquid is drained to special tank when the pump is not operating.

DIRECT SYSTEM

Suitable For

- Moderate climates (lowest temperature does not go below 10°C / 50°F)
- Low water hardness (mineral content) to avoid scale forming in the collector
- Residential and commercial buildings

Design Facts

- The potable water is passed through the collectors where it is heated. Then, the heated water will be used directly in the building applications.
- Freeze protection is activated by keeping the pump running when the outdoor temperature approaches the freezing point.

Any component in the system has contact with the water must be potable water rated.

Table 1.2- Advantages and disadvantages of direct system

Advantages	Disadvantages
• Offers higher efficiency to the system since there is no heat loss in heat transfer liquid. • Allows easier integrating to the existing water heater	• Not recommended in cold areas, however direct flow design can be modified to incorporate freezing protection • Not recommended for areas with hard water because it creates accumulations in the collector

System Diagram Example

The schematic diagram below shows an example of a direct flow system where the solar heated water is fed to the original water heater. The cold water is drawn by a pump from the bottom while hot water is supplied through a connection at ¼ of the tank height. Meanwhile, the water can be boosted in the top half of the tank as desired. Noticeably, an expansion tank is incorporated immediately after the pump to relief the extra pressure if occurs. This configuration is suitable for tight spaces or for large capacity tank.

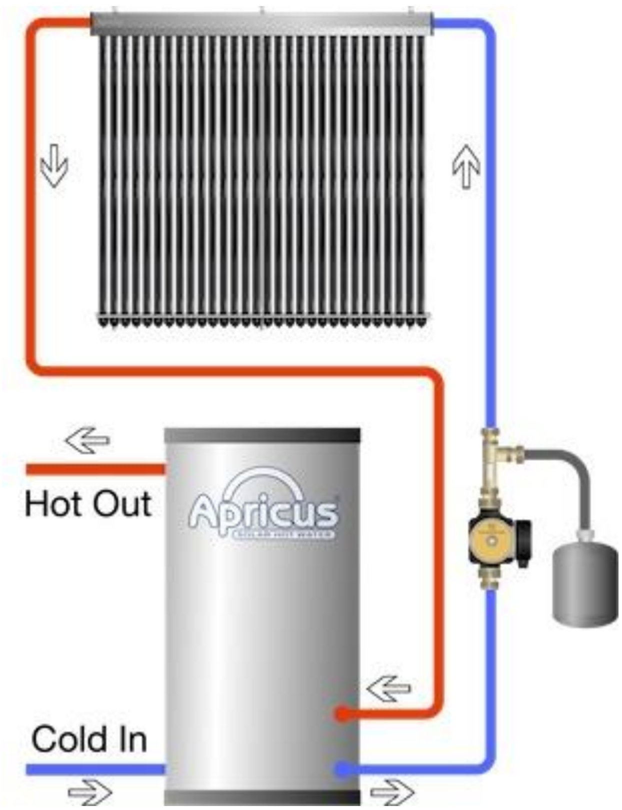


Figure 1.8- Direct flow ETC system [5]

Closed Loop

Suitable For

- Cold climates with lowest temperature below 10°C / 50°F
- Hard water that would eventually develop corrosion of the copper, or accumulation in the collector.
- Residential and commercial buildings

Design Facts

- The heat transfer liquid is circulated in a closed loop, so there it does not have contact with the potable water.
- Plain water can be used or glycol-water mix in cold areas to avoid freezing.
- The heat transfers between the closed loop and the main loop is achieved via an internal coil or a separate heat exchanger.

Table1.3- Advantages and disadvantages of closed-loop system

Advantages	Disadvantages

• Vigorous against freezing temperature
• Avoids the use of hard water
• Applicable for commercial purposes such as spas, pool heating
• Can resist stagnating conditions without heat loss if intended for steamback action
	• Efficiency reduction due to the use of heat transfer fluid
	• Anti-freeze mixture needs to inspected and changed periodically (2-5 years)
	• The system costs more due to the need of:
	    o Heat transfer fluid (usually glycol)
	    o More complex pump station (fill & drain valves, pressure relief valve, air separator etc.)

System Diagram Example

The diagram below illustrates two examples of closed-loop ETC system. The system in the left has an internal coil heat exchanger while the system on the right has an external heat exchanger. An extra pump is required for the second option to circulate the fluid in the downstream loop.

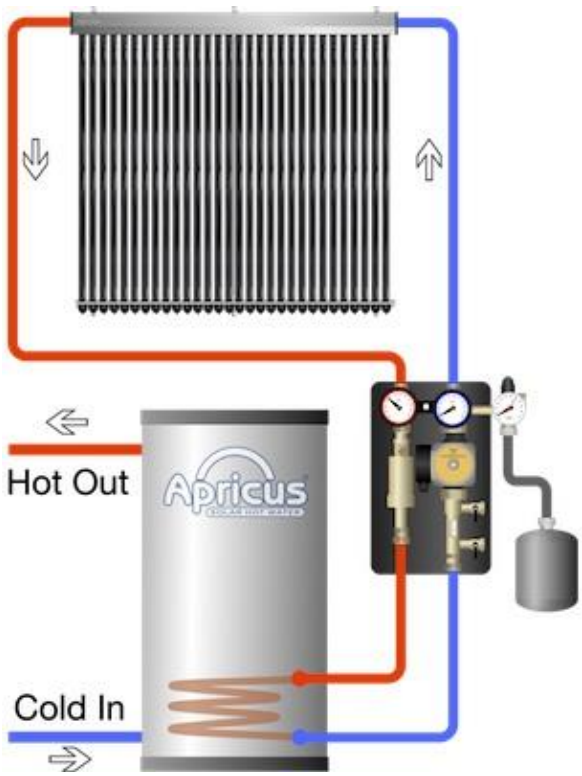


Figure1. 8- Closed-loop ETC system diagram [5]

Normally a coil heat exchanger is utilized in the domestic applications. However an external heat exchanger might be used for the same purpose if the tank is not suitable or does not have access for a coil exchanger. For commercial buildings, an external heat exchanger is selected as it can be designed to fulfill the building requirements. The external heat exchanger needs another pump which adds cost to the system as it is an extra piece and consumes electricity.

Drain back

Suitable For

- Cold climates with lowest temperature below 10°C / 50°F
- Hard water that would eventually develop corrosion of the copper, or accumulation in the collector.
- Applications of heating non-potable water.

- System where overheating becomes an issue
- Residential and commercial buildings

Design Facts

- The heat transfer liquid is circulated in a closed loop, so there it does not have contact with the potable water.
- The potential energy resulted from the height difference between the tank and the collectors need a high head pump to offset that potential energy.
- Above the tank level and below the collector level, a small tank is installed for the drained liquid when the pump is turned off.

Table 1.4- Advantages and disadvantages of drainback system

Advantages	Disadvantages
• Designed against freezing issues all the time • Designed against excessive heat related issues • Avoids the use for glycol-based fluid.	• Efficiency reduction due to the use of heat transfer fluid • The collector must be slightly sloped to facilitate the drainage action, and piping must be straight metal rather than flexible of soft copper. • A higher head pump is required which also consumes more electricity than the direct and indirect system, 2-4 times more.

System Diagram Example

A basic drainback system is illustrated in the diagram below. The configuration and complexity of plumbing is very simple. The heat exchanger can be either internal coil (as shown) or an external exchanger for commercial applications.

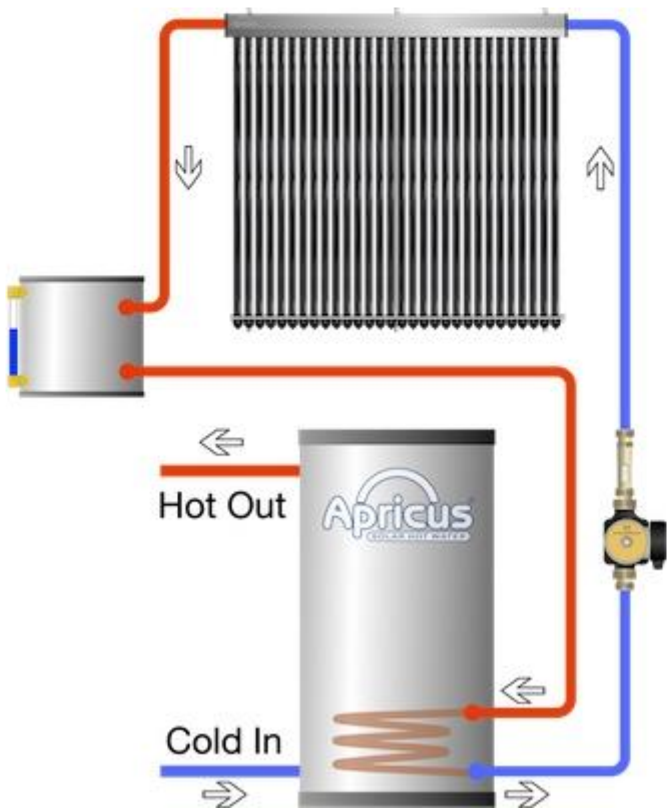


Figure 1.9 Drain-back system [5]

The matrix below rates the systems discussed above according to Apricus scoring. Generally, the simpler systems such as the direct system are more efficient and cheaper as the system does not require complex plumbing equipment and labor.

Table 1.5 - Comparing the available systems

	Direct	Closed with coil	Closed with ext. exchanger	Drain back
Cost	5	2	2	3
Maintenance	5	3	2	4
Installation process	5	3	3	2
Cold climate	2	5	5	5
Hot climate	5	3	3	5
Efficiency	5	4	3	4
Residential project	5	5	3	5
Commercial project	4	3	5	4
Reliability	5	3	3	4
Total Points	**41**	**31**	**29**	**36**

ETC FOR THE WHITMORE LABORATORY

Designing ETC system for the Whitmore Laboratory accounts for the main factors that affect the system performance. Therefore, the following criteria will be considered in the design process:

A. ETC most appropriate type
B. Solar collectors orientation
C. Solar collectors angle
D. Sizing the ETC system
E. Constructability concerns

A. ETC MOST APPROPRIATE SYSTEM

Reviewing the alternative systems presented above, drainback system with an exterior heat exchanger is selected for the following reasons:

- The system provides protection against freezing and overheating. Especially for cold area like State College, the system has to be designed for freezing weather.
- Drainback allows the use of plain water as the heat transfer fluid. That is to maximize fluid heat capacity leading to lower rate of pumping and lower energy consumption.
- The use of plain water as the heat transfer liquid minimize inspection and maintenance, while glycol-water mix needs to be replaced occasionally.

B. COLLECTORS ORIENTATION

As mentioned above the sun zenith angle varies from season to season. The design consider this aspect to determine the spacing between collector panels. The goal is to maximize the number of collector panels in a certain area without creating shade over each other. Therefore,

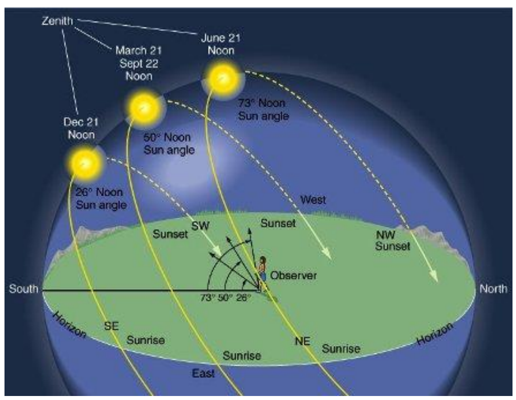


Figure 1.10- Sun angle in 4 seasons, source: http://scienceblogs.com/

the worst case scenario is considered which occures on summer solstice (December 3) when the sun is at its closest angle to the horizon (figure 1.10).

Spacing between panels rows depends on the height of the obstruction in south side because these obstructions create shadow on the collectors compromising the performance. With this in mind, the maximum shading distance will be calculated using an online tool to help finding the necessary variables. National Oceanic & Atmospheric Administration (NOAA) is utilized

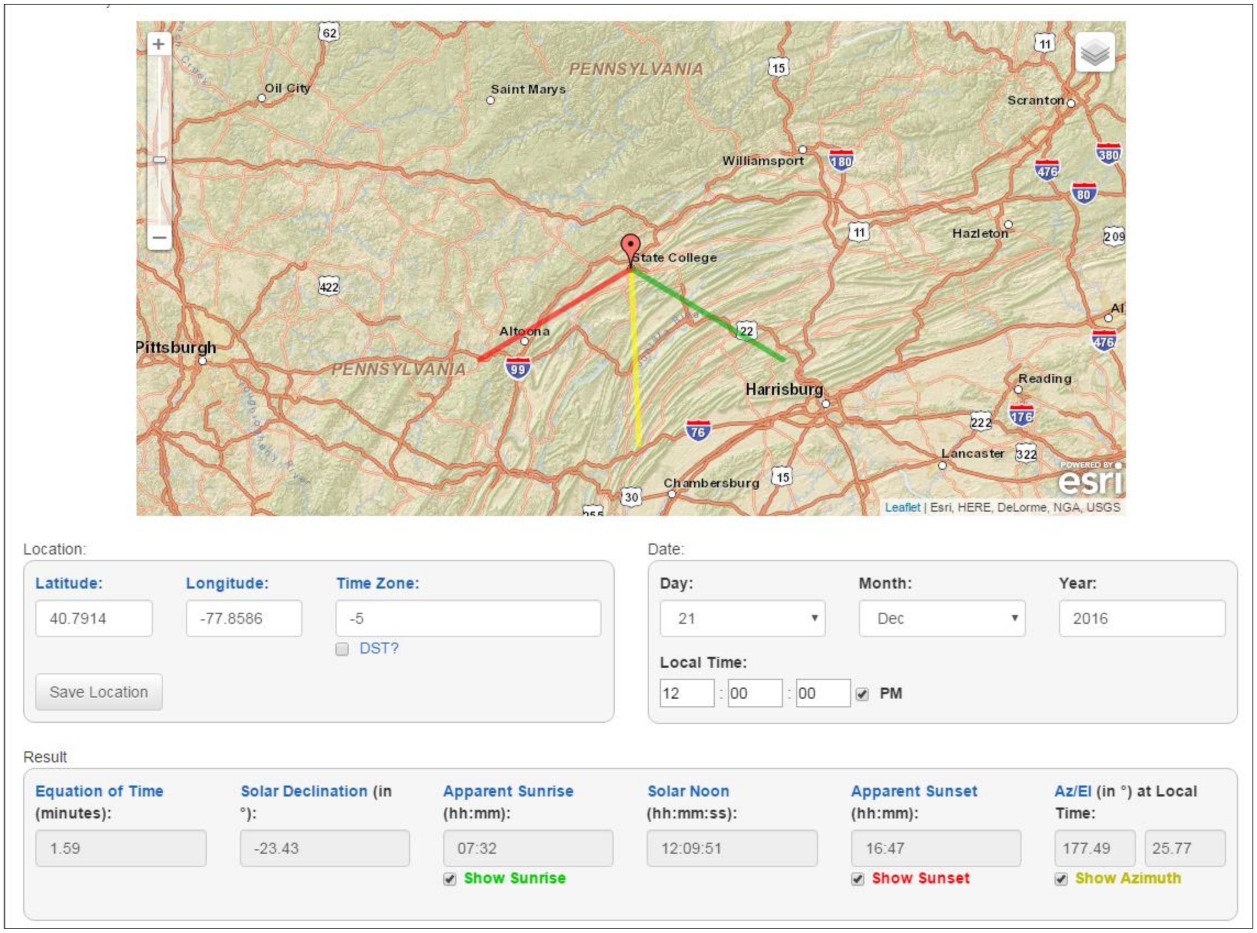


Figure 1.11- NOAA online calculator results [8]

to find the azimuth and altitude of the sun is State College on December 21 at 12:00 PM (figure 1.11).

Consequently the following formula is applied:

$$\acute{D} = \frac{h}{\tan(\alpha)} = \frac{65.4\ in}{\tan(25.77°)} = 135.5\ in$$

And then applying solar azimuth correction using the following formula:

$$D = \acute{D} \times \cos(\varphi - 180°) = 135.5\ in \times \cos(177.49° - 180°) = 135.4\ in$$

Where: $\acute{D}$= Maximum shadow length

D= Minimum array row spacing

α= solar altitude angle

φ= solar azimuth angle (afternoon)

The bottom of the collectors is rubber caps, so it is acceptable to be covered with the shadow. That being said the spacing will be adjusted by 2.4” (approximated). That will result in a distance of (135.4”-2.4”) 133” to be left between rows. The parapet wall height is 3’, so the distance between the parapet and the first row will be 60” as calculated flowing the same procedure above.

C. SOLAR COLLECTOR ANGLE

To optimize the performance of the ETC system the tubes need to be pointed toward the sun to absorb the most solar energy possible. However, the zenith angle of the sun is not consistent all year long; the sun zenith angle is lower in the summer and higher in the winter. There is a 47° difference between summer and winter zeniths leading to more energy during the summer and less during the winter. For the Whitmore Laboratory, the ETC system will be fixed at one angle to avoid cost manually or automatically adjusting the angle. The optimum full year angle can be calculated by the following formula[3]:

$$Optimium\ angle = (latitude \times 0.76) + 3.1°$$

Where State College latitude is 40.7914°

Thus the optimum angle is 34.1° ≅ 34°

Installing the system due south at tilt angle of 34° will reach up to 71% of optimum performance as if the system has an automated tracking device. The sun path during the day is not an issue for the tube solar collectors because the round tubes allow them to absorb sunlight from different angles.

D. SIZING ETC SYSTEM

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[3] http://www.solarpaneltilt.com/

In order to find the number of collectors required, the demand of domestic hot water should be calculated first. In any case, the building demand is too high to be met by the ETC only. In fact, the building has 220 faucets in total including the faucets in the labs, restrooms, kitchen and dishwashers' inlets. Plus, the building will be fully occupied during the day as students, researchers and staff will be utilizing the building services. Therefore, the solar collectors will take up the entire available area in the roof.

Regarding the roof area, the roof gross area is 23,500 SQFT where 11,781 SQFT only is available for the solar collectors because the roof contains 9 exhaust chimneys. Plus, the roof is built in two levels, main middle level and two side lower levels. The plan below shows the roof plan where the color grey indicates not usable area and blue indicates usable area. A 3 ft wide clear area is left around the solar collectors zones to allow access from all sides.

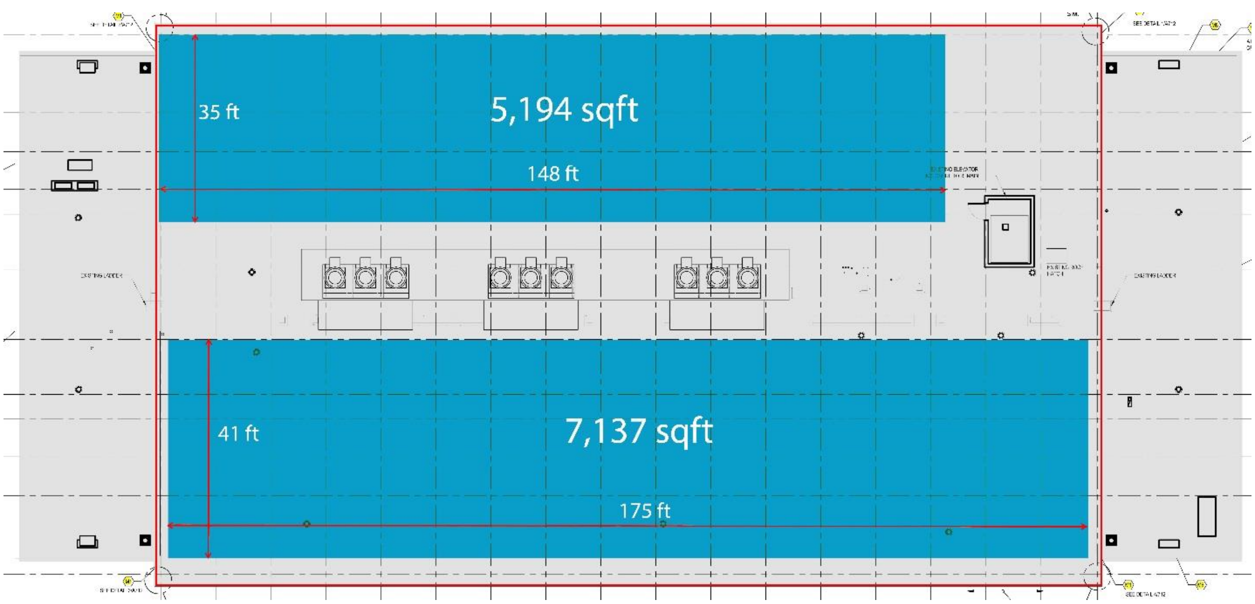

Figure 1.12- Roof available area

CONSTRUCTABILITY CONCERNS

The existing roof is to be replaced with a cold applied modified bitumen roofing supported by metal decks and steel joists. The Structural Breadth will discuss how the ETC system will be supported in details.

Like other construction activities, the installation of ETC is dependent on other prior activities. So the existing schedule needs to be adjusted in order to include the ETC tasks. The solar collectors' support racks will be connected to the roof steel joist by a steel leg. So, after installing the metal decks, the support legs will be welded to the steel joist and through the metal deck as shown in the Structural Breadth. Then, the schedule resumes normally by adding the roofing materials. Once the roofing is complete, the aluminum racks will be fixed, collectors will be attached to the racks and finally piping the system.

For the plumbing work in the mechanical room, the installation of the ETC system piping and equipment will go along with the existing schedule with some extra time.

Another constructability concern is the extra cost associated with the system. Apparently, the ETC system is estimated to cost … which is …% of the total project cost. The owner (Penn State) promotes sustainability in campus by building high performance facilities. So the owner is possibly willing to pay for the ETC system.

The supply and return pipes that are connected to the ETC system will be run long with the existing conduits and pipes to the mechanical room through the penetration well in the roof.

SYSTEM COST

As a construction concern, the cost aspects associated with the ETC system should be calculated in order to see the feasibility of the system. This section provides a detailed estimate of the cost including: materials, labor and equipment. For consistency, Building Construction Cost Data RSMeans 2016 only will be used to find the cost of materials and activities except for the solar collectors as the specified manufacturer cost will be used. In addition, energy saving rate and payback period will be calculated.

Material takeoff is accurately done using different tools including: AutoCAD and Acrobat. The mechanical and structural breadths contain the takeoff details while the aluminum tonnage calculation is as follows:

$$total\ tonnage = length \times weight\ per\ foot$$

$$= 0.55 plf \times 2024 = 1113.2\ lb$$

The table below lists the detailed quantities and costs associated with it.

Implementing a renewable resource by installing 4216 evacuated tubes in the Whitmore Laboratory building will cost $384,506.

Table 1.5 – Detailed cost estimate

Item	Amount	Unit cost	Material ($)	Unit cost2	Labor ($)	Unit cost3	Equipment ($)	Total ($)
1/2" Pipe	1056	3.68	3886.08	5.85	6177.6	0	0	10,063.68
1/2" insulation	1056	0.83	876.48	3.2	3379.2	0	0	4,255.68
Aluminum C-channel 2x1x0.13	1113.2	3.52	3918.464	0.68	756.976	0.35	389.62	5,065.06
J-bolts 5/8" diameter	67	1.72	115.24	3.87	259.29	0	0	374.53
3-way Valve	2	300	600	47.5	95	0	0	695
Pump 3/4 H.P.	1	2175	2175	139	139		0	2314
Drain-back tank	1	375	375	51.5	51.5	0	0	426.5
Heat exchanger 35 GPM	1	21800	21800	1325	1325	0	0	23,125
Solar collectors	1012	306.67	310,350.04	6	6072	0	0	316,422.04
							Subtotal	362,741.49
							Tax 6.00%	217,64.49
							Total Cost	$384,506

ENERGY SAVING

Each 7.2 feet of the solar collectors produces on average 40.9 kBTU/day, according the manufacturer specifications. So 1012 feet will generate 5,748.7 kBTU/day. As discussed earlier, the system efficiency is 71% due to varying sun angle during the year. And assuming the system is idle for 10% of the year due to weather conditions. So that totals up to

$$Total\ energy\ generated = \left(5{,}748.7\,\frac{kBTU}{day}\right) \times \left(365.25\,\frac{days}{year}\right) \times 71\% \times 90\% = 1{,}342\ MBTU$$

Hence, the ETC system will save 11,342 MBTU per year. One MBTU costs Penn State $9.00 to generates, so the ECT system will save $12,075 (1,342 MBTU x $9.00) annually.

PAYBACK PERIOD

Following the basic payback period formula:

$$Payback\ period = \frac{384{,}506}{12{,}075} = 31.8\ years$$

To conclude analysis one, it is suggested to install an ETC system in the roof of the Whitmore Laboratory. The collectors are designed to be facing north with a fixed angle of 34^{o}. detailed estimation was completed and the total cost summed up to $384,506 while the energy saving is $12,075 per year. That resulted in payback period of 31.8 years. Bearing that in mind, the proposed ETC system turned out to be too expensive in this case and it is not feasible.

MECHANICAL BREADTH: SYSTEMS INTEGRATION

BACKGROUND

The first analysis in this paper titled (Installation of evacuated-tube system) discusses the advantages brought to the project by the solar collectors. This section explains how the ETC system will be integrated to the existing water heating system. Nevertheless, the control system will not be fully addressed in this section as it requires advanced knowledge in the HVAC field. That being said, the proposed integrated system includes any additional pumps, valves or piping and excludes gauges, sensors and wiring.

The existing water heating system is an instantaneous heater as water is heated by a heat exchanger upon demand. Similarly, the proposed system will provide heat through a heat exchanger that will be installed downstream of the existing heat exchanger. Ideally, the full demand will be satisfied by the solar collector during the day, but due to the high demand or weather conditions, the energy can be compromised. Therefore, the proposed pluming configuration allows water to be heated by the solar collector only, campus steam loop only or both methods simultaneously. Below is a schematic plan of the hot water piping before and after integrating the ETC system. Here, it is assumed that Pumps 1 & 2 are individually capable to operate at full load, where Pump 1 is the main pump and Pump 2 is in a standby mode for emergency cases. For simplicity, the detailed sensors and gauges have been

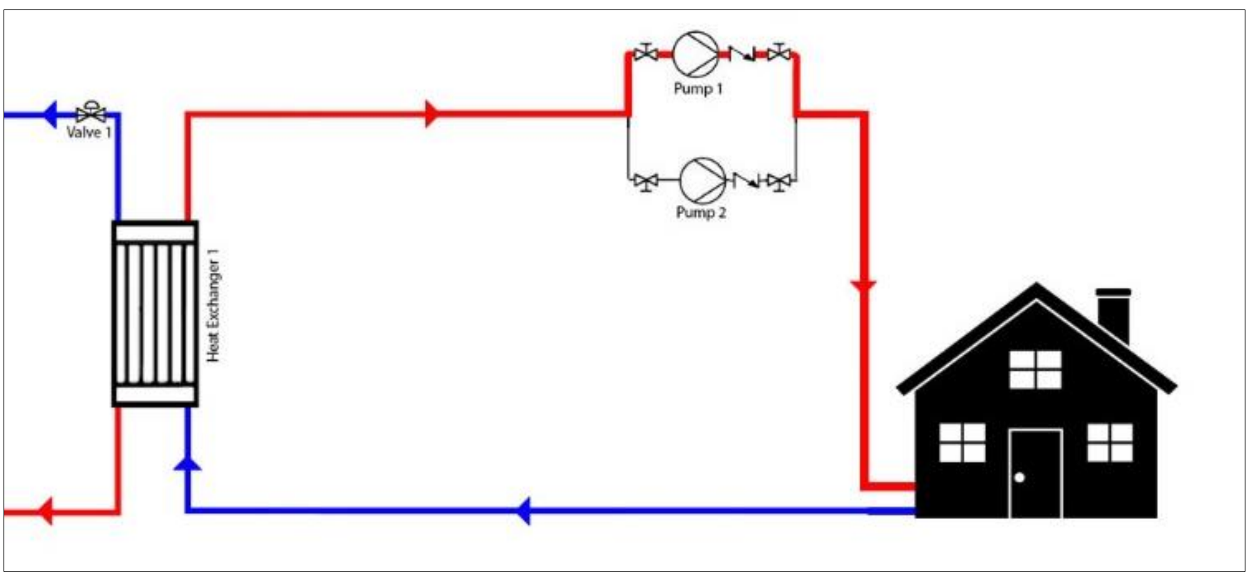

Figure 1.13 - Water heating system BEFORE installing ETC

eliminated from the plan. Likewise, the figure shows one heat exchanger from the campus loop side but actually there are two heat exchangers piped in parallel. The figure on the right is an example of a full load covered by the ETC system as the highlight lines represent the flow of water and the colors represent the temperature of the water.

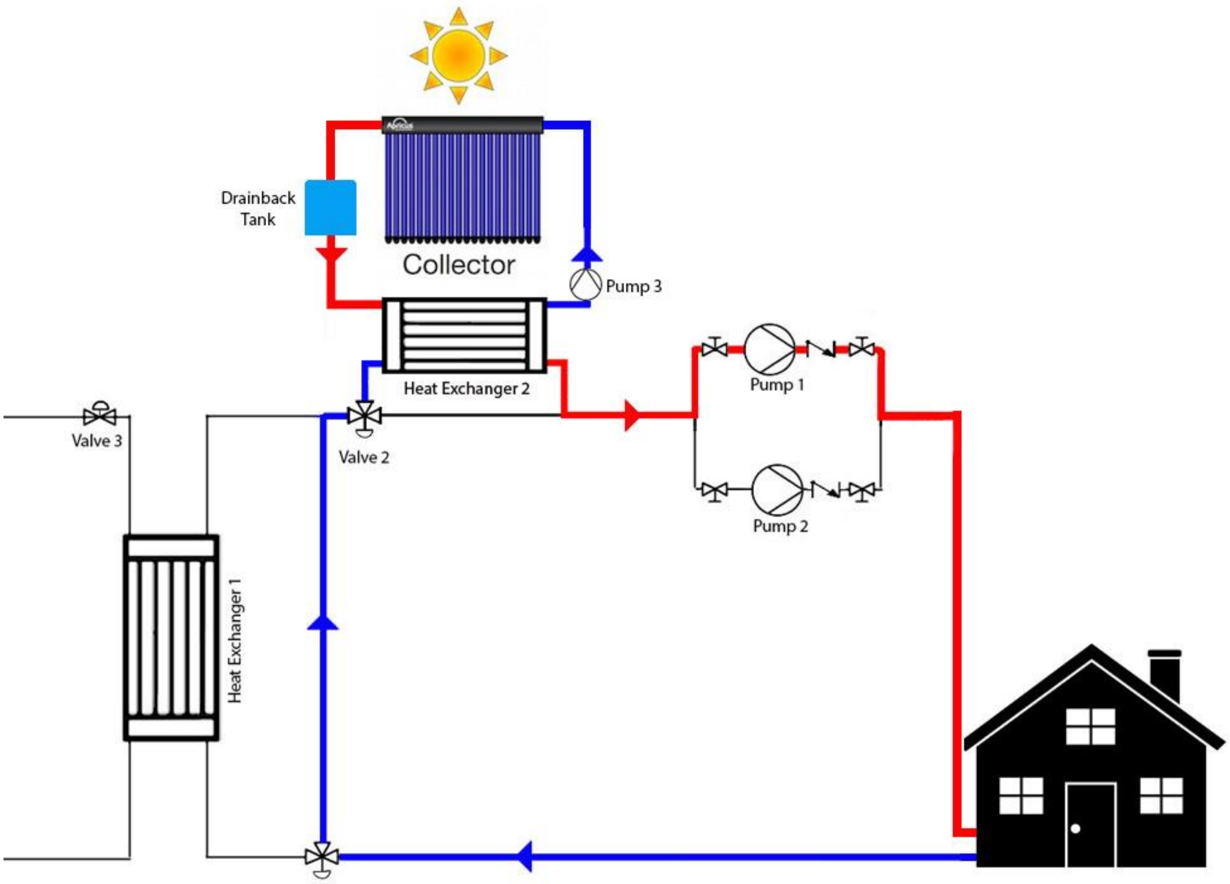

Figure 1.14 - Water heating system AFTER installing ETC

The integrated solar collector's loop is placed after the existing heat exchangers because it's easier as the two existing exchangers merge into one pipe. Connecting the heat exchanger 2 to one line is easier than connecting it to two different lines. Notably, the drainback tank must be higher than the pump so that when the pump is switched off, water drains bag to the tank.

Water can possibly be heated by three methods: (a) solar collector only, (b) campus steam loop only and (c) both solar collector and campus steam loop. The following lines analyzes each possibility and explain the logic of the control system.

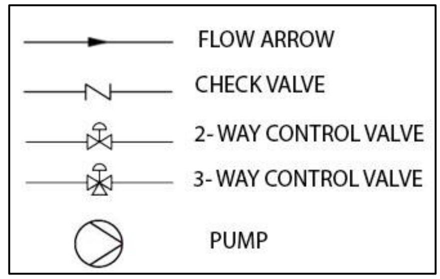

Figure 1.15- Schematic plan legend [CD]

Before explaining the cases, the reader should understand the piping symbols used in this plan, which is illustrated on the legend at the left. In addition, the following terminologies are defined to help develop better understanding.

A. Check valve: a valve that allows flow in one direction only.
B. 2-way control valve: is a valve that shuts up, regulate and control water flow.
C. 3-way control valve: it becomes mixing or diverting valve. The one used in this schematic is a diverting valve which has one inlet and two outlets. The valve control water outlets.

1. Case 1: Heat provided by the solar collector only

Hot water demand will be completely heated by the solar collector. This case is likely to happen at daytime when there is lesser water demand (e.g. weekends).

In this case the pump 3 in the solar collector's loop operates circulating the heat transfer liquid and conveying heat to water through heat exchanger 2 (figure 1.16). Meanwhile, the campus steam inlet is shut off (valve 3). To minimize pressure drop, valve 1 diverts the water directly to the solar collector's heat exchanger (heat exchanger 2) bypassing heat exchanger 1. Valve 2 diverts the water to heat exchanger 2 where water is heated. Then it flows making its way to the open faucet.

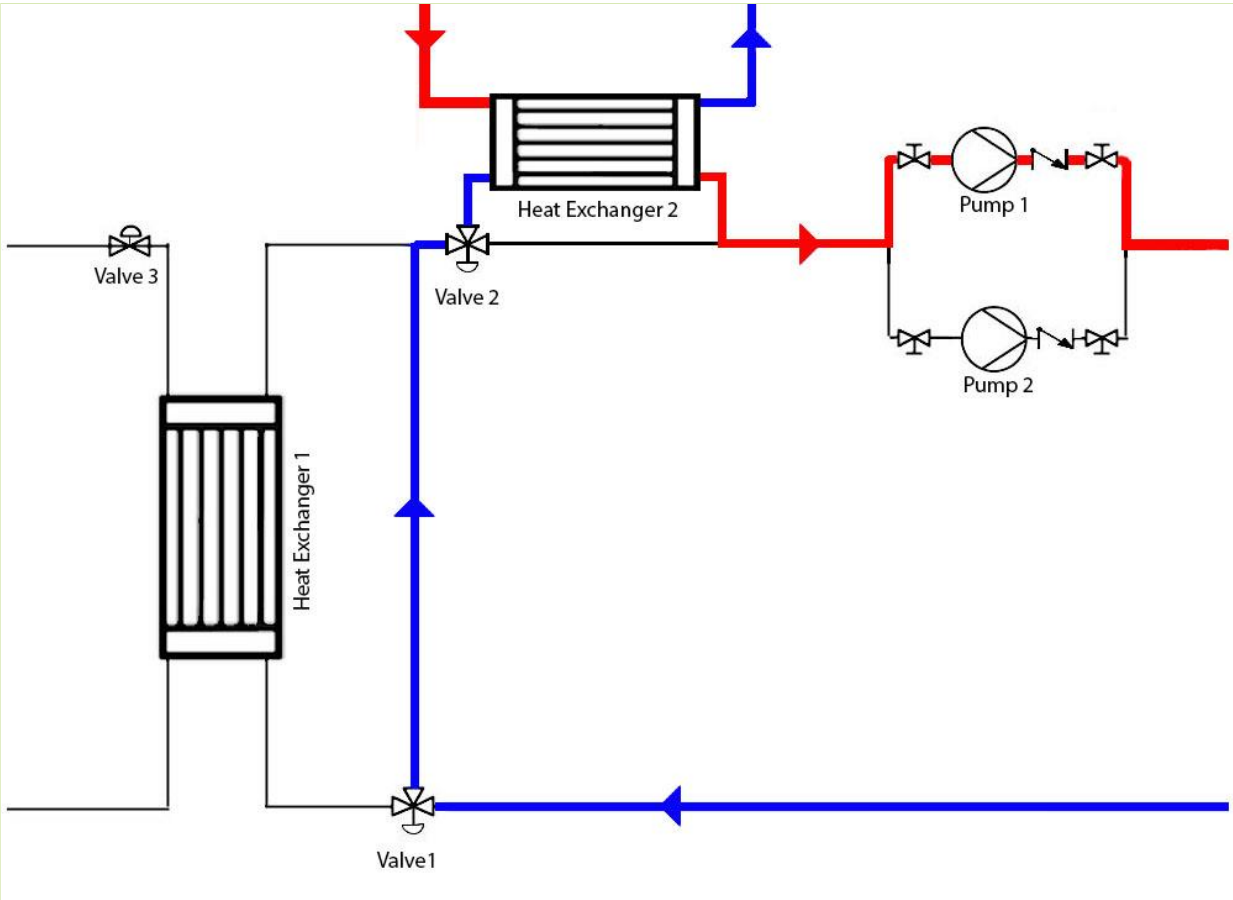

Figure 1.16-Case 1: water heated by the solar collector

Case 2: Heat provided by campus steam only

Hot water demand will be completely satisfied utilizing campus steam loop only. This case is likely to happen at night or on rainy days.

In this case, valve 1 direct the flow to heat exchanger 1 where water is heated by steam (figure 1.17). Then, the water flows to its demand point in the building. To minimize pressure drop,

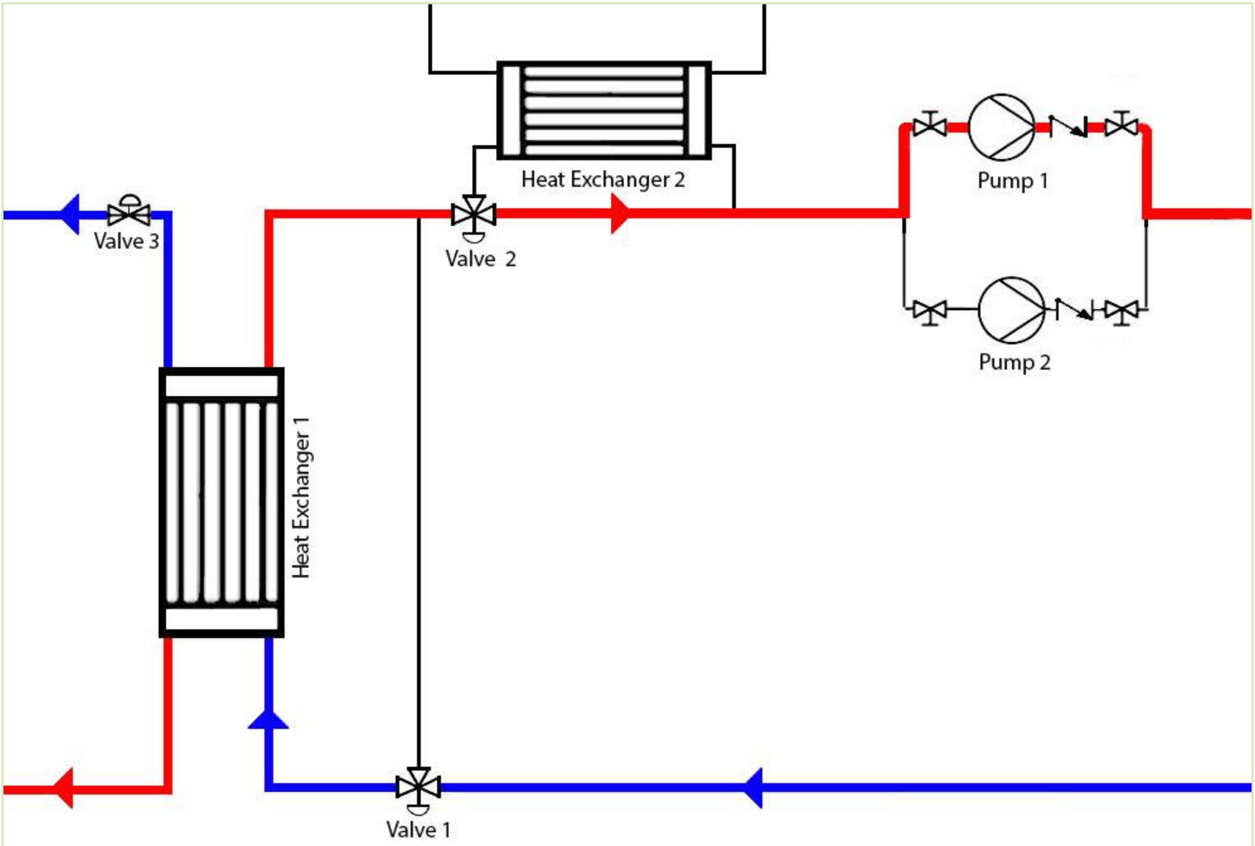

Figure 1.17- Case 2: water heated by campus steam loop

valve 2 diverts the water directly towards pump 1 bypassing heat exchanger 2. The figure below highlights the flow route. The black lines mean no water is flowing at that moment.

Case 3: Heat provided by the solar collector and campus steam

Hot water demand will be satisfied utilizing the solar collector and campus steam loop. This case is likely to happen at daytime on weekdays (Monday-Friday) since the building will be possibly fully occupied by students and staff.

In this case, valve 1 direct the flow to heat exchanger 1 where water temperature is increased by steam (figure 1.18). Valve 3 regulates the flow of steam depending on the amount of energy that will be supplied by the solar collector. Then, the water flows to heat exchanger 2 to where the water is heated to the required temperature. The control system recognizes the temperature of the solar collector loop in order to regulate the flow of steam. In this case, the solar collector is an assistant heat provider to reduce the consumption of campus steam. The more energy available in the solar collector, the less use of campus steam.

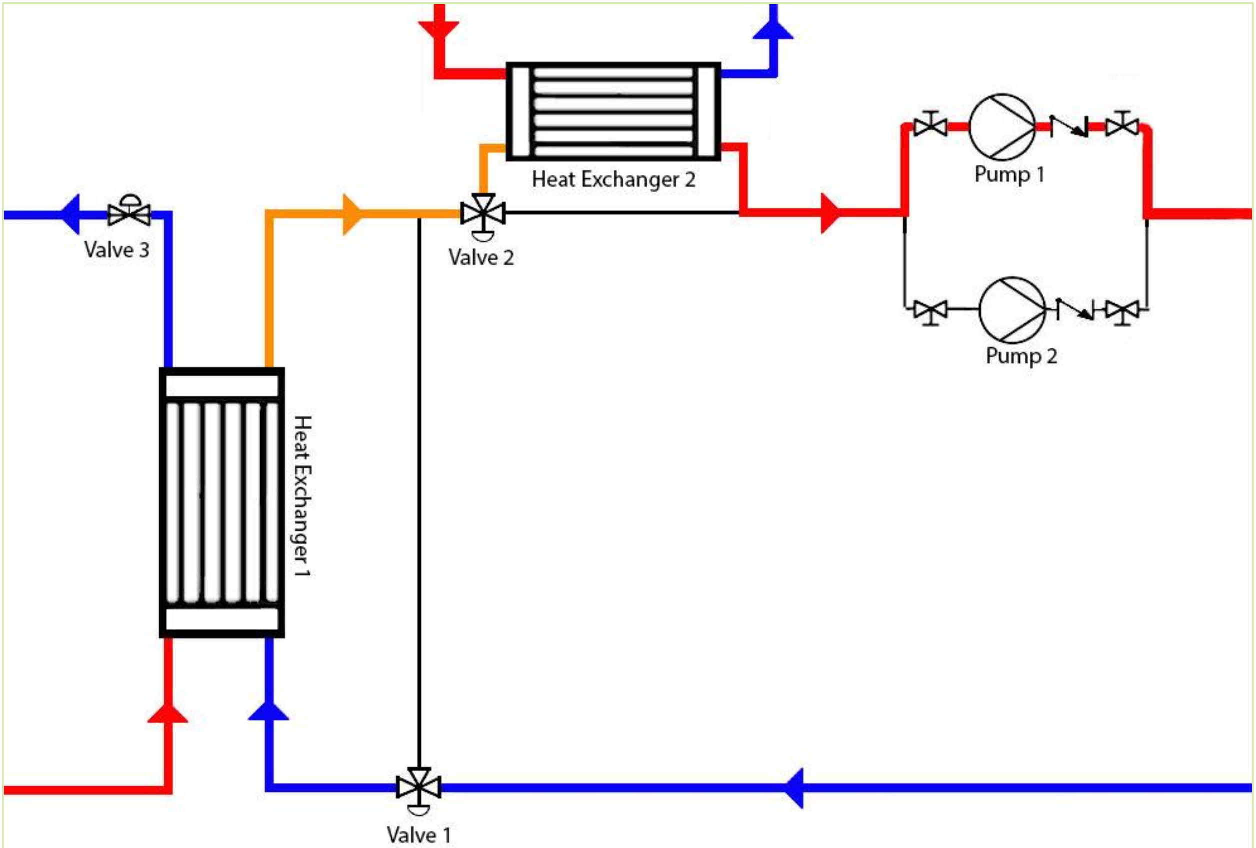

Figure 1.18 - Case 3: Water heated by solar collectors and campus steam

To sum up, the proposed piping configuration is designed to optimize domestic hot water heating system performance by using renewable energy. Solar energy is utilized when available and when it's not, the domestic heating system is operated. The matrix below summarizes the status of valves and pumps at each case.

Table 1.6 - control valves in all cases

	Case 1	Case 2	Case 3
Valve 1	Diverting flow to HX 2	Diverting flow to HX 1	Diverting flow to HX 1
Valve 2	Diverting flow to HX 2	Diverting flow to DHW distribution	Diverting flow to HX 2
Valve 3	Shut off	Open	Partially Open
Pump 1	Operating	Operating	Operating
Pump 3	Operating	Switched off	Operating

STRUCTURAL BREADTH: EXAMINING THE STRUCTRUAL FRAME

BACKGROUND

Part of the scope of work for Whitmore Laboratory Renovation project is replacing the existing roof. The replacement activity was added later to the contract; thus the replacement activity will take place later in the project. The roof is scheduled to be completed by May 30, 2016 where the final completion is planned to be on August 1, 2016. For the structural frame of the roof, it is to remain and to be used to support the new roof. Hence, the structural analysis of the roof system will be done based on the information provided in the drawings of the existing building which trace back to the 1950s.

Whitmore Laboratory has a flat roof with gravel as the topping material. And there are other layers beneath it such as: coat rain, vapor barrier and high densify fiberboard. A detailed roof section is shown in figure 1.19. More importantly, the roof structural system consists of 2" reinforced precast concrete slab resting on light steel joist trusses that are spanning 42'. The joists are spaced 5'-0 away and bridged at every 7' to add rigidity and lateral support to them. Half of the joists are supported by 10H33 column while the other half are supported by 10"x8" concrete column with 12C20. A structural roof framing plan is shown below; the plan was produced in 1953 when computers were not yet involved in the construction industry. Due to that reason, the plan was hand-drawn and some of the structural members' details faded out. Also, the structural members' designations and classification back then were not the same as today. Consequently, the maximum load capacity for these members is difficult to identify. Still, the support design for the solar collectors will be based on conservative assumptions to not compromise the structural system safety factors.

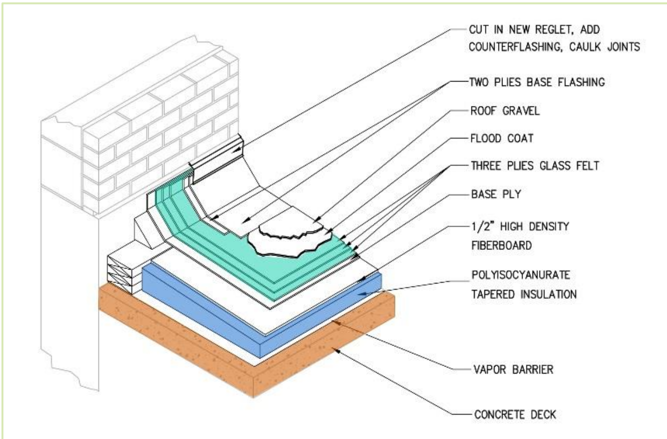

Figure 1.19 - Roof cross section

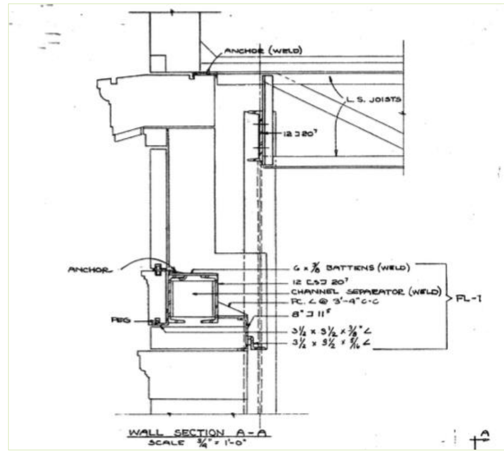

Figure 1.20 - Roof detailed joist connection [CD]

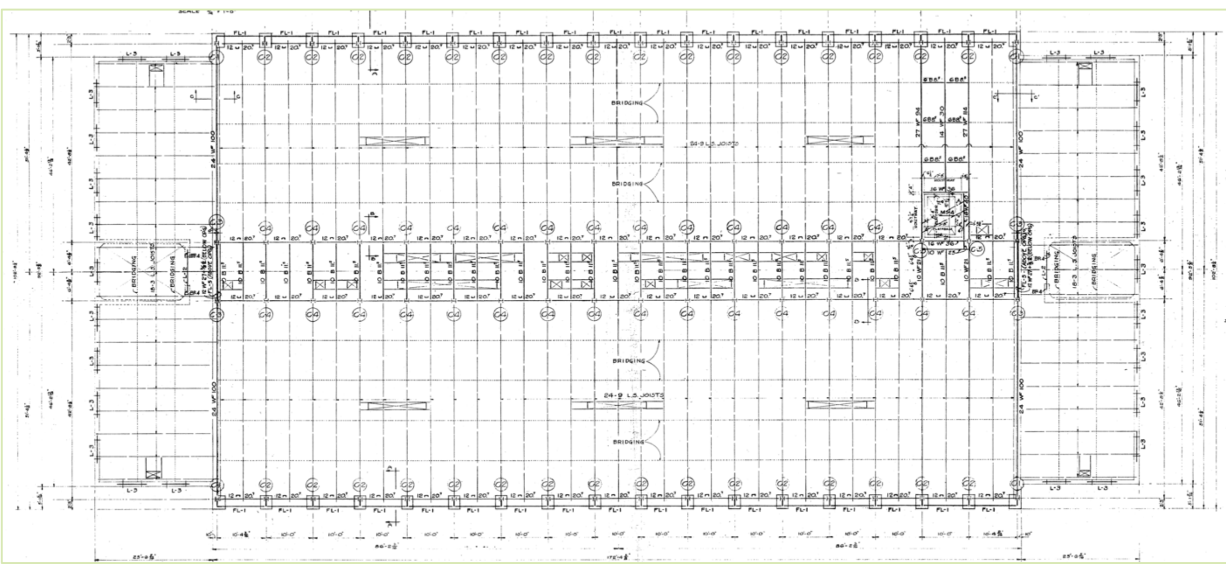

Figure 1.21 - Roof framing plan [CD]

LOAD OF SOLAR COLLECTORS

The design of the structural support system for the evacuate-tube collectors considers three types of loads: (a) gravitational load, (b) wind load and (c) snow load. In the following lines, an analysis is done for each type of load to determine the appropriate support method.

A) GRAVITATIONAL LOAD

Here, the total dead load of the collectors, piping and accessories are considered. Then, the total load is divided by the area that the collectors occupy to find the load per square foot. The loads of the components are as follows;

- Evacuated-tube solar collectors filled with plain water: 30 plf (per manufacturer specifications)
- Piping: 0.7 plf (3/4" copper pipe with insulation)
- Accessories :1 plf (conservative assumption)

Since the loads are given in plf, that number will be multiplied by the length of the row divided by the spacing between rows to find the load per square foot. However, the load of the pipe will be multiplied by the rows spacing because the pipe runs perpendicular to the rows.

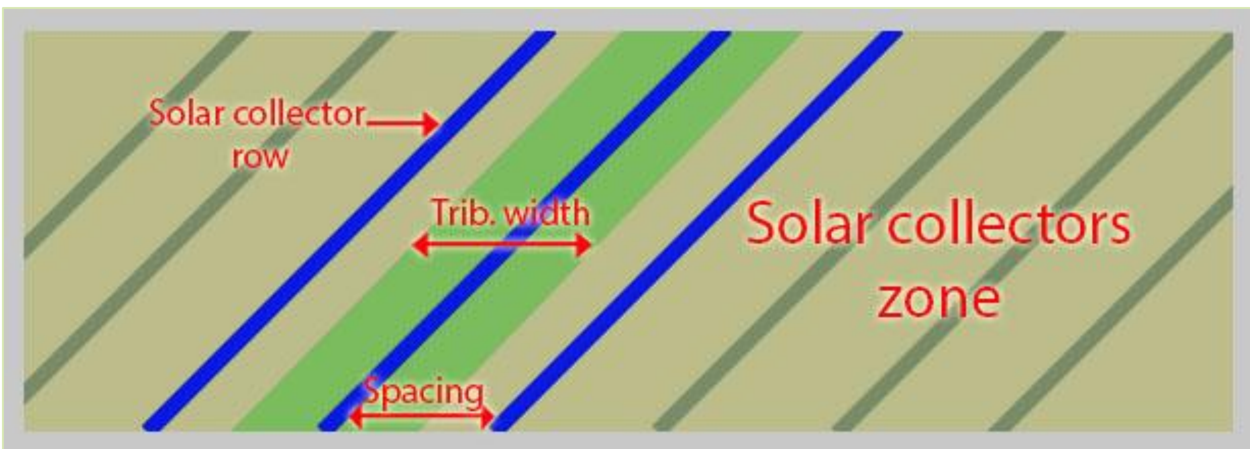

Figure 1.21- Roof area analysis

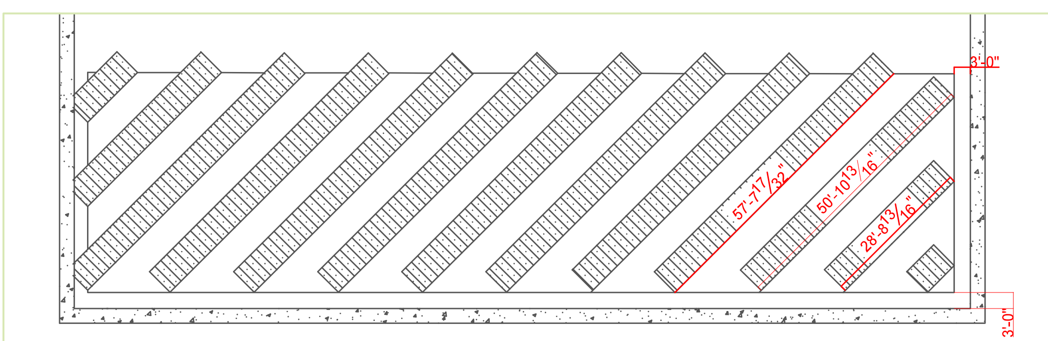

Figure 1.22- Solar collectors zone dimensions

This is illustrated in the figure below as the blue diagonal lines represent the solar collectors rows, green hatched area represents the tributary area and the grey hatched area is the solar collector zone on the roof. in order to find the exact dimensions of each raw, the system configuration was modeled in Autodesk AutoCAD as shown below. The figure shows a sample from the model, the diagonal hatched rectangles represent the rows of the collectors. The length of each row was measured in AutoCAD and recorded to the nearest 1/32 of an inch.

From this model the calculations were carried as the following:

$$Total\ occupied\ area = 12{,}331\ ft^2$$

$$Totlal\ linear\ feet\ of\ the\ rows = 1012.718'$$

$$Total\ liner\ feet\ of\ the\ copper\ pipe = 416'$$

$$Total\ solar\ ETC\ load = solar\ collector + accessories + piping$$

$$solar\ collectors\ and\ accessories = (30\ plf \times 1012.781') + (1plf \times 1012.718') = 31394.29lb$$

$$Copper\ pipe = 0.7plf \times 430' = 301\ lb$$

$$Load\ per\ SQFT = \frac{total\ load}{total\ area} = \frac{31394.26lb}{11{,}781ft^2} = 2.66\ psf$$

$$Factored\ Load = 1.4 \times Dead\ load = 1.4 \times 2.66 = 3.73psf$$

Thus, the roof will have an additional factored load of 3.73 lb/ft^2 which will be carried by the existing precast slabs. The load then is transferred to the joists, girders, columns and down to the footing.

B) WIND LOAD

The wind load, either lateral or uplift, exerted on the evacuated tubes is not effective as if it was exerted on a plain panel. According to the manufacturer item specification, ETC can resist wind up to 130 MPH. That can be explained by two reasons embedded in the design of the tubes. First, the cylindrical geometry of the tube allows the wind to flow smoothly with minimal impact on the tube itself. Similar to the design of sport vehicles, they feature smooth aerodynamic flow to reduce the drag force under high speed. Secondly, the spacing between the tubes permits wind to penetrate easily. In other words, the impact area is very small as opposed to impact area of photovoltaic panels or flat solar collectors. So these two factors help the evacuated-tube solar collectors standing high speed wind without actually having extra protection.

At any case, the tubes are held very tightly by the high-strength aluminum rack to ensure stability in extreme weather conditions. The rack is attached to the roof slab as it will be illustrated in detail at the end of this section. The bottom line is that ETC system does not require additional support for wind load.

C) SNOW LOAD

State College receives the highest amount of snowfall during January. On average the the

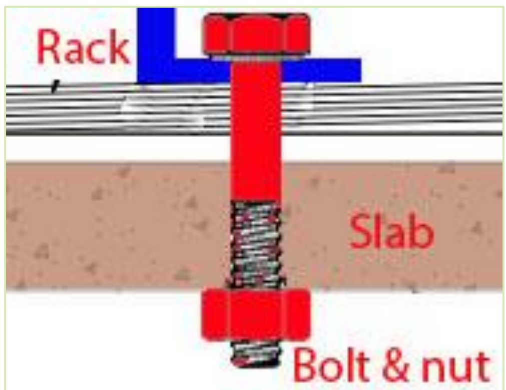

Figure 1.23- Bolt and nut

snowfall in January is 13 inches, 11 inches in February and 10 inches in March[4]. Undoubtedly, the existing roof is designed to for the mentioned snow load, still the concern is that if the solar collectors will help trapping snow leading to higher snow load. In fact, for a flat roof, the snow will be accumulated in roof anyways and the solar collectors will not make any difference. That also will compromise the performance of the solar collectors because some area in tube is covered with snow. It is worth mentioning that, the outer shell of the tube is not hot since the inner hot layer is well insulated by the vacuum space. Therefore, the snow will not be melted by the hot tubes.

In conclusion, snow load on the Whitmore Laboratory roof will be the same with or without the solar collectors.

[4] http://www.usclimatedata.com/climate/state-college/pennsylvania/united-states/uspa2543

EVACUATED-TUBE COLLECTORS SUPPORT DETAILS

Launching off from the analyses above of the three different types of load associated with the collectors, the system requires a support for its gravitational load. So the goal is to take the weight of the collectors and properly transfer the weight to the girders, columns and finally the foundation. In this case, there are two possible options. The first one is to bolt the racks to the precast slab as shown in the figure below.

However, this method does not seem to be practical in this case. That is because it is too risky to put the roof load plus the weight of the collectors on a 2" thick slab. Especially, the concentrated load at the racks legs is considered pint load that causes large bending moment if it happens to be located at the middles of the slab. In addition, bolting the racks on the slab requires at least four holes in the slab for each rack which will end up with too many holes in the slab. Consequently, the structural integrity will be compromised plus that increases the chance of water and vapor leaking into the building. Similarly, the large number of bolts having one end at the outside and the other end in the inside will cause cold bridge. Subsequently, water will condensate on the bolt and nut causing corrosion issues which also require more maintenance. As a result, this method is not appropriate for the purpose of this project.

The second option is to add structural beams that run under the collector rows and connect directly to the joists via J-bolts. It will be two beam per row, one beam supports the front legs of the rack and the second beam supports the back legs. This method provides linear load distribution, as opposed to point load in the first option. Aluminum structural channel is selected for this case because aluminum features high strength and light weight relatively. Also aluminum is corrosion resistant. The channel will be placed face down to provide enough area for the rack to attach as the flanges are narrower. Ideally, the connections to the trusses should be minimized for the same reasons associated with the first method above. Also, aluminum and concrete have different thermal expansion properties, so a puffer space should be left for expansion and contraction. Generally, three bolts per channel are enough to provide the required connection strength. Figure 24 shows a detailed cross section of the connection.

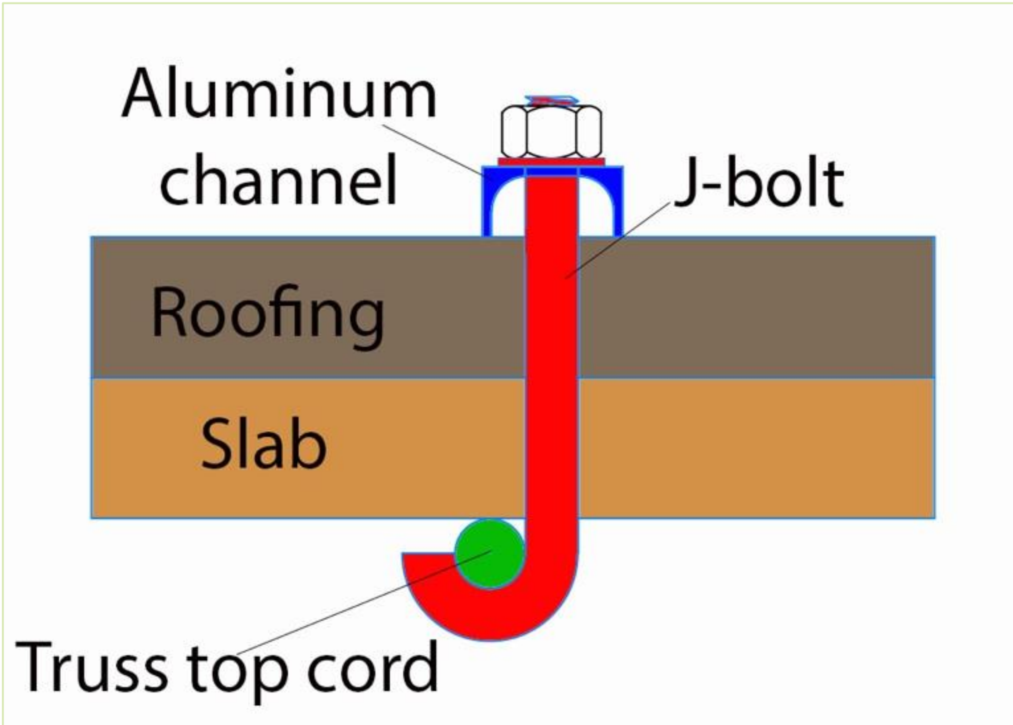

Figure 1.24- j-bolt connection details

In conclusion, the evacuated-tube solar collectors will experience gravitational, wind and snow load, and gravitational load governs. Therefor, a support method is suggested that transfers the weight of the collectors to the building structure. Aluminum structural channels will be used as the base that ground for the racks. The aluminum channel is secured using a j-bolt. Per the calculation the system will add 3.73 psf to the roof. The existing structural frame is assumed to be able to carry this weight.

ANALYSIS II: INSTALLING AQUATHERM PIPES

ANALYSIS SUMMARY

This analysis is proposed to find a better solution for the domestic cold water (DCW) distribution in the Whitmore Laboratory. After searching and comparing the different alternatives possible, Aquatherm pipe turns out to be the best option. It features: corrosion resistance, better water flow, cheaper material, labor and equipment and easier, quicker and safer installation process. Also it has a built-in R-value of one so that insulation is not necessary for DCW system.

In this analysis, we studied the compatibility of Aquatherm products for this particular project and it is concluded that the products would meet the owner specifications. Then, two detailed cost estimates are presented for the DCW pipes comparing the existing system (copper), with the potential system Aquatherm. After obtaining a permission from the related entity, materials quantities were acquired from them. Prices were found in RSMeans Open Shop Construction Cost Data 2015 and the manufacturer catalog (attached in appendix D). Labor and equipment costs are excluded from the estimate because of the unavailability of cost data, yet they are systematically discussed on how they would affect the estimate. The result shows that $80,125 can potentially be saved including $31,500 saving in fiberglass insulation.

OPPORTUNITY STATEMENT

The plumbing network in the Whitmore Laboratory Building is intensive and complicated due to the large number of appliances that requires water. Apparently, the amount of piping is significantly huge as will be determined later in the take off section. The figure below shows the intensity of domestic cold and hot water distribution in the a typical lab area.

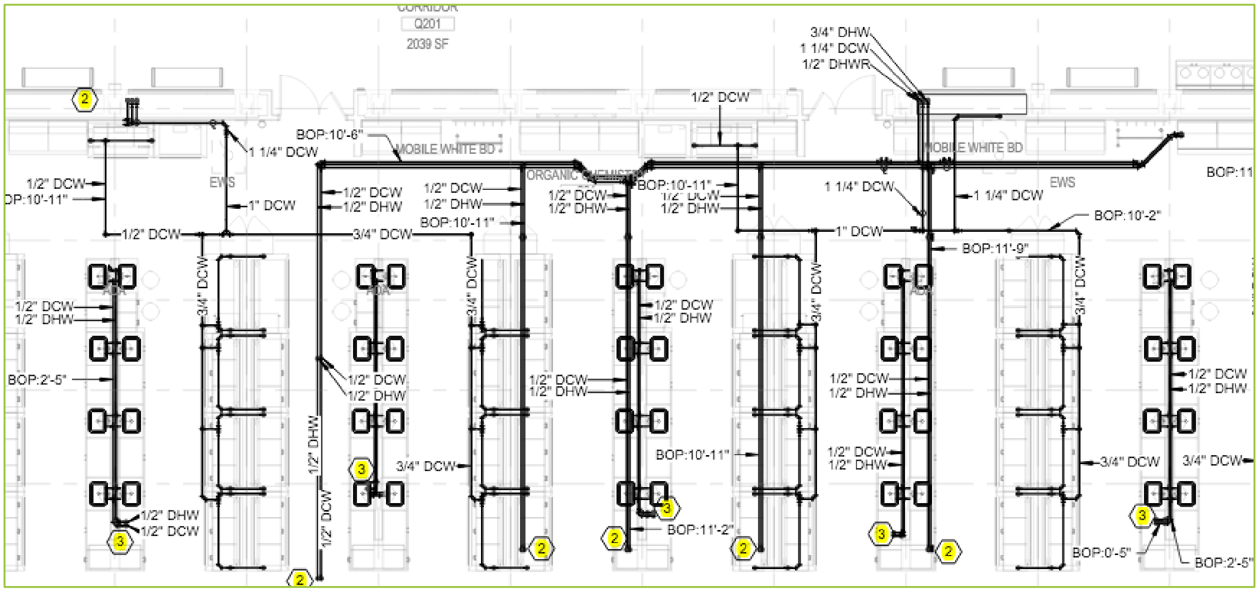

Figure 2.1 - Typical lab area DW distribution, Source: building drawings [CD]

The existing design specifies copper pipes with insulation for the domestic water distribution system. It is true that the pipes are assembled in shop to the largest assembly possible in order to reduce site work. Despite that fact, there is an opportunity for safer and quicker installation of the domestic water distribution system. In pursuing of schedule acceleration, Aquatherm pipes become a better choice since they are lighter in weight and have faster, easier and safer installation process. They can be preassembled in shop like the copper pipes. For some cases, Aquatherm pipes do not need insulation as if they are installed for the domestic cold water distribution because they have an R-value of 1.

BACKGROUND RESEARCH

Aquatherm pipes are a new green piping technology that is manufactured from polypropylene (PP-R), one of the longest lasting and most chemically inert piping materials in the industry. It is a pressure piping system that is designed for verity of applications such as: potable, hydronic and grey water applications. Lately, Aquatherm pipes are being used widely in residential and commercial buildings to improve HVAC and plumping efficiency.

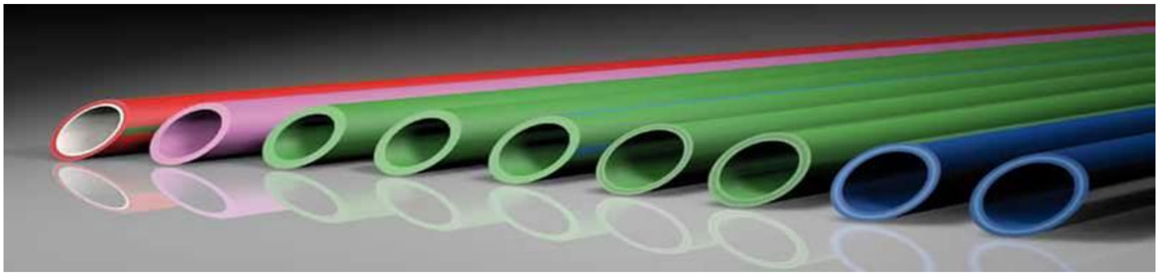

Figure 2.2 - Aquatherm different colors (applications) [2]

BENEFITS OF AQUATHERM:

Aquatherm pipes are lightweight, clean and environmentally friendly products. These pipes are long last because they are resistant to most chemicals. They also allow for an increase in the flow rate unlike most of the other piping systems.

In addition, Aquatherm piping system uses a threadless stepping from PP-R to copper fixture units and flush valves. This transition offers quicker installation process without any extra cost. In fact, it allows for cuts from the fittings cost.

Moreover, Aquatherm pipes are also corrosion resistant, fully recyclable and have heat and sound installing characteristics. They can endure high heat and remain stable. They are low material cost, quick installation and non-maintenance cost. Therefore, they are expected to be the piping system of the future projects. The figure below shows the wide verity of fittings and sizes available.

Figure 2.3 - Part of piping in a project [2]

Figure 2.4 - Easy maintenance [2]

Aquatherm pipes come in different sizes and different colors identifying the designated application of the pipe. The colored strips along the pipe decodes other properties of the pipe such as: specific use, wall thickness, maximum and minimum operating temperature and pressure. An example is shown in the figure below as an example. More details about the main types of aquatherm is included in the following lines. It is important to note that the manufacture customizes the pipes per order.

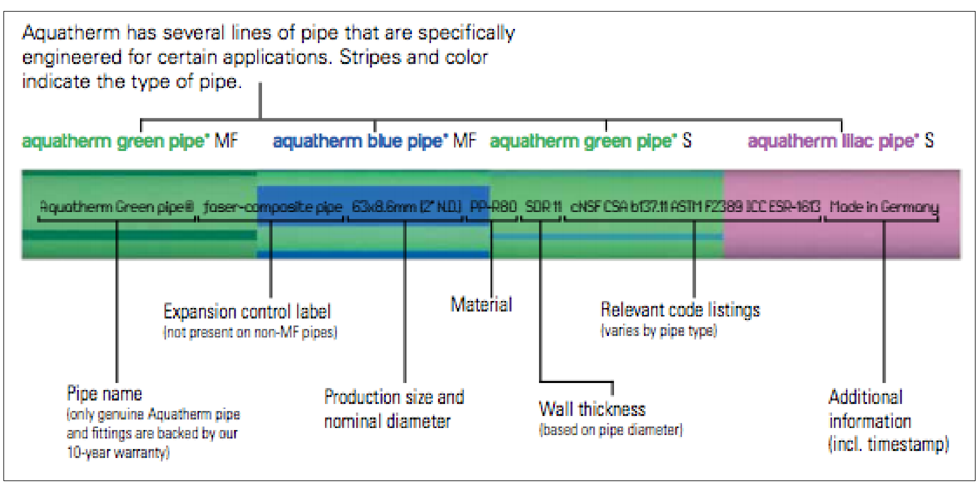

Figure 2.5 - Pipe identification color [2]

Green polypropylene is a pressure piping system, compatible for potable water either hot or cold and edible substances purposess. PP-R features excellent strong physical properties and high chemical purity, giving green colored pipe excellence and performance different from any other potable systems. For connection, Green Pipe utilizes heat fusion method which is considered one of the most sustainable method in the industry. Aquatherm Green Pipe comes in a range of sizes from 1/2" to 18", with a faser-composite layer per request for domestic hot distribution applications. An example is shown below, the green pipe with a dark green strip means the pipe is designed for cold water purposes.

Figure 2.6 - Green Pipe with dark green strip, source: http://www.aquatherm-

Blue Pipe takes the advantages of polypropylene to a completely new level. Engineered for hydronic, geothermal and industrial applications. Blue Pipe combines all the unique advantages of Green Pipe with thinner walls for higher flow rates. The heat fusion connections eliminate leaks plus PP-R pipe and fittings won't corrode or wear out. Blue Pipe includes the patented faser-composite layer, which reduces linear thermal strain by 75% and is available in sizes from 1/2" to 24". The pipe is made of the three layers: two polypropylene layers with the faser-composite layer in between to limit thermal shrinkage and elongation. The sample pipe in figure 2.7 is designed for HVAC piping, chemicals and compressed air. It could also be used in other non-potable application as irrigation.

Figure 2.7 - Blue Pipe with dark green strip, source: http://www.aquatherm-uk.com/products

Lilac Pipe is purposed for reclaimed and rainwater applications, the Lilac piping system offers the longevity and reliability of polypropylene at a competitive cost for any recycled water applications. Aquatherm Lilac Pipe uses the same fusion connections and fittings as Green Pipe and Blue Pipe, so the same advantages apply. The PP-R material is inert to a wide range of water qualities, making it ideal for grey water. A plain pink pipe shown in figure 38, this pipe is designed for grey water transport with operation temperature between 50 to 100 °F

Figure 2.8- Lilac Pipe with dark green strip, by aquatherm-uk.com

Heat fusion is the method utilized to connect Aquatherm pipe to another pipe or a fitting; three ways are available: fusion socket, fusion outlet, and butt welding. This method offers a wide verity of possible connections especially in tight or complicated configuration. It is known the joint or the weld is usually the weakest point in the stream and it is expected to be the first failure point. However, this does not apply to the fusion method as the heat actually alters the carbon and hydrogen bonds creating a very strong joint with fitting. The equipment used for connection, heating iron, does not require any electrical set up. It is basically plugged to the normal electrical outlet. It takes from 20-30 minutes to preheat and then it is ready to operate. The picture below shows the different parts of the equipment.

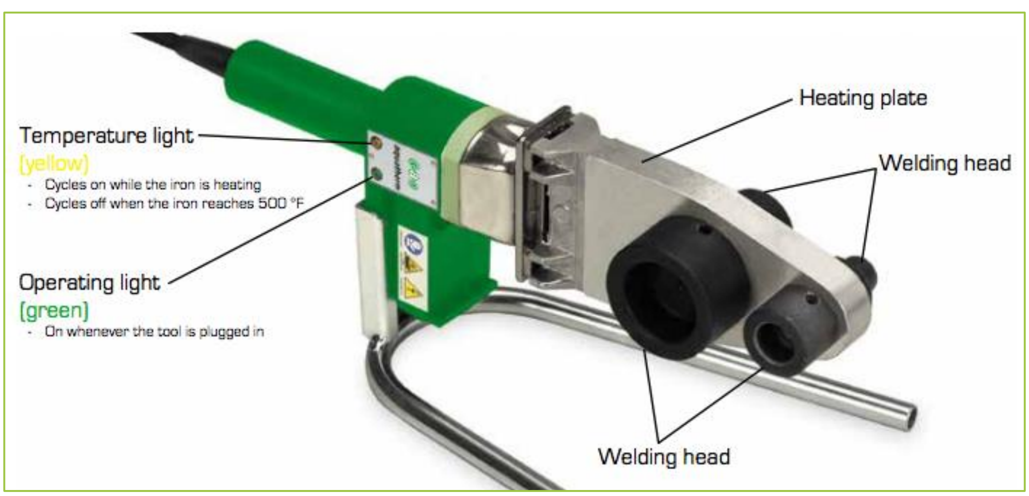

Figure 2.9 – Fusion Welding Tool [3]

POTENTIAL OPPORTUNITY

In this section, an investigation is carried out on how Aquatherm pipes will perform in the domestic cold water network in the Whitmore Laboratory. Besides, a comparison between copper and Aquatherm pipes will be conducted for the sake of looking for construction benefits.

Primarily, material take off of the domestic cold water distribution system is completed. This action is done by using the building drawings (PL-200, PL-201, PL-202 and PL-203) and Adobe Acrobat as the measuring tool. Pipe linear footage for the different sizes and fittings are accounted for. It is assumed the domestic cold waster piping is fully insulated so that the insulation linear footage is equivalent to the piping linear footage. Elbows are counted at any bend and couplings are counted at every straight continuous 20' of pipe. Hangers are excluded from the list because they are necessary in both systems, Aquatherm and copper piping. A sample from the take off process is shown in appendix A.

In fact, counting the linear footage of every pipe in the building is tedious work. Therefore, the numbers used in this estimate are legally taken from the detailed estimate document developed by the construction management company. For confidentiality reasons, only the quantities only are stated here while prices are taken from RSMeans. That is also to be consistent because RSMeans will be used in finding aquatherm products prices anyways. Thus, it is better to be use the same source for copper and aquatherm products. The table below summarizes the individual cost aspects for each system with the consideration of the following assumptions:

- Domestic cold water piping is 50% of the total domestic network. This percentage is concluded by analyzing the risers' sizes.
- For simplicity, fittings and valves are assigned a standard price for all sizes.

Table 2.1 - Detailed estimate for DCW distribution

		Copper system		Aquatherm system	
Item	Quantity (LF)	Unit cost	Total cost	Unit cost	Total cost
All service Jacket, 1" thick					
Pipe, 1/2"	1500	$0.83	$1,245	$0.00	$0
Pipe, 3/4"	1680	$0.90	$1,512	$0.00	$0
Pipe, 1"	600	$0.97	$582	$0.00	$0
Pipe, 1-1/4"	480	$1.05	$504	$0.00	$0
All service Jacket, 1-1/2" thick					
Pipe, 1-1/2"	600	$2.11	$1,266	$0.00	$0
Pipe, 1-1/2"	600	$2.11	$1,266	$0.00	$0
Pipe, 2"	180	$2.11	$380	$0.00	$0
Pipe, 2"	180	$2.11	$380	$0.00	$0
All service Jacket, 2-1/2" thick					
Pipe, 2-1/2"	180	$1.36	$245	$0.00	$0
Pipe, 2-1/2"	180	$1.36	$245	$0.00	$0
Fittings	1 set	$23,876.54	$23,877		
Valves	1 set	$23,876.54	$23,877	$23,877	$23,877
Pipe, 1/2"	1500	$3.70	$5,550	$1.54	$2,303
Pipe, 3/4"	1680	$5.20	$8,736	$2.31	$3,884
Pipe, 1"	600	$7.85	$4,710	$3.81	$2,288
Pipe, 1-1/4"	480	$10.35	$4,968	$5.76	$2,766
Pipe, 1-1/2"	600	$12.95	$7,770	$9.41	$5,648
Pipe, 2"	180	$18.80	$3,384	$14.36	$2,585
Pipe, 2-1/2"	180	$29.50	$5,310	$20.91	$3,764
Fittings and valves	1 set	$80,700.00	$80,700	$49,267.00	$49,267
Total system cost			**$176,505**		**$96,381**

Note: the prices presented in this table do not include tax or fees. Prices are not obtained from the construction management company's work and was obtained from RSMeans Open Shop Building Construction Cost Data 2015 section 221113. Due to the fact that RSMeans does not incorporates Aqautherm products cost data, the actual prices from the manufacturer's catalog were applied in the cost estimate. The catalog, produced by the manufacture in July 2014, is attached in the appendices.

Labor and equipment costs are not included in this estimate because of the unavailability of cost data for the Aquatherm labor and equipment unit cost. At any case, it is evident the labor for Aquatherm pipe must be less than copper pipe due to the ease and pace of installation. For example, in the socket fusion connection, heating the two sides of the joint takes 30 seconds while it takes much longer to melt the copper pipe. Also Aquatherm has the advantage from equipment cost side. Unlike copper welding torch, fusion iron does not continuously consume gas, plumber's dope and flux. The price of the iron is around $450 whereas the copper pipe welding torch is priced slightly more expensive.

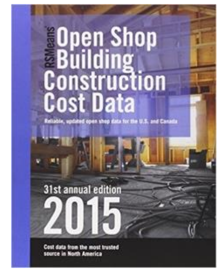

Figure 2.10 - RSMeans Open Shop 2015 by ecx.images-amazon.com

RESULTS:

Aquatherm is engineered to inherently have an R-value of one making the bare pipe valid for cold water distribution without the need of any type of insulation. This totally eliminate the cost associated with material, labor, equipment, inspection and maintenance of insulation. In the Whitmore Laboratory case, $31,501 is saved from excluding the fiberglass insulation accompanying the domestic cold water network.

Aquatherm pipe is made from petroleum, so its cost fluctuates according to the oil market. Bearing in mind Aquatherm is one of the leading brands in polypropylene industry in the world, its products are less expensive than copper products. The reason behind that can be linked to the crude source and the embedded energy in each product type. Contemporarily, oil byproducts are cheaper than metal products such as: iron, copper, aluminum and steel. That being said, a total of $80,124 can be potentially saved by replacing the copper pipes in the domestic cold water distribution network by Aquatherm pipes.

Besides, more robust system will be gained. Aquatherm pipes are made of very idle chemicals which in turn hardly interact with other particles from the flowing water. The products are designed to maintain high performance for at least 50 years. That brings many other benefits to the facility including: less maintenance and leakage issues. It is a common issue that copper pipes start leaking into the insulation causing mold stain whereas Aquatherm pipes do not react with other chemicals, so it does not corrode and leak. Farther, they don't have insulation, consequently any issue occurs will be clear and easier to fix.

It is worth mentioning that Aquatherm pipe solves the sedimentation problems caused in the copper pipes. Copper and iron pipes tend to trap tiny particles in the pipe inner wall. Over the time, the residuals grow up making the flow area smaller. An example is shown in the figure below. Subsequently, more pump power is required to reach the demanded flow.

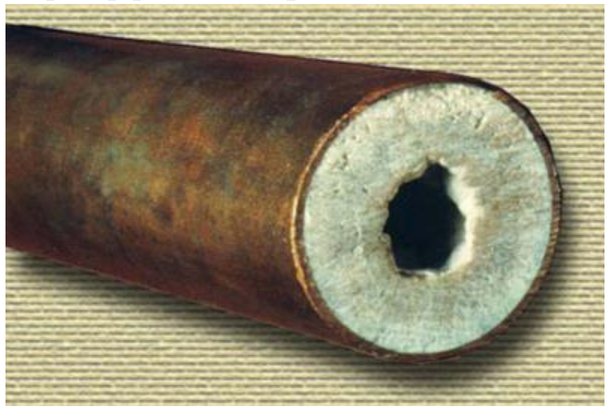

Figure 2.11 - Clogged copper pipe by Sources: http://pureelementswater.net/wp-content/uploads/2014/04/Scale-in-copper-pipe.jpg

ANALYSIS III: RECYCLING DEMOLISHED MATERIALS

ANALYSIS SUMMARY

The goal of this analysis is to develop a construction waste management plan that would potentially optimize the waste removal process. The environment is the primary concern and comes after that is the cost associated with operation. To determine the best option available, many waste plants around State College were examined. The priority goes to those plants that are closely distanced, have lower service cost, acceptance to wide variety of materials and their recycling versus disposal ratio.

The proposed plan suggests sorting out the waste materials into 11 designated categories. In an ideal case, all of the materials would be reused in later needs but this action applies to three sections of the materials. The owner and the contractors are responsible to keep some materials to be reused or repurposed later. The next option is recycling, which applies to 6 categories. The remainder categories are professionally disposed. Among the several waste management organizations available, Republic Services is selected to be the best option in the case of Whitmore Laboratory Renovation project. That is because, the facility is located outside of Pittsburgh, 133 miles away from University Park. This facility is the nearest one amid the chain locations across the country. The reasons to select this organization are: their known professional work and they accept the recycling and disposal categories. That is going to facilitate the waste management process and may save money as explained later in the analysis.

PROBLEM IDENTIFICATION

The scope of the project includes replacing the entire HVAC, plumbing and fire protection systems plus part of the electrical system. As a result, there will be a good stack of demolished materials ranging from easy recyclable to toxic materials.

Environmental protection is the main driver that encourages recycling of construction waste. That is to avoid stuffing the landfills irresponsibly. Besides, the energy consumed and emissions exhausted by hauling the waste to landfills are problematic to our future. Another driver for recycling is the returned monetary value that is brought by selling the HVAC and electrical equipment including the air handling units, heat exchangers, boilers, and other gears. The industry of material recycling is in its primitive stages as they fond metal highly recyclable but wood hard to recycle. However, recycling might take other shapes like reconditioning some equipment to be reused or repurposed. So recycling is an opportunity to hit two birds with one stone as it will promote sustainability and brings dollar value to the owner.

Figure 3.1 - Construction waste in a landfill [10]

On the other hand, the heat transfer liquids and the refrigerants are toxic chemicals which is considered hazardous to the environment. As the HVAC industry is advancing, the chemical constituents of refrigerants change. So, the old liquids need to be disposed properly. The disposal process is enforced by federal laws as these toxic substances require expertise and approved entities to take care of it.

BACKGROUND RESEARCH

The majority of construction and demolition waste is legally directed to landfills allowed by Code of Federal Regulation 40[5]. In some areas, waste is unlawfully dumped on land or in a natural drainage which lead to health issues. Progressively, construction waste is being diverted from the waste stream for subsequent recycle or reuse in some cases.

As opposed to guiding the construction and demolition waste to the landfill, there are some strategies for reducing or recovering materials. Construction professionals, owners, businesses entrepreneurs and governments have to take part of this responsibility in order to bring the stewardship of environment to life. That is done by industry professionals being aware of the temporary issues and spread the knowledge to lower piers. Governments should assign responsibilities to the proper entities, promote building-related waste awareness and encourages material reuse or repurposing. Business have a duty to return waste to the manufacturing process to make it later valid to be incorporated in the new products. It is essential to have coordinated arrangements of governmental, business and professional entities.

One of the main barriers for recycling is the high cost associated with the coordination and the process itself. However, it is a sustainable practice to reduce and reuse waste in the first place, otherwise it makes its trip to unwanted destination. Efficient and effective construction project adopts green practices such as: elimination or minimizing of waste and reusing the substances. The design team collectively develop a waste management plan using their knowledge of the regulations and available resources.

Eliminating the waste has been a goal in the construction and there are some great example proves the effort done. Prefabrication and modularization are examples of eliminating the waste. Products are made efficiently when they are produced in a control environment like a

[5] https://www.wbdg.org/resources/cwmgmt.php

factory leading to minimum waste as opposed if they are built on site. Another example is the use of reusable formwork such as the demountable steel formwork.

Similarly, minimizing waste helps achieving better sustainability. The manufacturers should take the responsibility in designing and delivering the products using minimal packaging materials. Also it should be considered that recyclable materials potentially reduce the amount of waste.

Penn State requires contractors to submit a Construction Waste Management Plan to be reviewed before executing the project. Once approved, all disciplines in the project have to comply with the plan and submit a monthly report showing what has been achieved in regard to the plan. Such a project has to meet the specifications set forth by Penn State to recycle or salvage a minimum of 75% by weight of non-hazardous construction waste.

The third strategy for recycling is reuse of some demolished assemblies and equipment. For example, using the doors and windows from a demolished building in a different building. Likewise, reusing the light fixtures, switch gears, panelboards, boilers, air handling units and heat exchangers. Sometimes these assemblies or equipment require reconditioning to meet the code or increase performance.

The old Whitmore laboratory contained several engineered complex systems that includes recyclable materials and toxic materials as well. At any case, these materials should be taken care of by the most efficient way. In this analysis, a process plan is proposed that illustrates how to handle the demolished debris efficiently taking advantage of the available opportunities in the region.

POTENTIAL SOLUTIONS

Fume hoods, lab casework, pipes, boilers, AHU’s, cooling towers, light fixtures, switch gears and panel boards hold a lot of value that can be taken advantage of. One option is to send the large equipment such as the fume hoods, cooling towers and air handlers to a recycling facility. They will take the responsibility of recycling these materials or disposing them responsibly. Another option is Bounty Program where the utility company would buy the appliances if they meet certain specifications. For the refrigerant, the local Hazardous Waste Facility should be consulted to find the best refrigerant removal option. Concerning the other materials, there are potential buyers such as: manufacturers and recycling facilities. Selling the scrap materials to the corresponding will ensure safer environment. Also the owner can get some cash value back from the demolished materials.

Primarily, construction and demolished materials are sorted by their most constituents. Then materials with the same final destination are grouped together. For example, if the drywalls and floor tiles are going to a construction waste recycling facility, they will be stacked together. Hence, the list is as the following:

1. Cardboard
2. Clean dimensional wood
3. Brick and CMU
4. Ferrous and non-Ferrous metals
5. Recyclable plastic
6. Gypsum wallboard
7. Carpets
8. Existing windows and doors
9. Used equipment liquids
10. Ceiling tiles
11. Other waste materials

Many opportunities exist for the beneficial recovery of materials that would otherwise be destined for disposal as waste. Despite the fact that recycling is favorable for the environment, separation and recovery of solid waste is substantially less expensive than the fees charged for the landfills. More importantly, this section of the analysis suggests the most efficient strategy for the different waste types taking into consideration environmental and financial importance. That being said, reuse of materials is optimum option since it offers minimal waste and return monetary value. If reuse is not feasible, recycling comes second in the list as the material is driven through process to be incorporated in new products. Finally, if recycling is not an option, the material will be disposed of at licensed and permitted landfill. The diagram below clearly illustrates the three options for designating waste materials.

Figure 3.2- Construction and demolished material refining process

The next step is grouping the 11 items from the list to three groups according their validities for reuse, recycling or disposal. Selecting what material goes where is decided by considering the most efficient option available. For example, if the used equipment oil can be reused in Brazil, it is not efficient to ship it all the way to Brazil. Besides, the cost required by the destined facility is also considered. Landfills license and permit and some recycling plants charge contractors per vehicle or per ton. However, the fees collected by the recycling facilities is very minimal which ranges from $0-$40 per ton[6]. Bearing that in mind the following materials are selected to be kept for reuse. The owner keeps what belongs to the building while the contractor keeps what belongs to the construction. Also Penn State can include the materials in the bedding organized by the Office of Physical Plant.

In this project, the owner keeps the demolished windows and doors. Meanwhile, the contractor saves the following materials for future projects:

1. Cardboard
2. Clean dimensional wood
3. Recyclable plastic; possible for some products such as: clear plastic cover.

[6] http://www.mininggazette.com

Up to this point, four categories out of eleven of the construction waste materials have cleared out. Proceeding to the next option, recycling materials primarily depends on the capabilities of the near construction waste recycling facilities. Only one recycling plant will be selected to receive the waste to minimize the number of truck trips. Also the waste will be hauled in the largest amount possible.

There is a number of available construction recycling plants around the area of central county. Republic Services is a chain recycling facility in the across the states. Their nearest facility is outside Pittsburgh, 133 miles away from State College. Another option is Waste Management transfer station where they accept shipments in Altoona and ship it to a recycling facility. It is 37 miles away. Construction Junction is based in Pittsburgh which is 130 away.

After comparing the options available, it turned out Republic Services is the best option because they accept the widest verity of materials including the toxic materials. In fact, this company is capable to handle recyclables and refuse waste as well. Consequently, it facilitates the waste management process. The following materials will be hauled to Republic services:

1. Brick and CMU
2. Ferrous and non-Ferrous metals
3. Recyclable plastic
4. Gypsum wallboard
5. Carpets
6. Used equipment liquids
7. Ceiling tiles
8. Other waste materials

Figure 3.3 - Construction waste recycling plant, source: http://contractorsdisposal.com/wp-content/uploads/2015/06/C-D-Recycling-

In conclusion, the purpose of this analysis is to investigate deep in the opportunities available that help promoting sustainability in the Whitmore Laboratory Renovation Project. The focus is in the demolished and construction waste. A new waste management plan is proposed. The demolished and construction materials are sorted by their main consistent. Then they are grouped into three groups: reuse materials, recyclables and refuse waste. The owner and the contractor are responsible for the reuse materials while the recyclables and refuse waste is hauled to Republic Services.

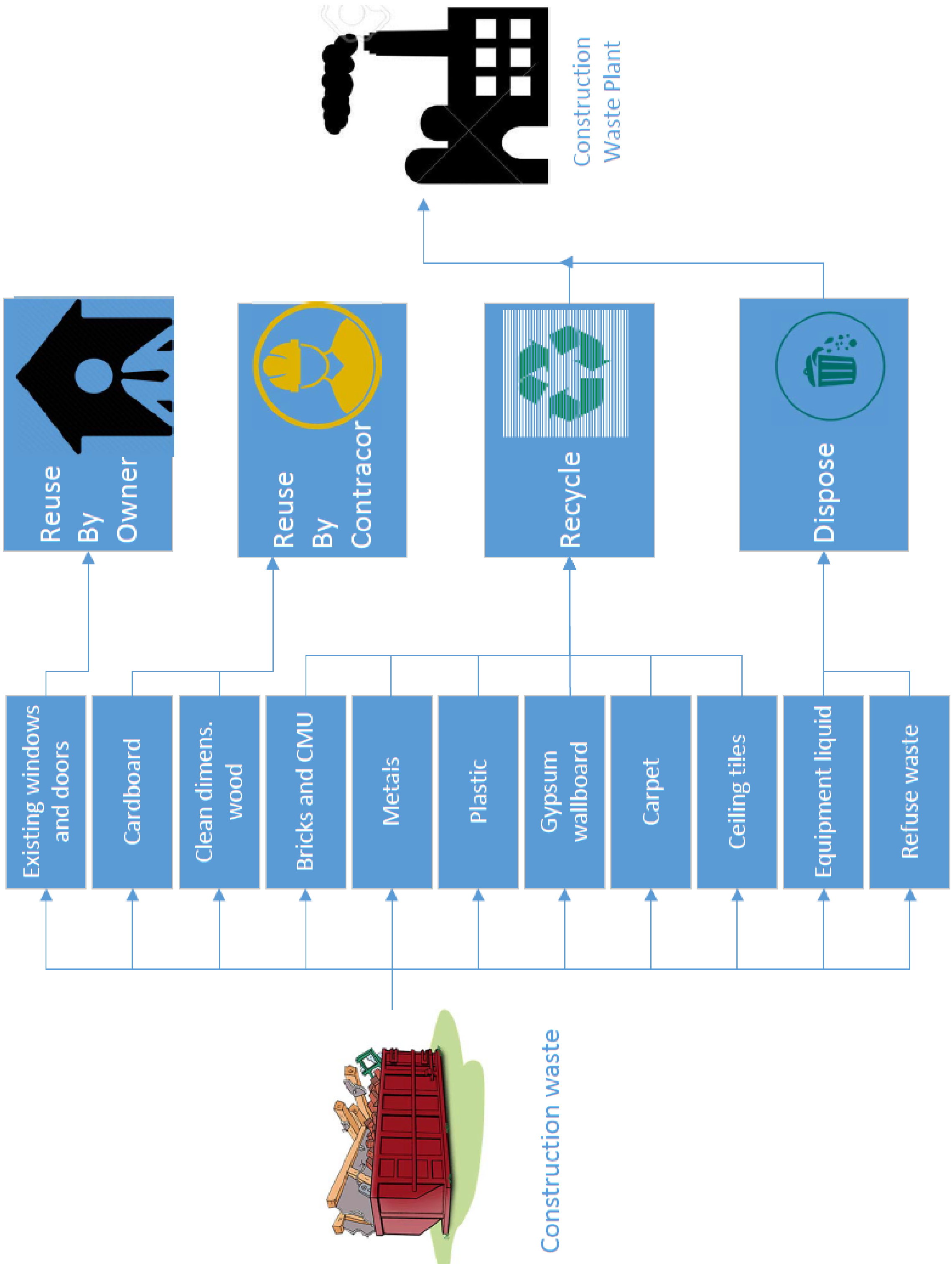

Figure 3.4 - Waste management process map

ANALYSIS IV: LEAN THINKING: IMPLEMENTING FIRST RUN STUDIES

ANALYSIS SUMMARY

This analysis investigates the schedule of activities of the Whitmore Laboratory Renovation project in sake of increasing labor productivity rate. Because the project incorporates several repetitive tasks, first run study seems to be a suitable lean tool for this purpose. Intentionally, one of the most sophisticated tasks is chosen to be the point of investigation. Fume hood installation process requires tremendous amount of coordination with different trades. Therefore, it is a bright idea to bring all of these trades in the same table and let them collectively improve the process.

In this study, the suggested team members are identified with their responsibilities throughout the process. Time and location of the experimented fume hoods are determined based on the project circumstances. Then the procedure is clearly presented mentioning the tools required in the operation. In addition, some calculation is suggested to represent the results in numeric values instead of text description. That will allow the team to use the results in future projects as reference points.

To get back to the point, the aim of this study is to minimize any of the seven types of waste to optimize the fume hood installation process. Consequently, productivity rate increases. It is also expected that some solid waste will be eliminated otherwise it ends up in the recycling containers. That being said, environmental and financial benefits are obtained.

OPPORTUNITY STATEMENT

When comparing the productivity of the construction industry with other industries, the construction industry is actually ranked at the bottom of the list. In a paper published by Intergraph, Factors Affecting Construction Labor Productivity, factors are mainly divided to three categories: labor factors, severity of insufficiencies and severity of extended insufficiencies [8].

In the Whitmore Laboratory Renovation project, there are many improvement opportunities exist. As mentioned at the beginning of this report, the focus of improvement will be in the big problems or opportunities. So it is decided to implement one of the lean construction techniques that would be the most suitable for this project. Looking at the different enhancement possibilities in this project, the fume hoods installation process appears to be an interesting research topic. The project scope includes installing 121 fume hoods, 113 of them are identical. Installing one fume hood involves the contribution of the Electrical, HVAC, plumber and lab case works subcontractors. Undoubtedly, that is a truly intense task which will be repeated 113 times. To avoid conflict issues and optimize the installation process, first run studies is suggested to be implemented in this task.

This analysis aligns with the M.A.E. requirements as the materials from AE 570 (Production Management in Construction) will be integrated here. The research about this lean construction technique will also incorporate other related publications. The goal of this analysis is to develop an implementation guide explaining how to implement first run studies in the fume hood installation process.

RESEARCH

INTRODUCTION

Customers' satisfaction is a goal that every business pursues. On the other side, customers main concern when buying a product or a service is the price. To meet such a customer fulfillment, the price should worth the product/service value. For example, an individual pays $50 for a book to get an equivalent value in return, the value is the knowledge imbedded in that book.

By minimizing the waste during the production process, the processing expenses decreases while the value of the product stays the same. That leads to greater profit brought to the business. First run studies is one of the lean construction techniques that minimizes or the waste produced during work. Namely, the waste can be in: transportation, inventory, motion, waiting, over production, over processing, defects and skills. The construction industry greatly aspires the manufacturing industry because of the advanced technology and techniques they have. For example, building information modeling (BIM) and building automation system (BAS) were borrowed from manufacturing as they were implemented first in manufacturing. Unlike technology and techniques, philosophy has made its way to the construction. By trail and error, some productivity enhancement philosophy has emerged.

In the late 1970's an array of new production management approaches has arisen: just in time (JIT), total quality management (TQM), lean production and concurrent engineering. Although these different approaches suggest varying actions, they share the same overall concept. For instance, JIT eliminates the waiting component while TQM minimizes the related error and rework but both aim to changing the flow of work, information or materials. As the knowledge in this field evolves, lean construction is now understood in three hierarchical tiers. Concept is the highest tier and it states "Production consists of flows and conversations". Then comes the principals such as: reduce variability, compress cycle time and simplify. The bottom tier is where the lean tools are suggested as the JIN, TQM and concurrent engineering [8]. The diagram below shows the three levels of lean construction.

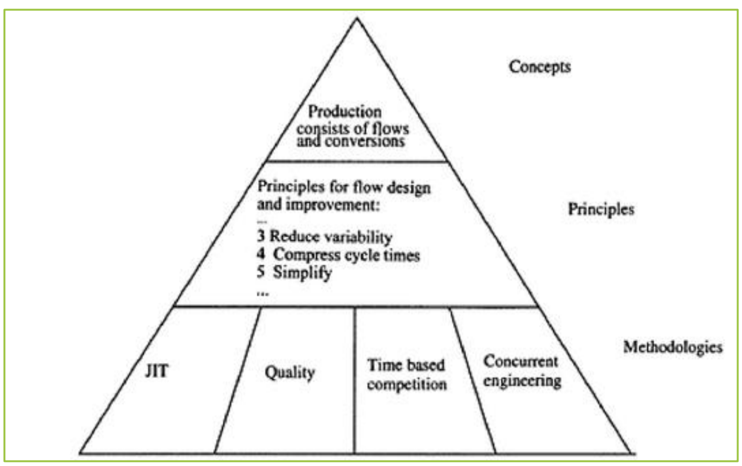

Figure 4.1 - Three levels of production philosophy [8]

In an attempt to bind this research topic with the preceding analysis, construction waste had been neglected for a long time till it became crucial issue. Besides the construction solid waste, non-value adding activities contribute negatively to the construction production. It is difficult to quantify the amount of waste produced by non-value adding activities, yet it is clear that there is a significant gap between the productivity of a construction worker and a manufacturing worker. It is unfortunate to state that construction productivity has been declining as other industries are rising [8].

Some scholar publication suggests conceptualizing the construction process as a flow rather than a series of activities. This concept is applied in the reference origin industry, manufacturing. Bearing that in mind, problem solving would be centralized rather than finding different solutions for multiple problems in hand. To employ this concept, the flows of information, materials and work should be identified and measures. The next step is to classify activities to value-adding, non-value adding and contributory work. Plus, durations and output value should be clearly identified. To improve the process productivity, the most appropriate lean tool should be implemented to the known problem. It is important to use an approach relying on solid theory or experiment results [8].

It is a fact that construction industry is a totally different classification than manufacturing. So what applies to manufacturing is not necessarily applicable for construction. There are some peculiarities in construction including: unique project design, varying site conditions, varying logistics and different facility sizes. These variables and others are distinctive for each particular project, which hinder visualizing construction as flows as observed in manufacturing. However, these peculiarities can be overcome to some degree depending on the complexity of the project. In other words, construction and manufacturing share the same challenge but in different situation. For example, manufacturer was able to develop a product that never existed before. Then they were able to shorten the takt time and increase the output quality using principles of the philosophy. Likewise, these principles can be tailored to construction. More specifically, each project would have a unique implementation guide as what will be presented later in this paper.

As a result, there is a series of practices developed to increase the construction industry. Standardization and modular conditions has been an evolving industry. For example, The Hilton Palacio del Rio Hotel in San Antonio is a 21-story modularized building. 496 rooms were lifted in 46 days[7]. Similarly, prefabrication is implemented to shift the work from the job site to the shop. A prefabricated part can be built by multiple disciplines such as the plenum rack that has: HVAC, plumbing, electrical, fire, and low-voltage systems preinstalled and rack

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[7] http://www.modular.org/htmlPage.aspx?HtmlPageId=400, March 24, 2016

is ready to be mounted to the slab. Another enhancement technique is the encouragement of long-term agreement among contractors and suppliers to reduce short linkages. That in turn lead to more cooperation between entities.

By now, a good background is presented of the effort done in improving construction industries. The next section focuses specifically on one of the construction lean tools known as first run studies.

FIRSTRUN STUDIES

First run study is a member of the continuous improvement (CI) family. Continuous improvement is defined as an on going effort to improve products, services or processes [9]. First run studies approach was first introduce by the Lean Construction Institute (LCI), which is a non-profitable organization founded in 1997 in Virginia. The mission of the institute is to transform the industry through lean project delivery utilizing an operating system centered on a common language, fundamental principles, and basic practices[8].

According to LCI, first run study is defined as trial execution of a process in order to determine the best means, methods, sequencing, etc. to perform it. First-run studies are completed few weeks in advance of the actual execution of the process, while there is time to attain different or additional prerequisites and resources. They may also be performed during design as a basis for evaluating options or designing the portion of the work [9]. For instance, a first run study is done during the design phase to determine which glazing type is going to work the best for the intended purpose. Not surprisingly, plan-do-study-act (PDCA) cycle is strongly related to first run studies as the process of firs run studies follow these four steps. In addition, other supporting materials such as: still photographs, videos, drawings, and sketches can accompany the process.

First run studies are beneficial for designers, general contractors, construction mangers and subcontractors. Alternatively, more than a discipline can share the same study, experiment. It is recommended to do the study in site to experiment the same variables, but that is not

[8] http://www.marketwired.com/press-release/lean-construction-institute-announces-17th-annual-lci-congress-october-12-16-2015-2031899.htm, March 24, 2016

necessary. It may be implemented at any time as long as it is few weeks prior to the scheduled execution time.

BENEFITS

Several beneficial points are gained from first run studies including:

- First run studies help identifying the issues associated with the task beforehand. As it sounds, the study is conducted first then the actual activity is carried on. Any problematic points can be addressed to optimize the process when it comes to the real execution.
- First run studies help developing better understanding of the task leading to reduced uncertainty. Workers, foremen and higher tiers get the chance to become familiar with the task, which is going to save them time and money by decreasing rework and error probability.
- It is a tool to check quality control before installation. For example, a mock-up of the roof at a drainage opening is built to test constructability.

MOCK-UPS

Mock ups are used to obtain the benefits mentioned above and minimize the potential waste that can be produced by rework. "Mock ups allow for discovery of questions and potential constructability issues prior to assembling the materials on the building which could lead to schedule delays and costly rework" Brian Stroik said [4]. By implementing first run studies, the flows of information, materials and work become clear to team which enable them to find solutions that would improve the overall process. Smaller details are revealed in the mock ups otherwise they would be hindering aspects later in the project. A section of the building envelope is often built in site to coordinate the different trades. Examples of common uses of mock ups are:

- Air infiltration
- Smoke tracer tester
- Static water pressure resistance
- Structural performance
- Dynamic water pressure resistance

The figure below illustrates the focus points in a building envelop mock-up.

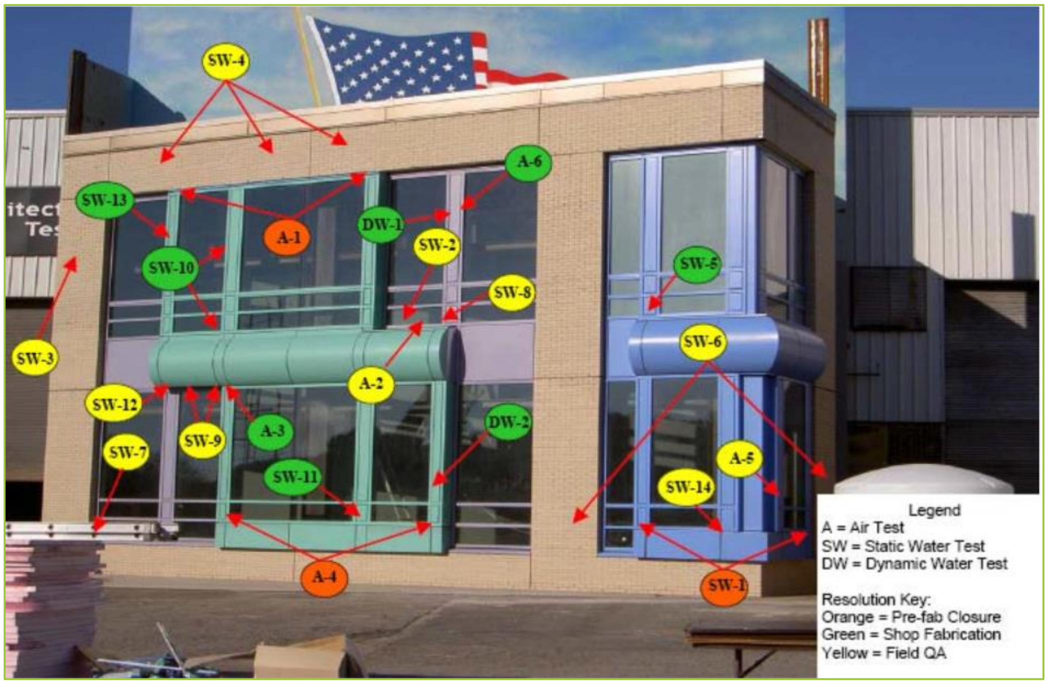

Figure 4.2 - Issues discovered in a mock-up [11]

Some mock ups require to be tested in a controlled environment as a laboratory because special equipment is used to complete the test. A good example is Dr. Memari, A. lab in the Engineering Unit A. They test the structural performance of different glazing systems. On the other hand, a mock up can be an actual part of the building built carefully in site in advance to

Figure 4.3 - on-site mock up testing [11]

Figure 4.4 - Mock up testing in lab [11]

get the owner and the architect agreement. It is preferred this way because it saves transportation and traveling fees. The two figures presented above, in-site and in lab testing.

Virtual first run studies (VFRS) is an emerging technology in the construction market. There are some software tools developed to prototype of the facility and perform some simulation. VFRS has been implemented in a Liquefied Natural Gas (LNG) plant refurbishment in West Australia [12]. Not like the physical mock up, VFRS is cost effective as it eliminates labor, material, and transportation cost.

CASE STUDY

A first run studies were done on a project along with other lean construction tools. The project is a four-story university garage facility. The structure is reinforced cast in place concrete which sits on top of a five-story retail shops and dormitories. The first five stories are streel framed with reinforced concrete walls. The total area of the project is around 133,500 SQFT. The research team (RT) limited participation to the general contractor, framework subcontractor and the rebar subcontractor. The GC is a mid size construction contractor and had past experience in lean construction. The GC management team has suggested using Last Planner in this project. On average, there are 7 staff and 26 laborers on site work for the GC. The other two subs have 14 and 15 workers respectively, on site everyday. The master schedule was distributed into four stages: general conditions, underground utilities, phase I and phase II. The project was expected for 171 working days based on 5 days per week. The lean tools research focused on phase one, which had 105 days but was finished within 81 days [12].

Due to the insufficient experience the GC and the subcontractors have in lean tools, there was a champion appointed for each lean tool. The responsibility of the champion is to follow the guidelines and report the feedback to the RT. Within each tool, there were two teams: planners' team and workers' team. The first one was managed by the project manager and involved the GC's superintendent, the foreman, both of the subcontractors, and the project engineer. Their responsibility was to plan and control the operational part. The second team consist of the foreman carpenter (leader) and laborers. They had their everyday huddle meetings.

Accompanying other case studies, the research team conducted two first run studies. One was on bumper walls while the other was on construction joints. The guideline was basically the PDCA cycle:

- Plan: the targeted activities were selected by the GC's superintendent depending on aimed cost and variability. The team then reviewed the drawings and specifications of each component. Next the foreman decided the dates of the study execution based on the scheduled tasks. The proposed procedure was reviewed with the foreman prior to the actual action was carried out.
- Do: as a step in the operation, documenting the process was essential because weather and surrounding constrains affected the activities time and duration. For better results, each element was repeated and data collected twice. Likewise, video was used to help tracking and ensuring all of the operation elements were performed.
- Check: the team held two meetings where part of the video is viewed and discussed. Then the activities are brainstormed for better performance. Series of ideas were proposed by the project manager, the foreman and the involved workers. Then these ideas were evaluated by the project manager and the foreman for feasibility. It was important in the meetings to let the workers speak freely about how the work can be improved.
- Act: the approved suggestions were integrated to the subsequent activities. The ideas were not limited to the meetings, yet the meetings assisted formalizing the ideas and actually applying them in the work area.

Figure 4.5- PDCA cycle, source: https://pbs.twimg.com/profile_images/2248203374/PDCA.jpg

The study went further and included productivity calculation to be used as a baseline for future projects. Going through out the videos, activities' durations were divided and sorted under one of the three labels: effective work (E), contributory work (C) and idle work (A). This way allowed the RT to numerically quantify the productivity rate. Then some productivity rating analysis were applied, Labor Utilization Factor (LUF). Data collected for field observation on one-minute intervals was plotted in a crew balance chart. Subsequently, the charts were used to calculate LUF and productivity rating as follows:

$$LUF = \frac{effective\ work + \frac{1}{4} essential\ work}{total\ observed} = \frac{E + \frac{1}{4} C}{E + C + A}$$

$$productivity\ rating = \frac{work}{total\ observed} = \frac{E + C}{E + C + A}$$

complying with the recommendations to improve productivity, the crew balance chart was modified accordingly, which in turn changed the LUF. As a result, the a standard crew and activity sequence were developed, but the estimations were not accurate due to some undocumented elements.

IMPLEMENTATION AND RESULTS

For the Whitmore Laboratory Renovation project, first run studies are suggested to be conducted on the process of installing the fume hoods. The proposed implementation guide is customized for one type of the fume hoods, 113 units to be installed. For continuity, the data will be collected from two subsequent units' installations. And this operation will take place two weeks prior to the scheduled activity. The fume hood is connected to the HVAC, plumbing, electrical systems. Also, alignment with lab casework is important. Apparently, there are four major trades involved in the operation. Therefore, the study team will include the project manager, project engineer, GC's superintendent and the foremen of each trade. The project manager will lead the team and the project engineer will coordinate documents, permissions and meetings. More specifically, the list below expand on the logistics of the operation.

Participants

1. Barton Malow (Project Manager)
2. Barton Malow (Project Engineer)
3. J.C. Orr (Superintendent)
4. North Central Mechanical (Ductwork Foreman)
5. North Central Mechanical (Plumbing Foreman)
6. Westmoreland Electrical (Electrical Foreman)
7. Northeast Interior Systems (Lab Casework Foreman)

Location

The first unit to be installed the one located in room 221 in the northern west corner and the second unit will be the one next to it from the east side.

Time

Fume hood installation is scheduled for September 10, 2015. Thus the study would be done on August 27, 2015. That is two weeks before the actual operation.

PDCA cycle is the primary four steps while there some calculation will be carried out to determine the results in numbers rather than text description. This would be reference point for future work. More importantly, the PDCA procedure is as follows:

- Plan: the superintendent is responsible for determining the activities that will be involved in the operation. For example: electric termination and plumbing connection are related tasks. Then, the team reviews the drawings and specifications associated with each element. In addition, a camera should be supplied and it is foremen responsibility to operate the camera. It is critical to ensure the foremen understand the procedure so they can convey accurate information to laborers. Logistics such as time and location are confirmed by the project manager.
- Do: the foremen provide their crews with with the agreed instructions. The work for each crew shall not be interrupted for the duration of installing two fume hoods. The foremen ensure the camera is recording and should check it every 30 minutes.
- Check: this action takes a place in a form of a meeting where important parts of the video are view to all the participants. Not to mention, laborers are involved in this meeting. Collectively, the big concerns are highlighted and brought to table. While, the project manager leads the meeting, everyone is welcome to give suggestions and recommendations. Especially, workers are encouraged to share their opinions on how the process can be improved. By the end of the meeting, the team should have agreed formalized decision which will be included in the succeeding activities.
- Act: the results from the meetings are incorporated in the schedule of activities. If some performance change is suggested, the responsible trade should comply. Ideas are accepted from the meeting and outside the meeting but they should be discussed and agreed on before implementation.

As part of the productivity analysis, the duration of a certain crew doing a certain task are recorded. Then, the data are represented in a plot of unit completed versus time. This will show the productivity rate for each crew. For example, the electric crew roughs in 10 feet of conduit in 1 hour while the ductwork crew install 5 feet of duct in 1 hour. In this case, the crew size can be manipulated to match productivity rates of the different trades.

To put it briefly, first run study is recommended for the Whitmore Laboratory Renovation project due to the fact that the project consists of many repetitive activities. As an investigation point, fume hood installation process appeared to be a suitable task for this purpose. Team members and operation time and location are determined considering some circumstances in the project. Also, members' responsibilities are demonstrated in the PDCA steps. The aim of this study is to minimize any of the seven types of waste to optimize the fume hood installation process. Consequently, productivity rate increases. It is also expected that some solid waste will be eliminated by having cooperation among the project parties. That being said, environmental and financial advantages are gained.

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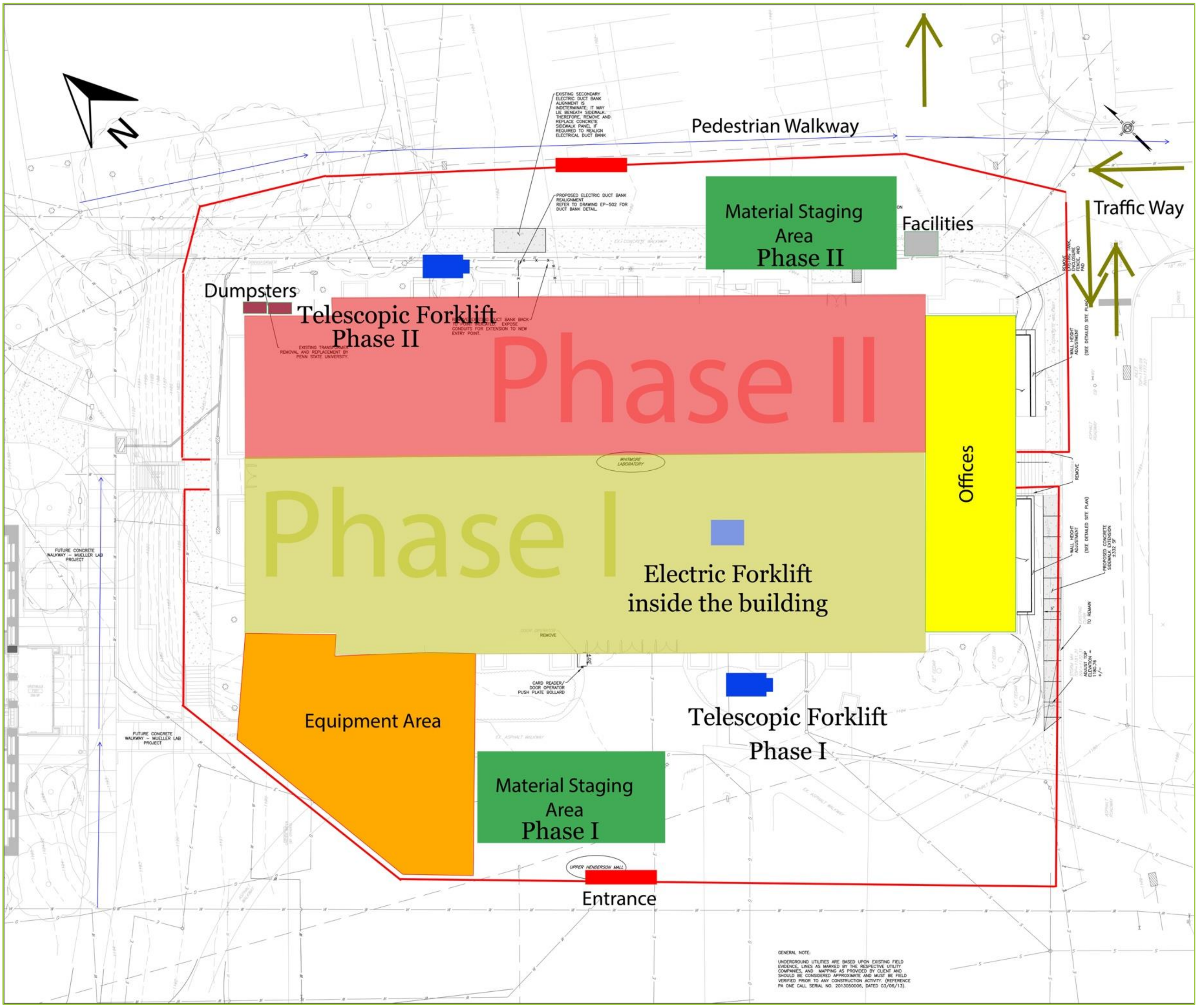
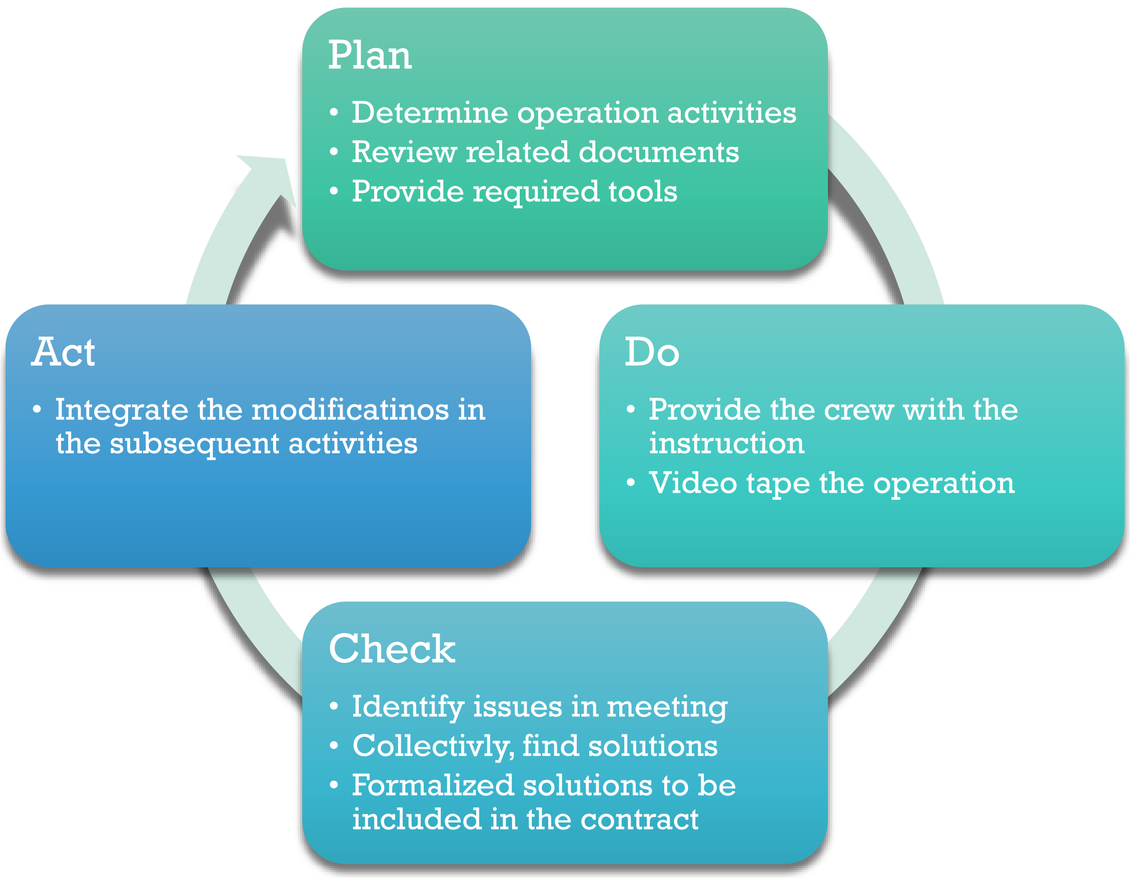
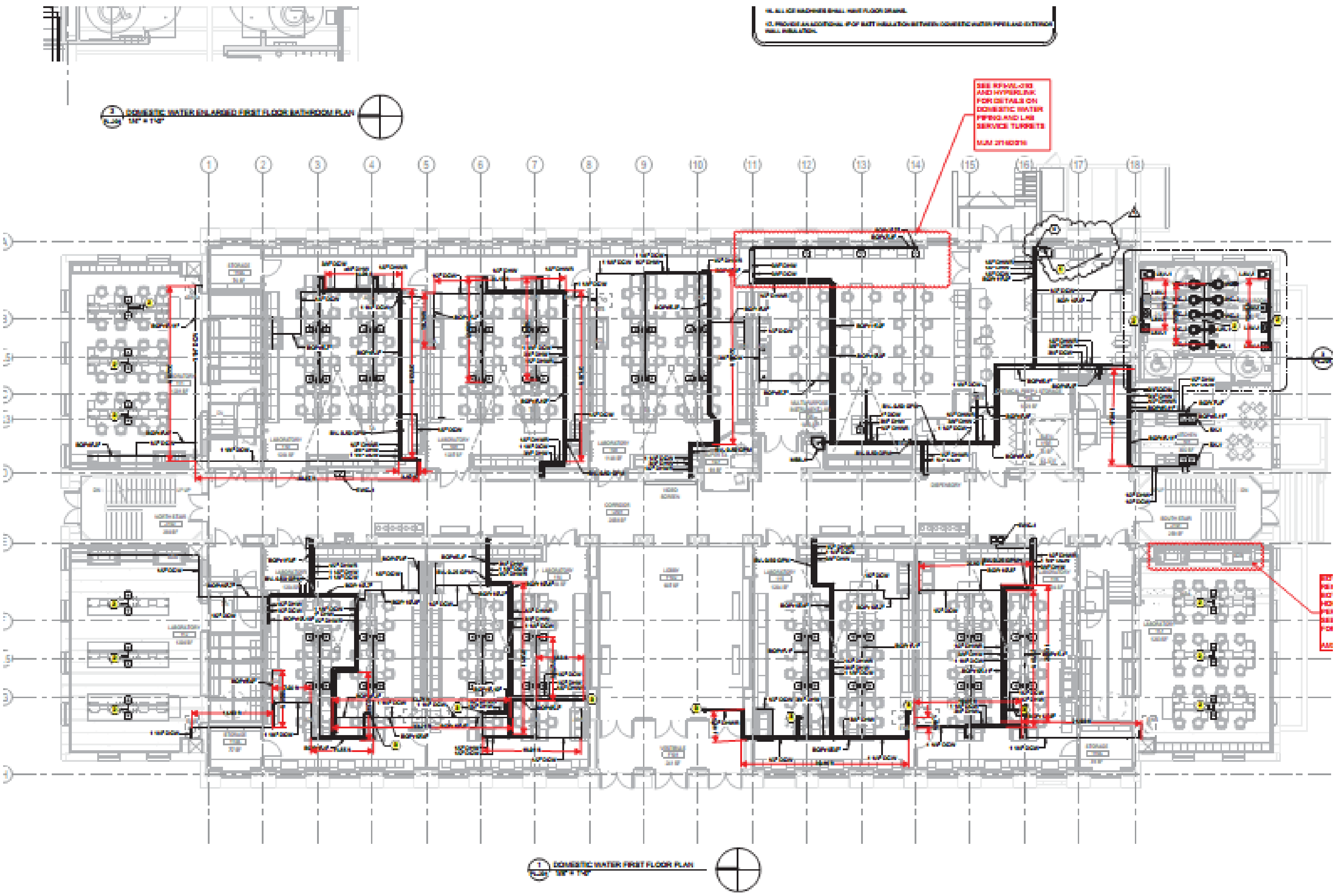
APPENDIX A: SITE PLAN



APPENDIX B: PDCA CYCLE



APPENDIX C: SAMPLE PIPING QUANTITY TAKE-OFF



Price List 2014

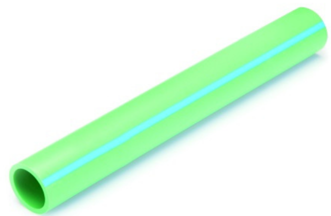
Effective July 1, 2014

Green pipe SDR 7.4 MF -- domestic hot water applications							
Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
0670708	1/2" (20 mm) Green Pipe SDR 7.4 MF	100 m	325 ft	4.989	1.535	
0670710	3/4" (25 mm) Green Pipe SDR 7.4 MF	100 m	325 ft	7.514	2.312	
0670712	1" (32 mm) Green Pipe SDR 7.4 MF	40 m	130 ft	12.392	3.813	
0670714	1 1/4" (40 mm) Green Pipe SDR 7.4 MF	40 m	130 ft	18.727	5.762	
0670716	1 1/2" (50 mm) Green Pipe SDR 7.4 MF	20 m	65 ft	30.592	9.413	
0670718	2" (63 mm) Green Pipe SDR 7.4 MF	20 m	65 ft	46.677	14.362	
0670720	2 1/2" (75 mm) Green Pipe SDR 7.4 MF	20 m	65 ft	67.961	20.911	
0670722	3" (90 mm) Green Pipe SDR 7.4 MF	12 m	39 ft	90.106	27.725	
0670724	3 1/2" (110 mm) Green Pipe SDR 7.4 MF	8 m	26 ft	128.200	39.446	
0670726	4" (125 mm) Green Pipe SDR 7.4 MF	4 m	13 ft	154.235	47.457	
0670730	6" (160 mm) Green Pipe SDR 7.4 MF	5.8 m	19 ft	213.557	65.191	Stick length is 4 m or 13' pipe 4" and down
0670734	8" (200 mm) Green Pipe SDR 7.4 MF	5.8 m	19 ft	333.450	101.790	Stick length is 5.8 m 19' for pipe 6" and up
0670738	10" (250 mm) Green Pipe SDR 7.4 MF	5.8 m	19 ft	516.662	157.718	
0070742	12" (315 mm) Green Pipe SDR 7.4 MF	5.8 m	19 ft	870.623	265.769	
0070744	14" (355 mm) Green Pipe SDR 7.4 MF	5.8 m	19 ft	1,198.661	365.907	

APPENDIX D: AQUATHERM PRICES LIST 2014

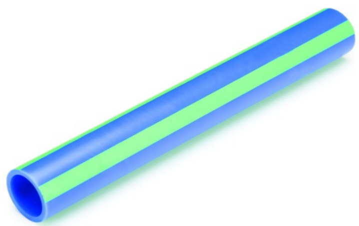
Green pipe SDR 11 -- domestic cold water applications

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
0610808	1/2" (20 mm) SDR 7.4 Green Pipe (non-MF)	100 m	325 ft	3.686	1.134	
0610810	3/4" (25 mm) SDR 7.4 Green Pipe (non-MF)	100 m	325 ft	5.629	1.732	
0610212	1" (32 mm) Green Pipe SDR 11	40 m	130 ft	7.745	2.383	
0610214	1 1/4" (40 mm) Green Pipe SDR 11	40 m	130 ft	11.921	3.668	
0610216	1 1/2" (50 mm) Green Pipe SDR 11	20 m	65 ft	18.723	5.761	
0610218	2" (63 mm) Green Pipe SDR 11	20 m	65 ft	29.799	9.169	
0610220	2 1/2" (75 mm) Green Pipe SDR 11	20 m	65 ft	41.980	12.917	
0610222	3" (90 mm) Green Pipe SDR 11	12 m	39 ft	57.541	17.705	
0610224	3 1/2" (110 mm) Green Pipe SDR 11	8 m	26 ft	87.328	26.870	
0610226	4" (125 mm) Green Pipe SDR 11	4 m	13 ft	105.788	32.550	
0610230	6" (160 mm) Green Pipe SDR 11	5.8 m	19 ft	139.601	42.615	
0610234	8" (200 mm) Green Pipe SDR 11	5.8 m	19 ft	218.739	66.773	Stick length is 4 m or 13' pipe 4" and down
0610238	10" (250 mm) Green Pipe SDR 11	5.8 m	19 ft	328.484	100.274	Stick length is 5.8 m 19' for pipe 6" and up
0010242	12" (315 mm) Green Pipe SDR 11	5.8 m	19 ft	498.383	152.138	
0010244	14" (355 mm) Green Pipe SDR 11	5.8 m	19 ft	751.090	229.280	
0010246	16" (400 mm) Green Pipe SDR 11	5.8 m	19 ft	1,205.298	367.933	
0010248	18" (450 mm) Green Pipe SDR 11	5.8 m	19 ft	1,486.760	453.853	
0010308	1/2" (20 mm) Green Pipe SDR 11 - coil	100 m	325 ft	3.422	1.053	Coil length is 100 m for 1/2" and 3/4"
0010310	3/4" (25 mm) Green Pipe SDR 11 - coil	100 m	325 ft	4.937	1.519	or 50 meters for 1"
0010312	1" (32 mm) Green Pipe SDR 11 - coil	50 m	162 ft	7.745	2.383	(325 or 162.5 feet)



Blue pipe SDR 11 MF -- hydronics, geothermal, and non-potable applications

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
2670708	1/2" (20 mm) Blue Pipe SDR 7.4 MF	100 m	325 ft	4.050	1.246	
2670710	3/4" (25 mm) Blue Pipe SDR 7.4 MF	100 m	325 ft	6.328	1.947	
2670112	1" (32 mm) Blue Pipe SDR 11 MF	40 m	130 ft	7.313	2.250	
2670114	1 1/4" (40 mm) Blue Pipe SDR 11 MF	40 m	130 ft	11.473	3.530	
2670116	1 1/2" (50 mm) Blue Pipe SDR 11 MF	20 m	65 ft	17.316	5.328	
2670118	2" (63 mm) Blue Pipe SDR 11 MF	20 m	65 ft	27.996	8.614	
2670120	2 1/2" (75 mm) Blue Pipe SDR 11 MF	20 m	65 ft	39.800	12.246	
2670122	3" (90 mm) Blue Pipe SDR 11 MF	12 m	39 ft	55.055	16.940	
2670124	3 1/2" (110 mm) Blue Pipe SDR 11 MF	8 m	26 ft	81.666	25.128	
2670126	4" (125 mm) Blue Pipe SDR 11 MF	4 m	13 ft	102.476	31.531	
2670130	6" (160 mm) Blue Pipe SDR 11 MF	5.8 m	19 ft	125.829	38.411	
2670134	8" (200 mm) Blue Pipe SDR 11 MF	5.8 m	19 ft	219.335	66.955	Stick length is 4 m or 13' pipe 4" and down
2670138	10" (250 mm) Blue Pipe SDR 11 MF	5.8 m	19 ft	330.177	100.791	Stick length is 5.8 m 19' for pipe 6" and up
2070142	12" (315 mm) Blue Pipe SDR 11 MF	5.8 m	19 ft	547.419	167.107	
2070144	14" (355 mm) Blue Pipe SDR 11 MF	5.8 m	20 ft	793.732	242.297	
2070146	16" (400 mm) Blue Pipe SDR 11 MF	5.8 m	21 ft	1,269.069	387.400	
2070148	18" (450 mm) Blue Pipe SDR 11 MF	5.8 m	22 ft	1,493.443	455.893	
2010308	1/2" (20 mm) Blue Pipe SDR 11 - coil (non-MF)	100 m	325 ft	2.977	0.916	Coil length is 100 m for 1/2" and 3/4"
2010310	3/4" (25 mm) Blue Pipe SDR 11 - coil (non-MF)	100 m	325 ft	4.095	1.260	or 50 meters for 1"
2010312	1" (32 mm) Blue Pipe SDR 11 - coil (non-MF)	50 m	162 ft	6.637	2.042	(325 or 162.5 feet)



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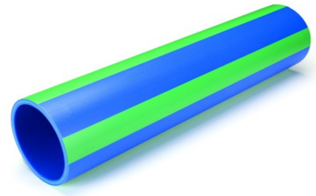
500 S 500 W Buliding #1
Lindon, UT 84042-
Phone: 801-805-6657
Fax: 801-326-4830

ussales@aquatherm.com
www.aquatherm.com

Blue pipe SDR 17.6 MF -- hydronics, geothermal, and non-potable applications

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
2570126	4" (125 mm) Aquatherm Blue Pipe SDR 17.6 MF	4 m	13 ft	82.316	25.128	
2570130	6" (160 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	108.487	33.117	
2570134	8" (200 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	173.804	53.056	
2570138	10" (250 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	259.494	79.214	
2570142	12" (315 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	397.722	121.410	
2570144	14" (355 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	504.083	153.878	
2570146	16" (400 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	642.223	196.047	
2570148	18" (450 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	821.413	250.747	
2570150	20" (500 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	1,036.276	316.337	
2570152	22" (560 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	1,350.291	412.194	Stick length is 4 m or 13' pipe 4" and down
2570154	24" (630 mm) Blue Pipe SDR 17.6 MF	5.8 m	19 ft	1,855.753	566.493	Stick length is 5.8 m or 19' for pipe 6" and up



Lilac pipe -- Reclaimed water applications

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
9010808	1/2" -- 20 mm SDR7.4 lilac	100 m	325 ft	4.050	1.246	
9010810	3/4" -- 25 mm SDR7.4 lilac	100 m	325 ft	6.328	1.947	
9010212	1" -- 32 mm SDR11 lilac	40 m	130 ft	7.745	2.383	
9010214	1.25" -- 40 mm SDR11 lilac	40 m	130 ft	11.921	3.668	
9010216	1.5" -- 50 mm SDR11 lilac	20 m	65 ft	18.723	5.761	
9010218	2" -- 63 mm SDR11 lilac	20 m	65 ft	29.799	9.169	
9010220	2.5" -- 75 mm SDR11 lilac	20 m	65 ft	41.980	12.917	
9010222	3" -- 90 mm SDR11 lilac	12 m	39 ft	57.541	17.705	
9010224	3.5" -- 110 mm SDR11 lilac	8 m	26 ft	87.328	26.870	
9010226	4" -- 125 mm SDR11 lilac	4 m	13 ft	105.788	32.550	
9010230	6" -- 160 mm SDR11 lilac	5.8 m	19 ft	139.601	42.615	Stick length is 4 m or 13' pipe 4" and down
9010234	8" -- 200 mm SDR11 lilac	5.8 m	19 ft	226.598	69.172	Stick length is 5.8 m 19' for pipe 6" and up
9010238	10" -- 250 mm SDR11 lilac	5.8 m	19 ft	340.257	103.868	

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Green pipe SDR 7.4 MF UV

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
0670758	1/2" (20 mm) Green Pipe SDR 7.4 UV MF	100 m	325 ft	5.811	1.788	8-12 week Lead Time
0670760	3/4" (25 mm) Green Pipe SDR 7.4 UV MF	100 m	325 ft	8.655	2.663	
0670762	1" (32 mm) Green Pipe SDR 7.4 UV MF	40 m	130 ft	13.647	4.199	
0670764	1 1/4" (40 mm) Green Pipe SDR 7.4 UV MF	40 m	130 ft	20.329	6.255	
0670766	1 1/2" (50 mm) Green Pipe SDR 7.4 UV MF	20 m	65 ft	35.211	10.834	
0670768	2" (63 mm) Green Pipe SDR 7.4 UV MF	20 m	65 ft	49.189	15.135	
0670770	2 1/2" (75 mm) Green Pipe SDR 7.4 UV MF	20 m	65 ft	71.529	22.009	
0670772	3" (90 mm) Green Pipe SDR 7.4 UV MF	12 m	39 ft	103.773	31.930	
0670774	3 1/2" (110 mm) Green Pipe SDR 7.4 UV MF	8 m	26 ft	134.482	41.379	
0670776	4" (125 mm) Green Pipe SDR 7.4 UV MF	4 m	13 ft	160.940	49.520	
0670780	6" (160 mm) Green Pipe SDR 7.4 UV MF	5.8 m	19 ft	277.580	84.735	Stick length is 4 m or 13' pipe 4" and down
0670784	8" (200 mm) Green Pipe SDR 7.4 UV MF	5.8 m	19 ft	409.296	124.943	Stick length is 5.8 m 19' for pipe 6" and up
0670788	10" (250 mm) Green Pipe SDR 7.4 UV MF	5.8 m	19 ft	531.296	162.185	

Blue pipe SDR 11 MF UV

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
2670758	1/2" (20 mm) Blue Pipe SDR 7.4 UV MF	100 m	325 ft	5.990	1.843	8-12 week Lead Time
2670760	3/4" (25 mm) Blue Pipe SDR 7.4 UV MF	100 m	325 ft	8.359	2.572	
2670162	1" (32 mm) Blue Pipe SDR 11 UV MF	40 m	130 ft	10.663	3.281	
2670164	1 1/4" (40 mm) Blue Pipe SDR 11 UV MF	40 m	130 ft	15.038	4.627	
2670166	1 1/2" (50 mm) Blue Pipe SDR 11 UV MF	20 m	65 ft	23.738	7.304	
2670168	2" (63 mm) Blue Pipe SDR 11 UV MF	20 m	65 ft	36.004	11.078	
2670170	2 1/2" (75 mm) Blue Pipe SDR 11 UV MF	20 m	65 ft	51.418	15.821	
2670172	3" (90 mm) Blue Pipe SDR 11 UV MF	12 m	39 ft	71.471	21.991	
2670174	3 1/2" (110 mm) Blue Pipe SDR 11 UV MF	8 m	26 ft	101.498	31.230	
2670176	4" (125 mm) Blue Pipe SDR 11 UV MF	4 m	13 ft	129.204	39.755	
2670180	6" (160 mm) Blue Pipe SDR 11 UV MF	5.8 m	19 ft	224.216	68.445	Stick length is 4 m or 13' pipe 4" and down
2670184	8" (200 mm) Blue Pipe SDR 11 UV MF	5.8 m	19 ft	372.079	113.582	Stick length is 5.8 m 19' for pipe 6" and up
2670188	10" (250 mm) Blue Pipe SDR 11 UV MF	5.8 m	19 ft	573.879	175.184	

Blue pipe SDR 17.6 MF UV

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot	Notes
2570180	6" (160 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	126.514	38.620	8-12 week Lead Time
2570184	8" (200 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	212.833	64.970	
2570188	10" (250 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	301.550	92.052	
2570192	12" (315 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	444.495	135.688	
2570194	14" (355 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	560.713	171.165	
2570196	16" (400 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	712.615	217.535	
2570198	18" (450 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	913.812	278.953	
2570200	20" (500 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	1,160.425	354.235	
2570202	22" (560 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	1,537.926	469.472	
2570204	24" (630 mm) Blue Pipe SDR 17.6 UV MF	5.8 m	19 ft	2,055.970	627.612	Stick length is 5.8 m 19' for pipe 6" and up

Accessories

Pipe Clamps

Item No.	Description	Packing Unit	Price Unit	List price each
0060520	1/2" (20 mm) Pipe Clamps	50	each	4.108
0060525	3/4" (25 mm) Pipe Clamps	50	each	4.734
0060532	1" (32 mm) Pipe Clamps	50	each	5.152
0060540	1 1/4" (40 mm) Pipe Clamps	50	each	5.291
0060550	1 1/2" (50 mm) Pipe Clamps	50	each	5.778
0060563	2" (63 mm) Pipe Clamps	25	each	7.170
0060575	2 1/2" (75 mm) Pipe Clamps	25	each	9.190
0060590	3" (90 mm) Pipe Clamps	25	each	9.886
0060594	3 1/2" (110 mm) Pipe Clamps	25	each	10.861
0060595	4" (125 mm) Pipe Clamps	25	each	12.183
0060597	6" (160 mm) Pipe Clamps	25	each	14.829
0060650	8" (200 mm) Pipe Clamps	1	each	53.094
0060654	10" (250 mm) Pipe Clamps	1	each	60.680
0060658	12" (315 mm) Pipe Clamps	1	each	73.160
0060660	14" (355 mm) Pipe Clamps	1	each	83.572

Pipe fastening bows

Item No.	Description	Packing Unit	Price Unit	List price each
0060604	1 3/8" (45 mm) Fastening Strap - Single	50	each	0.721
0060606	2 1/2" (75 mm) Fastening Strap - Single	50	each	0.891
0060608	1 3/8" (45 mm) Fastening Strap - Double	50	each	0.972
0060610	2 1/2" (75 mm) Fastening Strap - Double	50	each	1.033

Notes

Suitable for 20 - 32 mm aquatherm-pipe and aquatherm-SHT-Pipe.

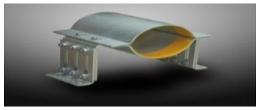
(shaft ø = 3/16" (8mm))

Plastic pipe clamps

Item No.	Description	Packing Unit	Price Unit	List price each
0060620	1/2" (20 mm) Plastic Pipe Clamps	50	each	0.729
0060625	3/4" (25 mm) Plastic Pipe Clamps	30	each	1.154

Pipe clamps for fixed-point installation

Item No.	Description	Packing Unit	Price Unit	List price each
0060668	6" (160 mm) Pipe Clamps	1	each	334.530
0060670	8" (200 mm) Pipe Clamps	1	each	809.109
0060674	10" (250 mm) Pipe Clamps	1	each	835.254
0060678	12" (315 mm) Pipe Clamps	1	each	1,017.261



Fittings

Couplings

Item No.	Description	Packing Unit	Price Unit	List price each
0111008	1/2" (20 mm) Coupling	10	each	1.765
0111010	3/4" (25 mm) Coupling	10	each	1.972
0111012	1" (32 mm) Coupling	5	each	2.600
0111014	1 1/4" (40 mm) Coupling	5	each	3.114
0111016	1 1/2" (50 mm) Coupling	5	each	6.539
0111018	2" (63 mm) Coupling	1	each	13.079
0111020	2 1/2" (75 mm) Coupling	1	each	14.636
0111022	3" (90 mm) Coupling	1	each	32.172
0111024	3 1/2" (110 mm) Coupling	1	each	52.328
0111026	4" (125 mm) Coupling	1	each	68.663

Bushings

Item No.	Description	Packing Unit	Price Unit	List price each
0111112	3/4" to 1/2" (25 mm to 20 mm) Bushing	10	each	1.972
0111114	1" to 1/2" (32 mm to 20 mm) Bushing	5	each	2.633
0111116	1" to 3/4" (32 mm to 25 mm) Bushing	5	each	2.633
0111118	1 1/4" to 1/2" (40 mm to 20 mm) Bushing	5	each	4.051
0111120	1 1/4" to 3/4" (40 mm to 25 mm) Bushing	5	each	4.051
0111122	1 1/4" to 1" (40 mm to 32 mm) Bushing	5	each	4.051
0111124	1 1/2" to 1/2" (50 mm to 20 mm) Bushing	5	each	6.699
0111126	1 1/2" to 3/4" (50 mm to 25 mm) Bushing	5	each	6.699
0111128	1 1/2" to 1" (50 mm to 32 mm) Bushing	5	each	6.699
0111130	1 1/2" to 1 1/4" (50 mm to 40 mm) Bushing	5	each	6.699
0111131	2" to 1/2" (63 mm to 20 mm) Bushing	1	each	13.398
0111132	2" to 3/4" (63 mm to 25 mm) Bushing	1	each	13.398
0111134	2" to 1" (63 mm to 32 mm) Bushing	1	each	13.398
0111136	2" to 1 1/4" (63 mm to 40 mm) Bushing	1	each	13.398
0111138	2" to 1 1/2" (63 mm to 50 mm) Bushing	1	each	13.398
0111143	2 1/2" to 1/2" (75 mm to 20 mm) Bushing	1	each	14.993
0111144	2 1/2" to 3/4" (75 mm to 25 mm) Bushing	1	each	14.993
0111145	2 1/2" to 1" (75 mm to 32 mm) Bushing	1	each	14.993

Notes

the bushing will socket fuse into a
2" fitting (tee, elbow, outlet, etc)

a 1" pipe will socket fuse into the bushing

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Bushings Continued

0111139	2 1/2" to 1 1/4" (75 mm to 40 mm) Bushing	1	each	14.993
0111140	2 1/2" to 1 1/2" (75 mm to 50 mm) Bushing	1	each	14.993
0111142	2 1/2" to 2" (75 mm to 63 mm) Bushing	1	each	14.993
0111151	3" to 1 1/2" (90 mm to 50 mm) Bushing	1	each	33.388
0111152	3" to 2" (90 mm to 63 mm) Bushing	1	each	33.388
0111153	3" to 2 1/2" (90 mm to 75 mm) Bushing	1	each	33.388
0111155	3 1/2" to 2" (110 mm to 63 mm) Bushing	1	each	53.373
0111157	3 1/2" to 2 1/2" (110 mm to 75 mm) Bushing	1	each	53.373
0111159	3 1/2" to 3" (110 mm to 90 mm) Bushing	1	each	53.373
0111161	4" to 2 1/2" (125 mm to 75 mm) Bushing	1	each	65.127
0111163	4" to 3" (125 mm to 90 mm) Bushing	1	each	81.004
0111165	4" to 3 1/2" (125 mm to 110 mm) Bushing	1	each	83.421

Butt Weld Reducers

Item No.	Description	Packing Unit	Price Unit	List price each
0111174	6" to 3 1/2" (160 mm to 110 mm) SDR 7.4 Reducing Coupling	1	each	99.811
0111176	6" to 4" (160 mm to 125 mm) SDR 7.4 Reducing Coupling	1	each	99.811
0111182	8" to 4" (200 mm to 125 mm) SDR 7.4 Reducing Coupling	1	each	147.277
0111184	8" to 6" (200 mm to 160 mm) SDR 7.4 Butt Weld Reducer	1	each	147.277
0111188	10" to 6" (250 mm to 160 mm) SDR 7.4 Butt Weld Reducer	1	each	201.678
0111190	10" to 8" (250 mm to 200 mm) SDR 7.4 Butt Weld Reducer	1	each	201.678
0111192	12" to 8" (315 mm to 200 mm) SDR 7.4 Butt Weld Reducer	1	each	306.109
0111194	12" to 10" (315 mm to 250 mm) SDR 7.4 Butt Weld Reducer	1	each	773.024
0111196	14" to 10" (355 mm to 250 mm) SDR 7.4 Butt Weld Reducer	1	each	905.184
0111198	14" to 12" (355 mm to 315 mm) SDR 7.4 Butt Weld Reducer	1	each	1,202.851
0111175	6" to 3 1/2" (160 mm to 110 mm) SDR 11 Reducing Coupling	1	each	99.811
0111177	6" to 4" (160 mm to 125 mm) SDR 11 Reducing Coupling	1	each	99.811
0111183	8" to 4" (200 mm to 125 mm) SDR 11 Reducing Coupling	1	each	134.796
0111185	8" to 6" (200 mm to 160 mm) SDR 11 Butt Weld Reducer	1	each	134.796
0111189	10" to 6" (250 mm to 160 mm) SDR 11 Butt Weld Reducer	1	each	176.027
0111191	10" to 8" (250 mm to 200 mm) SDR 11 Butt Weld Reducer	1	each	176.027
0111193	12" to 8" (315 mm to 200 mm) SDR 11 Butt Weld Reducer	1	each	306.109
0111195	12" to 10" (315 mm to 250 mm) SDR 11 Butt Weld Reducer	1	each	581.750
0111197	14" to 10" (355 mm to 250 mm) SDR 11 Butt Weld Reducer	1	each	764.046
0111199	14" to 12" (355 mm to 315 mm) SDR 11 Butt Weld Reducer	1	each	1,069.584
0111201	16" to 10" (400 mm to 250 mm) SDR 11 Butt Weld Reducer	1	each	1,962.758
0111203	16" to 12" (400 mm to 315 mm) SDR 11 Butt Weld Reducer	1	each	1,700.944
0111204	16" to 14" (400 mm to 355 mm) SDR 11 Butt Weld Reducer	1	each	1,645.853
0111206	18" to 12" (450 mm to 315 mm) SDR 11 Butt Weld Reducer	1	each	2,644.022
0111207	18" to 14" (450 mm to 355 mm) SDR 11 Butt Weld Reducer	1	each	2,451.641
0111208	18" to 16" (450 mm to 400 mm) SDR 11 Butt Weld Reducer	1	each	2,377.836

Butt Weld Reducers continued

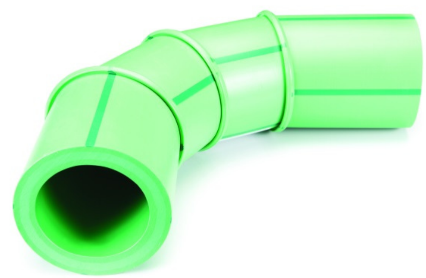
2511174	6" to 3 1/2" (160 mm to 110 mm) SDR 17.6 Reducing Coupling	1	each	44.513
2511176	6" to 4" (160 mm to 125 mm) SDR 17.6 Reducing Coupling	1	each	41.438
2511182	8" to 4" (200 mm to 125 mm) SDR 17.6 Reducing Coupling	1	each	66.234
2511184	8" to 6" (200 mm to 160 mm) SDR 17.6 Butt Weld Reducer	1	each	69.242
2511188	10" to 6" (250 mm to 160 mm) SDR 17.6 Butt Weld Reducer	1	each	103.997
2511190	10" to 8" (250 mm to 200 mm) SDR 17.6 Butt Weld Reducer	1	each	156.450
2511193	12" to 8" (315 mm to 200 mm) SDR 17.6 Butt Weld Reducer	1	each	231.000
2511195	12" to 10" (315 mm to 250 mm) SDR 17.6 Butt Weld Reducer	1	each	299.250
2511197	14" to 10" (355 mm to 250 mm) SDR 17.6 Butt Weld Reducer	1	each	432.733
2511199	14" to 12" (355 mm to 315 mm) SDR 17.6 Butt Weld Reducer	1	each	733.382
2511201	16" to 10" (400 mm to 250 mm) SDR 17.6 Butt Weld Reducer	1	each	1,740.528
2511203	16" to 12" (400 mm to 315 mm) SDR 17.6 Butt Weld Reducer	1	each	1,494.688
2511204	16" to 14" (400 mm to 355 mm) SDR 17.6 Butt Weld Reducer	1	each	1,432.251
2511206	18" to 12" (450 mm to 315 mm) SDR 17.6 Butt Weld Reducer	1	each	2,418.469
2511207	18" to 14" (450 mm to 355 mm) SDR 17.6 Butt Weld Reducer	1	each	2,247.541
2511208	18" to 16" (450 mm to 400 mm) SDR 17.6 Butt Weld Reducer	1	each	2,160.912
2511209	20" to 12" (500 mm to 315 mm) SDR 17.6 Butt Weld Reducer	1	each	2,786.267
2511210	20" to 14" (500 mm to 355 mm) SDR 17.6 Butt Weld Reducer	1	each	2,621.577
2511211	20" to 16" (500 mm to 400 mm) SDR 17.6 Butt Weld Reducer	1	each	2,446.394
2511212	20" to 18" (500 mm to 450 mm) SDR 17.6 Butt Weld Reducer	1	each	2,273.076
2511213	22" to 16" (560 mm to 400 mm) SDR 17.6 Butt Weld Reducer	1	each	3,776.275
2511214	22" to 18" (560 mm to 450 mm) SDR 17.6 Butt Weld Reducer	1	each	3,401.713
2511215	22" to 20" (560 mm to 500 mm) SDR 17.6 Butt Weld Reducer	1	each	3,254.804
2511216	24" to 16" (630 mm to 400 mm) SDR 17.6 Butt Weld Reducer	1	each	4,610.977
2511217	24" to 18" (630 mm to 450 mm) SDR 17.6 Butt Weld Reducer	1	each	4,300.660
2511218	24" to 20" (630 mm to 500 mm) SDR 17.6 Butt Weld Reducer	1	each	3,895.202
2511219	24" to 22" (630 mm to 560 mm) SDR 17.6 Butt Weld Reducer	1	each	3,790.325

Reducing Couplings

Item No.	Description	Packing Unit	Price Unit	List price each
0111222	1 1/4" to 1" (40 mm to 32 mm) Reducing Coupling	1	each	6.258
0111228	1 1/2" to 1" (50 mm to 32 mm) Reducing Coupling	1	each	9.440
0111230	1 1/2" to 1 1/4" (50 mm to 40 mm) Reducing Coupling	1	each	9.440
0111236	2" to 1 1/4" (63 mm to 40 mm) Reducing Coupling	1	each	18.828
0111238	2" to 1 1/2" (63 mm to 50 mm) Reducing Coupling	1	each	18.828
0111240	2 1/2" to 1 1/2" (75 mm to 50 mm) Reducing Coupling	1	each	20.693
0111242	2 1/2" to 2" (75 mm to 63 mm) Reducing Coupling	1	each	20.693
0111252	3" to 2" (90 mm to 63 mm) Reducing Coupling	1	each	27.889
0111253	3" to 2 1/2" (90 mm to 75 mm) Reducing Coupling	1	each	27.889
0111257	3 1/2" to 2 1/2" (110 mm to 75 mm) Reducing Coupling	1	each	48.384
0111259	3 1/2" to 3" (110 mm to 90 mm) Reducing Coupling	1	each	48.384
0111263	4" to 3" (125 mm to 90 mm) Reducing Coupling	1	each	64.407
0111265	4" to 3 1/2" (125 mm to 110 mm) Reducing Coupling	1	each	70.886

Elbows - 90°

Item No.	Description	Packing Unit	Price Unit	List price each
0112108	1/2" (20 mm) Elbow 90°	10	each	1.894
0112110	3/4" (25 mm) Elbow 90°	10	each	2.431
0112112	1" (32 mm) Elbow 90°	5	each	3.509
0112114	1 1/4" (40 mm) Elbow 90°	5	each	5.397
0112116	1 1/2" (50 mm) Elbow 90°	5	each	11.626
0112118	2" (63 mm) Elbow 90°	1	each	17.861
0112120	2 1/2" (75 mm) Elbow 90°	1	each	39.609
0112122	3" (90 mm) Elbow 90°	1	each	65.837
0112124	3 1/2" (110 mm) Elbow 90°	1	each	93.500
0112126	4" (125 mm) Elbow 90°	1	each	144.034
0112130	6" (160 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	164.214
0112134	8" (200 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	641.387
0112138	10" (250 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	978.897
0112142	12" (315 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	1,813.758
0112144	14" (355 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	2,521.385
0112131	6" (160 mm) SDR 11 Elbow 90° (molded)	1	each	128.731
0112135	8" (200 mm) Green Pipe SDR 11 Elbow 90°	1	each	546.851
0112139	10" (250 mm) Green Pipe SDR 11 Elbow 90°	1	each	887.229
0112143	12" (315 mm) Green Pipe SDR 11 Elbow 90°	1	each	1,523.267
0112145	14" (355 mm) Green Pipe SDR 11 Elbow 90°	1	each	2,101.859
0112147	16" (400 mm) Green Pipe SDR 11 Elbow 90°	1	each	2,870.154
0112149	18" (450 mm) Green Pipe SDR 11 Elbow 90°	1	each	3,846.812
2612135	8" (200 mm) Blue SDR 11 Elbow 90°	1	each	532.728
2612139	10" (250 mm) Blue SDR 11 Elbow 90°	1	each	887.229
2012143	12" (315 mm) Blue SDR 11 Elbow 90°	1	each	1,523.267
2012145	14" (355 mm) Blue SDR 11 Elbow 90°	1	each	2,101.859
2012147	16" (400 mm) Blue SDR 11 Elbow 90°	1	each	2,870.154
2012149	18" (450 mm) Blue SDR 11 Elbow 90°	1	each	3,846.812
2512130	6" (160 mm) Blue SDR 17.6 Elbow 90°	1	each	261.366
2512134	8" (200 mm) Blue SDR 17.6 Elbow 90°	1	each	414.729
2512138	10" (250 mm) Blue SDR 17.6 Elbow 90°	1	each	658.214
2512142	12" (315 mm) Blue SDR 17.6 Elbow 90°	1	each	1,035.920
2512144	14" (355 mm) Blue SDR 17.6 Elbow 90°	1	each	1,335.401
2512146	16" (400 mm) Blue SDR 17.6 Elbow 90°	1	each	1,735.052
2512148	18" (450 mm) Blue SDR 17.6 Elbow 90°	1	each	2,310.819
2512150	20" (500 mm) Blue SDR 17.6 Elbow 90°	1	each	3,178.434
2512152	22" (560 mm) Blue SDR 17.6 Elbow 90°	1	each	4,326.242
2512154	24" (630 mm) Blue SDR 17.6 Elbow 90°	1	each	6,253.559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Elbows 90° Short Radius				
Item No.	**Description**	**Packing Unit**	**Price Unit**	**List price each**
112130SZ	6" (160 mm) Green SDR 7.4 Elbow 90° - short radius	1	each	226.490
112134SZ	8" (200 mm) Green SDR 7.4 Elbow 90° - short radius	1	each	384.990
112138SZ	10" (250 mm) Green SDR 7.4 Elbow 90° - short radius	1	each	586.990
112142SZ	12" (315 mm) Green SDR 7.4 Elbow 90° - short radius	1	each	1,178.990
112144SZ	14" (355 mm) Green SDR 7.4 Elbow 90° - short radius	1	each	1,638.820
112131SZ	6" (160 mm) Green SDR 11 Elbow 90° - short radius	1	each	177.490
112135SZ	8" (200 mm) Green SDR 11 Elbow 90° - short radius	1	each	327.990
112139SZ	10" (250 mm) Green SDR 11 Elbow 90° - short radius	1	each	531.990
112143SZ	12" (300 mm) Green SDR 11 Elbow 90° - short radius	1	each	990.130
112145SZ	14" (355 mm) Green SDR 11 Elbow 90° - short radius	1	each	1,366.130
112147SZ	16" (400 mm) Green SDR 11 Elbow 90° - short radius	1	each	1,865.740
112149SZ	18" (450 mm) Green DR 11 Elbow 90° - short radius	1	each	2,500.560
2612131SZ	6" (160 mm) Blue SDR 11 Elbow 90° - short radius	1	each	177.490
2612135SZ	8" (200 mm) Blue SDR 11 Elbow 90° - short radius	1	each	327.990
2612139SZ	10" (250 mm) Blue SDR 11 Elbow 90° - short radius	1	each	531.990
2012143SZ	12" (315 mm) Blue SDR 11 Elbow 90° - short radius	1	each	990.130
2012145SZ	14" (355 mm) Blue SDR 11 Elbow 90° - short radius	1	each	1,366.130
2012147SZ	16" (400 mm) Blue SDR 11 Elbow 90° - short radius	1	each	1,865.740
2012149SZ	18" (450 mm) Blue SDR 11 Elbow 90° - short radius	1	each	2,500.560
2512130SZ	6" (160 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	156.990
2512134SZ	8" (200 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	248.990
2512138SZ	10" (250 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	394.990
2512142SZ	12" (315 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	673.350
2512144SZ	14" (355 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	867.950
2512146SZ	16" (400 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	1,127.780
2512148SZ	18" (450 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	1,502.070
2512150SZ	20" (500 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	2,065.910
2512152SZ	22" (560 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	2,812.010
2512154SZ	24" (630 mm) Blue SDR 17.6 Elbow 90° - short radius	1	each	4,064.630

Elbows - Street 90°

Item No.	Description	Packing Unit	Price Unit	List price each
0112308	1/2" (20 mm) Street 90°	10	each	1.894
0112310	3/4" (25 mm) Street 90°	10	each	2.431
0112312	1" (32 mm) Street 90°	5	each	3.509
0112314	1 1/4" (40 mm) Street 90°	5	each	5.397

Elbows - 45°

Item No.	Description	Packing Unit	Price Unit	List price each
0112508	1/2" (20 mm) Elbow 45°	10	each	1.894
0112510	3/4" (25 mm) Elbow 45°	10	each	2.431
0112512	1" (32 mm) Elbow 45°	5	each	3.509
0112514	1 1/4" (40 mm) Elbow 45°	5	each	5.397
0112516	1 1/2" (50 mm) Elbow 45°	5	each	11.626
0112518	2" (63 mm) Elbow 45°	1	each	17.645
0112520	2 1/2" (75 mm) Elbow 45°	1	each	39.132
0112522	3" (90 mm) Elbow 45°	1	each	72.243
0112524	3 1/2" (110 mm) Elbow 45°	1	each	102.864
0112526	4" (125 mm) Elbow 45°	1	each	158.397
0112530	6" (160 mm) Green SDR 7.4 Elbow 45°	1	each	182.685
0112534	8" (200 mm) Green SDR 7.4 Elbow 45°	1	each	501.311
0112538	10" (250 mm) Green SDR 7.4 Elbow 45°	1	each	805.981
0112542	12" (315 mm) Green SDR 7.4 Elbow 45°	1	each	1,289.331
0112544	14" (355 mm) Green SDR 7.4 Elbow 45°	1	each	1,675.968
0112531	6" (160 mm) SDR 11 Elbow 45° (molded)	1	each	150.923
0112535	8" (200 mm) Green SDR 11 Elbow 45°	1	each	436.979
0112539	10" (250 mm) Green SDR 11 Elbow 45°	1	each	667.706
0112543	12" (315 mm) Green SDR 11 Elbow 45°	1	each	1,032.339
0112545	14" (355 mm) Green SDR 11 Elbow 45°	1	each	1,438.794
0112547	16" (400 mm) Green SDR 11 Elbow 45°	1	each	2,130.839
0112549	18" (450 mm) Green SDR 11 Elbow 45°	1	each	2,612.558
2612535	8" (200 mm) Blue SDR 11 Elbow 45°	1	each	436.979
2612539	10" (250 mm) Blue SDR 11 Elbow 45°	1	each	667.706
2012543	12" (315 mm) Blue SDR 11 Elbow 45°	1	each	1,032.339
2012545	14" (355 mm) Blue SDR 11 Elbow 45°	1	each	1,438.794
2012547	16" (400 mm) Blue SDR 11 Elbow 45°	1	each	2,130.839
2012549	18" (450 mm) Blue SDR 11 Elbow 45°	1	each	2,612.558
2512530	6" (160 mm) Blue SDR 17.6 Elbow 45°	1	each	215.208
2512534	8" (200 mm) Blue SDR 17.6 Elbow 45°	1	each	276.035
2512538	10" (250 mm) Blue SDR 17.6 Elbow 45°	1	each	459.827
2512542	12" (315 mm) Blue SDR 17.6 Elbow 45°	1	each	680.516
2512544	14" (355 mm) Blue SDR 17.6 Elbow 45°	1	each	925.691
2512546	16" (400 mm) Blue SDR 17.6 Elbow 45°	1	each	1,186.364
2512548	18" (450 mm) Blue SDR 17.6 Elbow 45°	1	each	1,557.822
2512550	20" (500 mm) Blue SDR 17.6 Elbow 45°	1	each	2,170.434
2512552	22" (560 mm) Blue SDR 17.6 Elbow 45°	1	each	2,886.807
2512554	24" (630 mm) Blue SDR 17.6 Elbow 45°	1	each	4,099.725

Elbows 45° - Short Radius

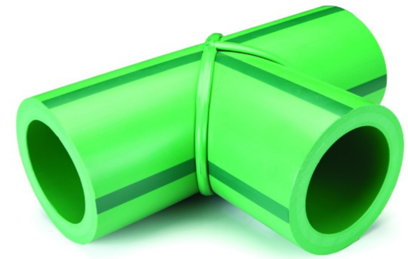
Item No.	Description	Packing Unit	Price Unit	List price each
112530SZ	6" (160 mm) Green SDR 7.4 Elbow 45° - short radius	1	each	221.490
112534SZ	8" (200 mm) Green SDR 7.4 Elbow 45° - short radius	1	each	375.990
112538SZ	10" (250 mm) Green SDR 7.4 Elbow 45° - short radius	1	each	604.990
112542SZ	12" (315 mm) Green SDR 7.4 Elbow 45° - short radius	1	each	902.470
112544SZ	14" (355 mm) Green SDR 7.4 Elbow 45° - short radius	1	each	1,173.200
112531SZ	6" (160 mm) Green SDR 11 Elbow 45° - short radius	1	each	185.490
112535SZ	8" (200 mm) Green SDR 11 Elbow 45° - short radius	1	each	327.990
112539SZ	10" (250 mm) Green SDR 11 Elbow 45° - short radius	1	each	499.990
112543SZ	12" (315 mm) Green SDR 11 Elbow 45° - short radius	1	each	722.670
112545SZ	14" (355 mm) Green SDR 11 Elbow 45° - short radius	1	each	1,007.160
112547SZ	16" (400 mm) Green SDR 11 Elbow 45° - short radius	1	each	1,491.540
112549SZ	18" (450 mm) Green SDR 11 Elbow 45° - short radius	1	each	1,828.690
2612531SZ	6" (160 mm) Blue SDR 11 Elbow 45° - short radius	1	each	185.490
2612535SZ	8" (200 mm) Blue SDR 11 Elbow 45° - short radius	1	each	327.990
2612539SZ	10" (250 mm) Blue SDR 11 Elbow 45° - short radius	1	each	499.990
2012543SZ	12" (315 mm) Blue SDR 11 Elbow 45° - short radius	1	each	722.670
2012545SZ	14" (355 mm) Blue SDR 11 Elbow 45° - short radius	1	each	1,007.160
2012547SZ	16" (400 mm) Blue SDR 11 Elbow 45° - short radius	1	each	1,491.540
2012549SZ	18" (450 mm) Blue SDR 11 Elbow 45° - short radius	1	each	1,828.690
2512530SZ	6" (160 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	161.990
2512534SZ	8" (200 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	206.990
2512538SZ	10" (250 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	344.990
2512542SZ	12" (315 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	476.360
2512544SZ	14" (355 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	647.960
2512546SZ	16" (400 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	830.440
2512548SZ	18" (450 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	1,090.420
2512550SZ	20" (500 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	1,519.410
2512552SZ	22" (560 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	2,020.720
2512554SZ	24" (630 mm) Blue SDR 17.6 Elbow 45° - short radius	1	each	2,869.710

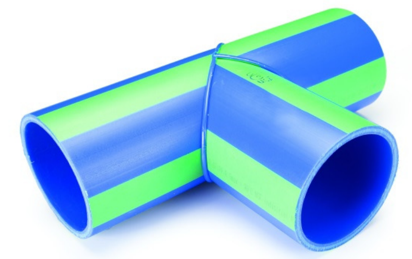
Elbows - Street 45°

Item No.	Description	Packing Unit	Price Unit	List price each
0112708	1/2" (20 mm) Street 45°	10	each	1.872
0112710	3/4" (25 mm) Street 45°	10	each	2.431
0112712	1" (32 mm) Street 45°	5	each	3.509
0112714	1 1/4" (40 mm) Street 45°	5	each	5.397

Tees

Item No.	Description	Packing Unit	Price Unit	List price each
0113108	1/2" (20 mm) Tee	10	each	2.552
0113110	3/4" (25 mm) Tee	10	each	3.509
0113112	1" (32 mm) Tee	5	each	4.464
0113114	1 1/4" (40 mm) Tee	5	each	6.805
0113116	1 1/2" (50 mm) Tee	5	each	19.437
0113118	2" (63 mm) Tee	1	each	27.842
0113120	2 1/2" (75 mm) Tee	1	each	46.648
0113122	3" (90 mm) Tee	1	each	77.020
0113124	3 1/2" (110 mm) Tee	1	each	120.071
0113126	4" (125 mm) Tee	1	each	159.590
0113130	6" (160 mm) Green SDR 7.4 Tee	1	each	198.352
0113134	8" (200 mm) Green SDR 7.4 Tee	1	each	544.523
0113138	10" (250 mm) Green SDR 7.4 Tee	1	each	937.622
0113142	12" (315 mm) Green SDR 7.4 Tee	1	each	1,716.599
0113144	14" (355 mm) Green SDR 7.4 Tee	1	each	2,095.077
0113131	6" (160 mm) SDR 11 Tee (molded)	1	each	150.719
0113135	8" (200 mm) Green SDR 11 Tee	1	each	480.543
0113139	10" (250 mm) Green SDR 11 Tee	1	each	814.548
0113143	12" (315 mm) Green SDR 11 Tee	1	each	1,400.753
0113145	14" (355 mm) Green SDR 11 Tee	1	each	1,831.547
0113147	16" (400 mm) Green SDR 11 Tee	1	each	2,648.384
0113149	18" (450 mm) Green SDR 11 Tee	1	each	3,509.646
2613135	8" (200 mm) Blue SDR 11 Tee	1	each	480.543
2613139	10" (250 mm) Blue SDR 11 Tee	1	each	814.548
2013143	12" (315 mm) Blue SDR 11 Tee	1	each	1,400.753
2013145	14" (355 mm) Blue SDR 11 Tee	1	each	1,831.547
2013147	16" (400 mm) Blue SDR 11 Tee	1	each	2,648.384
2013149	18" (450 mm) Blue SDR 11 Tee	1	each	3,509.646
2513130	6" (160 mm) Blue SDR 17.6 Tee	1	each	239.728
2513134	8" (200 mm) Blue SDR 17.6 Tee	1	each	373.716
2513138	10" (250 mm) Blue SDR 17.6 Tee	1	each	622.965
2513142	12" (315 mm) Blue SDR 17.6 Tee	1	each	980.732
2513144	14" (355 mm) Blue SDR 17.6 Tee	1	each	1,263.434
2513146	16" (400 mm) Blue SDR 17.6 Tee	1	each	1,666.235
2513148	18" (450 mm) Blue SDR 17.6 Tee	1	each	2,194.458
2513150	20" (500 mm) Blue SDR 17.6 Tee	1	each	3,054.734
2513152	22" (560 mm) Blue SDR 17.6 Tee	1	each	4,228.739
2513154	24" (630 mm) Blue SDR 17.6 Tee	1	each	5,856.186



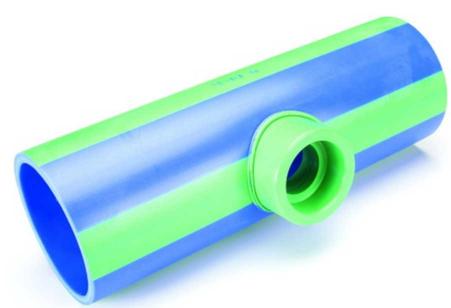


Reducing Tees

Item No.	Description	Packing Unit	Price Unit	List price each
0113511	1/2" x 1/2" x 3/4" (20 mm x 20 mm x 25 mm) Reducing Tee	10	each	3.509
0113520	3/4" x 1/2" x 1/2" (25 mm x 20 mm x 20 mm) Reducing Tee	10	each	3.509
0113522	3/4" x 3/4" x 1/2" (25 mm x 25 mm x 20 mm) Reducing Tee	10	each	3.509
0113532	1" x 1/2" x 1/2" (32 mm x 20 mm x 20 mm) Reducing Tee	5	each	4.409
0113534	1" x 1" x 1/2" (32 mm x 32 mm x 20 mm) Reducing Tee	5	each	4.409
0113538	1" x 3/4" x 3/4" (32 mm x 25 mm x 25 mm) Reducing Tee	5	each	4.409
0113540	1" x 1" x 3/4" (32 mm x 32 mm x 25 mm) Reducing Tee	5	each	4.409
0113542	1 1/4" x 1 1/4" x 1/2" (40 mm x 40 mm x 20 mm) Reducing Tee	5	each	6.805
0113544	1 1/4" x 1 1/4" x 3/4" (40 mm x 40 mm x 25 mm) Reducing Tee	5	each	6.805
0113546	1 1/4" x 1 1/4" x 1" (40 mm x 40 mm x 32 mm) Reducing Tee	5	each	6.805
0113547	1 1/2" x 1 1/2" x 1/2" (50 mm x 50 mm x 20 mm) Reducing Tee	5	each	19.437
0113548	1 1/2" x 1 1/2" x 3/4" (50 mm x 50 mm x 25 mm) Reducing Tee	5	each	19.437
0113550	1 1/2" x 1 1/2" x 1" (50 mm x 50 mm x 32 mm) Reducing Tee	5	each	19.437
0113551	1 1/2" x 1 1/2" x 1 1/4" (50 mm x 50 mm x 40 mm) Reducing Tee	5	each	19.437
0113552	2" x 2" x 1/2" (63 mm x 63 mm x 20 mm) Reducing Tee	5	each	26.161
0113554	2" x 2" x 3/4" (63 mm x 63 mm x 25 mm) Reducing Tee	1	each	26.161
0113556	2" x 2" x 1" (63 mm x 63 mm x 32 mm) Reducing Tee	1	each	26.161
0113558	2" x 2" x 1 1/4" (63 mm x 63 mm x 40 mm) Reducing Tee	1	each	26.161
0113560	2" x 2" x 1 1/2" (63 mm x 63 mm x 50 mm) Reducing Tee	1	each	26.161
0113561	2 1/2" x 2 1/2" x 1/2" (75 mm x 75 mm x 20 mm) Reducing Tee	1	each	42.656
0113562	2 1/2" x 2 1/2" x 3/4" (75 mm x 75 mm x 25 mm) Reducing Tee	1	each	42.656
0113564	2 1/2" x 2 1/2" x 1" (75 mm x 75 mm x 32 mm) Reducing Tee	1	each	42.656
0113566	2 1/2" x 2 1/2" x 1 1/4" (75 mm x 75 mm x 40 mm) Reducing Tee	1	each	42.656
0113568	2 1/2" x 2 1/2" x 1 1/2" (75 mm x 75 mm x 50 mm) Reducing Tee	1	each	42.656
0113570	2 1/2" x 2 1/2" x 2" (75 mm x 75 mm x 63 mm) Reducing Tee	1	each	42.656
0113576	3" x 3" x 1" (90 mm x 90 mm x 32 mm) Reducing Tee	1	each	85.523
0113578	3" x 3" x 1 1/4" (90 mm x 90 mm x 40 mm) Reducing Tee	1	each	85.523
0113580	3" x 3" x 1 1/2" (90 mm x 90 mm x 50 mm) Reducing Tee	1	each	85.523
0113582	3" x 3" x 2" (90 mm x 90 mm x 63 mm) Reducing Tee	1	each	85.523
0113584	3" x 3" x 2 1/2" (90 mm x 90 mm x 75 mm) Reducing Tee	1	each	85.523
0113586	3 1/2" x 3 1/2" x 2" (110 mm x 110 mm x 63 mm) Reducing Tee	1	each	133.642
0113588	3 1/2" x 3 1/2" x 2 1/2" (110 mm x 110 mm x 75 mm) Reducing Tee	1	each	133.642
0113590	3 1/2" x 3 1/2" x 2 1/2" (110 mm x 110 mm x 90 mm) Reducing Tee	1	each	133.642
0113592	4" x 4" x 2 1/2" (125 mm x 125 mm x 75 mm) Reducing Tee	1	each	154.767
0113594	4" x 4" x 3" (125 mm x 125 mm x 90 mm) Reducing Tee	1	each	160.142
0113596	4" x 4" x 3 1/2" (125 mm x 125 mm x 110 mm) Reducing Tee	1	each	160.747

Reducing Tees continued

0113600	6" x 6" x 2 1/2" (160 mm x 160 mm x 75 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	361.200
0113602	6" x 6" x 3" (160 mm x 160 mm x 90 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	387.450
0113608	8" x 8" x 2 1/2" (200 mm x 200 mm x 75 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	450.000
0113610	8" x 8" x 3" (200 mm x 200 mm x 90 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	500.000
0113612	8" x 8" x 3 1/2" (200 mm x 200 mm x 110 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	550.000
0113614	8" x 8" x 4" (200 mm x 200 mm x 125 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	600.000
0113618	8" x 8" x 6" (200 mm x 200 mm x 160 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	650.000
0113619	8" x 8" x 6" (200 mm x 200 mm x 160 mm) Green SDR 11 Segmented Reducing Tee	1	each	650.000
0113624	10" x 10" x 2 1/2" (250 mm x 250 mm x 75 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	600.000
0113626	10" x 10" x 3" (250 mm x 250 mm x 90 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	700.000
0113628	10" x 10" 3 1/2" (250 mm x 250 mm x 110 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	800.000
0113630	10" x 10" x 4" (250 mm x 250 mm x 125 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	900.000
0113634	10" x 10" x 6" (250 mm x 250 mm x 160 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	1,000.000
0113640	10" x 10" x 8" (250 mm x 250 mm x 200 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	1,100.000
0113904	12" x 12" x 4" (315 mm x 315 mm x 125 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	1,400.000
0113906	12" x 12" x 6" (315 mm x 315 mm x 160 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	1,600.000
0113908	12" x 12" x 8" (315 mm x 315 mm x 200 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	1,800.000
0113910	12" x 12" x 10" (315 mm x 315 mm x 250 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	2,000.000
0113916	14" x 14" x 4" (355 mm x 355 mm x 125 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	1,800.000
0113918	14" x 14" x 6" (355 mm x 355 mm x 160 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	2,000.000
0113920	14" x 14" x 8" (355 mm x 355 mm x 200 mm) Green SDR 7.4 Outlet Reducing Tee	1	each	2,200.000
0113922	14" x 14" x 10" (355 mm x 355 mm x 250 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	2,400.000
0113924	14" x 14" x 12" (355 mm x 355 mm x 315 mm) Green SDR 7.4 Segmented Reducing Tee	1	each	2,600.000
0113601	6" x 6" x 2 1/2" (160 mm x 160 mm x 75 mm) Green SDR 11 Outlet Reducing Tee	1	each	302.400
0113603	6" x 6" x 3" (160 mm x 160 mm x 90 mm) Green SDR 11 Outlet Reducing Tee	1	each	328.650
0113611	8" x 8" x 3" (200 mm x 200 mm x 90 mm) Green SDR 11 Outlet Reducing Tee	1	each	500.000
0113609	8" x 8" x 2 1/2" (200 mm x 200 mm x 75 mm) Green SDR 11 Outlet Reducing Tee	1	each	450.000
0113613	8" x 8" x 3 1/2" (200 mm x 200 mm x 110 mm) Green SDR 11 Outlet Reducing Tee	1	each	550.000
0113615	8" x 8" x 4" (200 mm x 200 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	600.000
0113625	10" x 10" x 2 1/2" (250 mm x 250 mm x 75 mm) Green SDR 11 Outlet Reducing Tee	1	each	600.000
0113627	10" x 10" x 3" (250 mm x 250 mm x 90 mm) Green SDR 11 Outlet Reducing Tee	1	each	700.000
0113629	10" x 10" x 3 1/2" (250 mm x 250 mm x 110 mm) Green SDR 11 Outlet Reducing Tee	1	each	800.000
0113631	10" x 10" x 4" (250 mm x 250 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	900.000
0113635	10" x 10" x 6" (250 mm x 250 mm x 160 mm) Green SDR 11 Segmented Reducing Tee	1	each	1,000.000
0113641	10" x 10" x 8" (250 mm x 250 mm x 200 mm) Green SDR 11 Segmented Reducing Tee	1	each	1,100.000
0113651	12" x 12" x 4" (315 mm x 315 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	1,200.000
0113653	12" x 12" x 6" (315 mm x 315 mm x 160 mm) Green SDR 11 Outlet Reducing Tee	1	each	1,400.000
0113655	12" x 12" x 8" (315 mm x 315 mm x 200 mm) Green SDR 11 Segmented Reducing Tee	1	each	1,600.000
0113657	12" x 12" x 10" (315 mm x 315 mm x 250 mm) Green SDR 11 Segmented Reducing Tee	1	each	1,800.000
0113663	14" x 14" x 4" (355 mm x 355 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	1,700.000
0113665	14" x 14" x 6" (355 mm x 355 mm x 160 mm) Green SDR 11 Outlet Reducing Tee	1	each	1,900.000
0113667	14" x 14" x 8" (355 mm x 355 mm x 200 mm) Green SDR 11 Outlet Reducing Tee	1	each	2,100.000
0113669	14" x 14" x 10" (355 mm x 355 mm x 250 mm) Green SDR 11 Segmented Reducing Tee	1	each	2,300.000
0113671	14" x 14" x 12" (355 mm x 355 mm x 315 mm) Green SDR 11 Segmented Reducing Tee	1	each	2,500.000
0113676	16" x 16" x 4" (400 mm x 400 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	2,600.000
0113678	16" x 16" x 6" (400 mm x 400 mm x 160 mm) Green SDR 11 Outlet Reducing Tee	1	each	2,800.000
0113680	16" x 16" x 8" (400 mm x 400 mm x 200 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,000.000
0113682	16" x 16" x 10" (400 mm x 400 mm x 250 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,200.000
0113684	16" x 16" x 12" (400 mm x 400 mm x 315 mm) Green SDR 11 Segmented Reducing Tee	1	each	3,400.000



Reducing Tees continued

0113685	16" x 16" x 14" (400 mm x 400 mm x 355 mm) Green SDR 11 Segmented Reducing Tee	1	each	3,600.000
0113690	18" x 18" x 4" (450 mm x 450 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,000.000
0113692	18" x 18" x 6" (450 mm x 450 mm x 160 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,200.000
0113694	18" x 18" x 8" (450 mm x 450 mm x 200 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,400.000
0113696	18" x 18" x 10" (450 mm x 450 mm x 250 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,600.000
0113698	18" x 18" x 12" (450 mm x 450 mm x 315 mm) Green SDR 11 Outlet Reducing Tee	1	each	3,800.000
0113699	18" x 18" x 14" (450 mm x 450 mm x 355 mm) Green SDR 11 Segmented Reducing Tee	1	each	4,000.000
0113700	18" x 18" x 16" (450 mm x 450 mm x 400 mm) Green SDR 11 Segmented Reducing Tee	1	each	4,200.000
2613609	8" x 8" x 2 1/2" (200 mm x 200 mm x 75 mm) Blue SDR 11 Outlet Reducing Tee	1	each	450.000
2613611	8" x 8" x 3" (200 mm x 200 mm x 90 mm) Blue SDR 11 Outlet Reducing Tee	1	each	500.000
2613613	8" x 8" x 3 1/2" (200 mm x 200 mm x 110 mm) Blue SDR 11 Outlet Reducing Tee	1	each	550.000
2613615	8" x 8" x 4" (200 mm x 200 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	600.000
2613619	8" x 8" x 6" (200 mm x 200 mm x 160 mm) Blue SDR 11 Segmented Reducing Tee	1	each	650.000
2613625	10" x 10" x 2 1/2" (250 mm x 250 mm x 75 mm) Blue SDR 11 Outlet Reducing Tee	1	each	600.000
2613627	10" x 10" x 3" (250 mm x 250 mm x 90 mm) Blue SDR 11 Outlet Reducing Tee	1	each	700.000
2613629	10" x 10" x 3 1/2" (250 mm x 250 mm x 110 mm) Blue SDR 11 Outlet Reducing Tee	1	each	800.000
2613631	10" x 10" x 4" (250 mm x 250 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	900.000
2613635	10" x 10" x 6" (250 mm x 250 mm x 160 mm) Blue SDR 11 Segmented Reducing Tee	1	each	1,000.000
2613641	10" x 10" x 8" (250 mm x 250 mm x 200 mm) Blue SDR 11 Segmented Reducing Tee	1	each	1,100.000
2013651	12" x 12" x 4" (315 mm x 315 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	1,200.000
2013653	12" x 12" x 6" (315 mm x 315 mm x 160 mm) Blue SDR 11 Outlet Reducing Tee	1	each	1,400.000
2013655	12" x 12" x 8" (315 mm x 315 mm x 200 mm) Blue SDR 11 Segmented Reducing Tee	1	each	1,600.000
2013657	12" x 12" x 10" (315 mm x 315 mm x 250 mm) Blue SDR 11 Segmented Reducing Tee	1	each	1,800.000
2013663	14" x 14" x 4" (355 mm x 355 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	1,700.000
2013665	14" x 14" x 6" (355 mm x 355 mm x 160 mm) Blue SDR 11 Outlet Reducing Tee	1	each	1,900.000
2013667	14" x 14" x 8" (355 mm x 355 mm x 200 mm) Blue SDR 11 Outlet Reducing Tee	1	each	2,100.000
2013669	14" x 14" x 10" (355 mm x 355 mm x 250 mm) Blue SDR 11 Segmented Reducing Tee	1	each	2,300.000
2013671	14" x 14" x 12" (355 mm x 355 mm x 315 mm) Blue SDR 11 Segmented Reducing Tee	1	each	2,500.000
2013676	16" x 16" x 4" (400 mm x 400 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	2,600.000
2013678	16" x 16" x 6" (400 mm x 400 mm x 160 mm) Blue SDR 11 Outlet Reducing Tee	1	each	2,800.000
2013680	16" x 16" x 8" (400 mm x 400 mm x 200 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,000.000
2013682	16" x 16" x 10" (400 mm x 400 mm x 250 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,200.000
2013684	16" x 16" x 12" (400 mm x 400 mm x 315 mm) Blue SDR 11 Segmented Reducing Tee	1	each	3,400.000
2013685	16" x 16" x 14" (400 mm x 400 mm x 355 mm) Blue SDR 11 Segmented Reducing Tee	1	each	3,600.000
2013690	18" x 18" x 4" (450 mm x 450 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,000.000
2013692	18" x 18" x 6" (450 mm x 450 mm x 160 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,200.000
2013694	18" x 18" x 8" (450 mm x 450 mm x 200 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,400.000
2013696	18" x 18" x 10" (450 mm x 450 mm x 250 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,600.000
2013698	18" x 18" x 12" (450 mm x 450 mm x 315 mm) Blue SDR 11 Outlet Reducing Tee	1	each	3,800.000
2013699	18" x 18" x 14" (450 mm x 450 mm x 355 mm) Blue SDR 11 Segmented Reducing Tee	1	each	4,000.000
2013700	18" x 18" x 16" (450 mm x 450 mm x 400 mm) Blue SDR 11 Segmented Reducing Tee	1	each	4,200.000
2513600	6" x 6" x 2 1/2" (160 mm x 160 mm x 75 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	290.850
2513602	6" x 6" x 3" (160 mm x 160 mm x 90 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	318.150
2513608	8" x 8" x 2 1/2" (200 mm x 200 mm x 75 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	350.000
2513610	8" x 8" x 3" (200 mm x 200 mm x 90 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	400.000
2513612	8" x 8" x 3 1/2" (200 mm x 200 mm x 110 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	450.000
2513614	8" x 8" x 4" (200 mm x 200 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	500.000

Reducing Tees continued

2513618	8" x 8" x 6" (200 mm x 200 mm x 160 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	550.000
2513624	10" x 10" x 2 1/2" (250 mm x 250 mm x 75 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	500.000
2513626	10" x 10" x 3" (250 mm x 250 mm x 90 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	550.000
2513628	10" x 10" 3 1/2" (250 mm x 250 mm x 110 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	600.000
2513630	10" x 10" x 4" (250 mm x 250 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	650.000
2513634	10" x 10" x 6" (250 mm x 250 mm x 160 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	700.000
2513640	10" x 10" x 8" (250 mm x 250 mm x 200 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	750.000
2513651	12" x 12" x 4" (315 mm x 315 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	900.000
2513653	12" x 12" x 6" (315 mm x 315 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	1,000.000
2513655	12" x 12" x 8" (315 mm x 315 mm x 200 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	1,100.000
2513657	12" x 12" x 10" (315 mm x 315 mm x 250 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	1,200.000
2513663	14" x 14" x 4" (355 mm x 355 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	1,200.000
2513665	14" x 14" x 6" (355 mm x 355 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	1,300.000
2513667	14" x 14" x 8" (355 mm x 355 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	1,400.000
2513669	14" x 14" x 10" (355 mm x 355 mm x 250 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	1,500.000
2513671	14" x 14" x 12" (355 mm x 355 mm x 315 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	1,600.000
2513676	16" x 16" x 4" (400 mm x 400 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	1,800.000
2513678	16" x 16" x 6" (400 mm x 400 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,000.000
2513680	16" x 16" x 8" (400 mm x 400 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,200.000
2513682	16" x 16" x 10" (400 mm x 400 mm x 250 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,400.000
2513684	16" x 16" x 12" (400 mm x 400 mm x 315 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	2,600.000
2513685	16" x 16" x 14" (400 mm x 400 mm x 355 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	2,800.000
2513690	18" x 18" x 4" (450 mm x 450 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,000.000
2513692	18" x 18" x 6" (450 mm x 450 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,300.000
2513694	18" x 18" x 8" (450 mm x 450 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,600.000
2513696	18" x 18" x 10" (450 mm x 450 mm x 250 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,900.000
2513698	18" x 18" x 12" (450 mm x 450 mm x 315 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	3,200.000
2513699	18" x 18" x 14" (450 mm x 450 mm x 355 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	3,500.000
2513700	18" x 18" x 16" (450 mm x 450 mm x 400 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	3,800.000
2513804	20" x 20" x 4" (500 mm x 500 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	2,600.000
2513806	20" x 20" x 6" (500 mm x 500 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	3,000.000
2513808	20" x 20" x 8" (500 mm x 500 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	3,400.000
2513810	20" x 20" x 10" (500 mm x 500 mm x 250 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	3,800.000
2513812	20" x 20" x 12" (500 mm x 500 mm x 315 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	4,200.000
2513813	20" x 20" x 14" (500 mm x 500 mm x 355 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	4,800.000
2513814	20" x 20" x 16" (500 mm x 500 mm x 400 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	4,800.000
2513815	20" x 20" x 18" (500 mm x 500 mm x 450 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	4,800.000
2513821	22" x 22" x 4" (560 mm x 560 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	3,500.000
2513823	22" x 22" x 6" (560 mm x 560 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	4,000.000
2513825	22" x 22" x 8" (560 mm x 560 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	4,500.000
2513827	22" x 22" x 10" (560 mm x 560 mm x 250 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	5,000.000
2513829	22" x 22" x 12" (560 mm x 560 mm x 315 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	5,500.000
2513830	22" x 22" x 14" (560 mm x 560 mm x 355 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	6,000.000
2513831	22" x 22" x 16" (560 mm x 560 mm x 400 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	6,500.000
2513832	22" x 22" x 18" (560 mm x 560 mm x 450 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	7,000.000
2513833	22" x 22" x 20" (560 mm x 560 mm x 500 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	7,500.000
2513839	24" x 24" x 4" (630 mm x 630 mm x 125 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	4,200.000
2513841	24" x 24" x 6" (630 mm x 630 mm x 160 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	4,800.000
2513843	24" x 24" x 8" (630 mm x 630 mm x 200 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	5,400.000

Reducing Tees continued

2513845	24" x 24" x 10" (630 mm x 630 mm x 250 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	6,000.000
2513847	24" x 24" x 12" (630 mm x 630 mm x 315 mm) Blue SDR 17.6 Outlet Reducing Tee	1	each	6,600.000
2513848	24" x 24" x 14" (630 mm x 630 mm x 355 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	8,600.000
2513849	24" x 24" x 16" (630 mm x 630 mm x 400 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	8,600.000
2513850	24" x 24" x 18" (630 mm x 630 mm x 450 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	8,600.000
2513851	24" x 24" x 20" (630 mm x 630 mm x 500 mm) Blue SDR 17.6 Segmented Reducing Tee	1	each	8,600.000
2513852	24" x 24" x 22" (630 mm x 630 mm x 56) Blue SDR 17.6 Segmented Reducing Tee	1	each	8,600.000

Tee Wyes

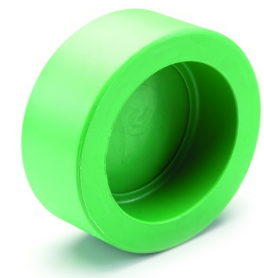
Item No.	Description	Packing Unit	Price Unit	List price each
2113722	3" (90 mm) Green SDR 7.4 Tee Wye	1	each	151.990
2113724	3.5" (110 mm) Green SDR 7.4 Tee Wye	1	each	193.990
2113726	4" (125 mm) Green SDR 7.4 Tee Wye	1	each	230.990
2113730	6" (160 mm) Green SDR 7.4 Tee Wye	1	each	354.990
2113734	8" (200 mm) Green SDR 7.4 Tee Wye	1	each	587.990
2113738	10" (250 mm) Green SDR 7.4 Tee Wye	1	each	950.990
2113122	3" (90 mm) Green SDR 11 Tee Wye	1	each	101.990
2113124	3.5" (110 mm) Green SDR 11 Tee Wye	1	each	132.990
2113126	4" (125 mm) Green SDR 11 Tee Wye	1	each	161.990
2113130	6" (160 mm) Green SDR 11 Tee Wye	1	each	223.990
2113134	8" (200 mm) Green SDR 11 Tee Wye	1	each	396.990
2113138	10" (250 mm) Green SDR 11 Tee Wye	1	each	622.990
2113123	3" (90 mm) Blue SDR 11 Tee Wye	1	each	101.990
2113125	3.5" (110 mm) Blue SDR 11 Tee Wye	1	each	132.990
2113127	4" (125 mm) Blue SDR 11 Tee Wye	1	each	161.990
2113131	6" (160 mm) Blue SDR 11 Tee Wye	1	each	223.990
2113135	8" (200 mm) Blue SDR 11 Tee Wye	1	each	396.990
2113139	10" (250 mm) Blue SDR 11 Tee Wye	1	each	622.990
2113128	4" (125 mm) Blue SDR 17.6 Tee Wye	1	each	150.990
2113132	6" (160 mm) Blue SDR 17.6 Tee Wye	1	each	186.990
2113136	8" (200 mm) Blue SDR 17.6 Tee Wye	1	each	312.990
2113140	10" (250 mm) Blue SDR 17.6 Tee Wye	1	each	488.990

Crosses

Item No.	Description	Packing Unit	Price Unit	List price each
0113708	1/2" (20 mm) Cross	10	each	4.360
0113710	3/4" (25 mm) Cross	10	each	4.785
0113712	1" (32 mm) Cross	5	each	7.550
0113714	12" (40 mm) Cross	5	each	9.245

End Caps

Item No.	Description	Packing Unit	Price Unit	List price each
0114108	1/2" (20 mm) End Cap	10	each	2.769
0114110	3/4" (25 mm) End Cap	10	each	3.509
0114112	1" (32 mm) End Cap	5	each	4.254
0114114	1 1/4" (40 mm) End Cap	5	each	6.699
0114116	1 1/2" (50 mm) End Cap	5	each	9.238
0114118	2" (63 mm) End Cap	1	each	15.465
0114120	2 1/2" (75 mm) End Cap	1	each	22.421
0114122	3" (90 mm) End Cap	1	each	50.654
0114124	3 1/2" (110 mm) End Cap	1	each	60.929
0114126	4" (125 mm) End Cap	1	each	92.796
0114130	6" (160 mm) SDR 7.4 End Cap	1	each	127.351
0114134	8" (200 mm) SDR 7.4 End Cap	1	each	127.738
0114138	10" (250 mm) SDR 7.4 End Cap	1	each	191.349
0114142	12" (315 mm) SDR 7.4 End Cap	1	each	1,176.588
0114144	14" (355 mm) SDR 7.4 End Cap	1	each	1,489.832
0114131	6" (160 mm) SDR 11 End Cap	1	each	127.351
0114135	8" (200 mm) SDR 11 End Cap	1	each	110.522
0114139	10" (250 mm) SDR 11 End Cap	1	each	162.427
0114143	12" (315 mm) SDR 11 End Cap	1	each	582.704
0114145	14" (355 mm) SDR 11 End Cap	1	each	778.958
0114147	16" (400 mm) SDR 11 End Cap	1	each	1,469.095
0114149	18" (450 mm) SDR 11 End Cap	1	each	1,903.827



End Caps Continued

2514130	6" (160 mm) SDR 17.6 End Cap	1	each	94.942
2514134	8" (200 mm) SDR 17.6 End Cap	1	each	113.742
2514138	10" (250 mm) SDR 17.6 End Cap	1	each	146.847
2514142	12" (315 mm) SDR 17.6 End Cap	1	each	651.412
2514144	14" (355 mm) SDR 17.6 End Cap	1	each	934.549
2514146	16" (400 mm) SDR 17.6 End Cap	1	each	1,308.257
2514148	18" (450 mm) SDR 17.6 End Cap	1	each	1,675.468
2514150	20" (500 mm) SDR 17.6 End Cap	1	each	2,188.902
2514152	22" (560 mm) SDR 17.6 End Cap	1	each	2,757.989
2514154	24" (630 mm) SDR 17.6 End Cap	1	each	3,723.020

Overbridge Bows

Item No.	Description	Packing Unit	Price Unit	List price each
0116108	1/2" (20 mm) Cross-Over	10	each	5.294
0116110	3/4" (25 mm) Cross-Over	10	each	9.861
0116112	1" (32 mm) Cross-Over	5	each	19.752

Fusion Outlets

Item No.	Description	Packing Unit	Price Unit	List price each
0115156	1 1/4" x 1/2" (40 mm x 20 mm) Fusion Outlet	5	each	4.790
0115158	1 1/4" x 3/4" (40 mm x 25 mm) Fusion Outlet	5	each	4.790
0115160	1 1/2" x 1/2" (50 mm x 20 mm) Fusion Outlet	5	each	5.443
0115162	1 1/2" x 3/4" (50 mm x 25 mm) Fusion Outlet	5	each	5.443
0115164	2 x 1/2" (63 mm x 20 mm) Fusion Outlet	5	each	6.532
0115166	2" x 3/4" (63 mm x 25 mm) Fusion Outlet	5	each	6.532
0115168	2" x 1" (63 mm x 32 mm) Fusion Outlet	5	each	6.532
0115170	2 1/2" x 1/2" (75 mm x 20 mm) Fusion Outlet	5	each	7.620
0115172	2 1/2" x 3/4" (75 mm x 25 mm) Fusion Outlet	5	each	7.620
0115174	2 1/2" x 1" (75 mm x 32 mm) Fusion Outlet	5	each	7.620
0115175	2 1/2" x 1 1/4" (75 mm x 40 mm) Fusion Outlet	5	each	7.620
0115176	3" x 1/2" (90 mm x 20 mm) Fusion Outlet	5	each	8.709
0115178	3" x 3/4 (90 mm x 25 mm) Fusion Outlet	5	each	8.709
0115180	3" x 1" (90 mm x 32 mm) Fusion Outlet	5	each	8.709
0115181	3" x 1 1/4" (90 mm x 40 mm) Fusion Outlet	5	each	8.709
0115182	3 1/2" x 1/2" (110 mm x 20 mm) Fusion Outlet	5	each	8.709
0115184	3 1/2" x 3/4" (110 mm x 25 mm) Fusion Outlet	5	each	9.798
0115186	3 1/2" x 1" (110 mm x 32 mm) Fusion Outlet	5	each	9.798
0115188	3 1/2" x 1 1/4" (110 mm x 40 mm) Fusion Outlet	5	each	9.798
0115189	3 1/2" x 1 1/2" (110 mm x 50 mm) Fusion Outlet	5	each	12.405
0115190	4" x 1/2" (125 mm x 20 mm) Fusion Outlet	5	each	10.886
0115192	4" x 3/4" (125 mm x 25 mm) Fusion Outlet	5	each	10.886
0115194	4" x 1" (125 mm x 32 mm) Fusion Outlet	5	each	10.886
0115196	4" x 1 1/4" (125 mm x 40 mm) Fusion Outlet	5	each	10.886
0115197	4" x 1 1/2" (125 mm x 50 mm) Fusion Outlet	5	each	12.405
0115198	4" x 2 (125 mm x 63 mm) Fusion Outlet	5	each	17.013
0115206	6" x 1/2" (160 mm x 20 mm) Fusion Outlet	5	each	11.836

Notes

Fusion outlets require welding heads 50614-50699 and drill bits 50940-50958

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Fusion Outlets Continued

0115208	6" x 3/4" (160 mm x 25 mm) Fusion Outlet	5	each	11.836
0115210	6" x 1" (160 mm x 32 mm) Fusion Outlet	5	each	11.836
0115212	6" x 1 1/4" (160 mm x 40 mm) Fusion Outlet	5	each	11.836
0115214	6" x 1 1/2" (160 mm x 50 mm) Fusion Outlet	5	each	21.769
0115216	6" x 2" (160 mm x 63 mm) Fusion Outlet	5	each	26.841
0115218	6" x 2 1/2" (160 mm x 75 mm) Fusion Outlet	5	each	39.099
0115220	6" x 3" (160 mm x 90 mm) Fusion Outlet	5	each	65.940
0115228	8 to10" x 1/2" (200 mm to 250 mm x 20 mm) Fusion Outlet	5	each	13.948
0115229	8 to10" x 3/4" (200 mm to 250 mm x 25 mm) Fusion Outlet	5	each	13.948
0115230	8 to10" x 1" (200 mm to 250 mm x 32 mm) Fusion Outlet	5	each	13.948
0115231	8" x 1 1/4" (200 mm x 40 mm) Fusion Outlet	5	each	17.118
0115232	8" x 1 1/2" (200 mm x 50 mm) Fusion Outlet	5	each	27.685
0115233	8" x 2" (200 mm x 63 mm) Fusion Outlet	5	each	32.335
0115234	8" x 2 1/2" (200 mm x 75 mm) Fusion Outlet	5	each	49.453
0115235	8" x 3" (200 mm x 90 mm) Fusion Outlet	5	each	64.246
0115236	8" x 3 1/2" (200 mm x 110 mm) Fusion Outlet	5	each	71.432
0115237	8" x 4" (200 mm x 125 mm) Fusion Outlet	5	each	109.683
0115251	10" x 1 1/4" (250 mm x 40 mm) Fusion Outlet	5	each	26.840
0115252	10" x 1 1/2" (250 mm x 50 mm) Fusion Outlet	5	each	29.799
0115253	10" x 2" (250 mm x 63 mm) Fusion Outlet	5	each	34.871
0115254	10" x 2 1/2" (250 mm x 75 mm) Fusion Outlet	5	each	49.875
0115255	10" x 3" (250 mm x 90 mm) Fusion Outlet	5	each	51.566
0115256	10" x 3 1/2" (250 mm x 110 mm) Fusion Outlet	5	each	71.008
0115257	10" x 4" (250 mm x 125 mm) Fusion Outlet	5	each	107.146
0115260	12" to 14" x 2" (315 mm to 355 mm x 63 mm) Fusion Outlet	1	each	66.214
0115261	12" to 14" x 2 1/2" (315 mm to 355 mm x 75 mm) Fusion Outlet	1	each	71.430
0115262	12" x 3" (315 mm x 90 mm) Fusion Outlet	1	each	110.527
0115263	12" x 3 1/2" (315 mm x 110 mm) Fusion Outlet	1	each	177.308
0115264	12" x 4" (315 mm x 125 mm) Fusion Outlet	1	each	235.214
0115265	12" x 6" (315 mm x 160 mm) Fusion Outlet	1	each	275.156
0115268	14" x 3" (355 mm x 90 mm) Fusion Outlet	1	each	133.563
0115269	14" x 3 1/2" (355 mm x 110 mm) Fusion Outlet	1	each	208.376
0115270	14" x 4" (355 mm x 125 mm) Fusion Outlet	1	each	291.008
0115271	14" x 6" (355 mm x 160 mm) Fusion Outlet	1	each	336.867
0115272	14" x 8" (355 mm x 200 mm) Fusion Outlet	1	each	416.118
0115275	16" to 20" x 2 1/2" (400 mm to 500 mm x 75 mm) Fusion Outlet	1	each	92.568
0115277	16" to18" x 3 1/2" (400 mm to 450 mm x 110 mm) Fusion Outlet	1	each	122.955
0115278	16" x 4" (400 mm x 125 mm) Fusion Outlet	1	each	156.762
0115280	16" x 6" to 10" (400 mm x 160 mm to 250 mm) Fusion Outlet	1	each	1,025.571
0115288	16" to 20" x 3" (400 mm to 500 mm x 90 mm) Fusion Outlet	1	each	180.709
0115290	18" to 20" x 4" (450 mm to 500 mm x 125 mm) Fusion Outlet	1	each	261.807
0115292	18" x 6" to 10" (450 mm x 160 mm to 250 mm) Fusion Outlet	1	each	1,028.689
0115298	18" x 12" (450 mm x 315 mm) Fusion Outlet	1	each	1,168.398
0115300	16" to 24" x 2" (400 mm to 630 mm x 63 mm) Fusion Outlet	1	each	322.781
0115303	20" to 22" x 3 1/2" (500 mm to 560 mm x 110 mm) Fusion Outlet	1	each	360.009
0115306	20" x 6" to 10" (500 mm x 160 mm to 250 mm) Fusion Outlet	1	each	1,029.729
0115312	20" x 12" (500 mm x 315 mm) Fusion Outlet	1	each	1,180.456
0115315	22" to 24" x 2 1/2" (560 mm to 630 mm x 75 mm) Fusion Outlet	1	each	474.914
0115316	22" to 24" x 3" (560 mm to 630 mm x 90 mm) Fusion Outlet	1	each	536.492

Fusion Outlets Continued

0115318	22" to 24" x 4" (560 mm to 630 mm x 125 mm) Fusion Outlet	1	each	542.328
0115331	24" x 3 1/2" (630 mm x 110 mm) Fusion Outlet	1	each	480.951
0115334	24" x 6" to 10" (630 mm x 160 mm to 250 mm) Fusion Outlet	1	each	1,050.311
0115340	24" x 12" (630 mm x 315 mm) Fusion Outlet	1	each	1,350.103

Flange Connections

Flange Adaptors

Item No.	Description	Packing Unit	Price Unit	List price each
0115512	1" (32 mm) Flange Adapter	1	each	6.111
0115514	1 1/4" (40 mm) Flange Adapter	1	each	7.209
0115516	1 1/2" (50 mm) Flange Adapter	1	each	11.280
0115518	2" (63 mm) Flange Adapter	1	each	12.722
0115520	2 1/2" (75 mm) Flange Adapter	1	each	17.810
0115522	3" (90 mm) Flange Adapter	1	each	36.215
0115524	3 1/2" (110 mm) Flange Adapter	1	each	53.940
0115526	4" (125 mm) Flange Adapter	1	each	92.000
0115527	4" (125 mm) Flange Adapter	1	each	64.796
0115530	6" (160 mm) SDR 7.4 Flange Adapter	1	each	87.949
0115530BV	6" (160 mm) SDR 7.4 Flange Adapter BV	1	each	87.949
0115531	6" (160 mm) SDR 11 Flange Adapter	1	each	87.949
0115531BV	6" (160 mm) SDR 11 Flange Adapter BV	1	each	87.949
2915530	6" (160 mm) SDR 17.6 Flange Adapter	1	each	62.959
2915530BV	6" (160 mm) SDR 17.6 Flange Adapter BV	1	each	62.959
0115534	8" (200 mm) SDR 7.4 Flange Adapter	1	each	311.740
0115534BV	8" (200 mm) SDR 7.4 Flange Adapter BV	1	each	311.740
0115535	8" (200 mm) SDR 11 Flange Adapter	1	each	311.740
0115535BV	8" (200 mm) SDR 11 Flange Adapter BV	1	each	311.740
2915534	8" (200 mm) SDR 17.6 Flange Adapter	1	each	180.123
2915534BV	8" (200 mm) SDR 17.6 Flange Adapter BV	1	each	180.123
0115538	10" (250 mm) SDR 7.4 Flange Adapter	1	each	371.041
0115538BV	10" (250 mm) SDR 7.4 Flange Adapter BV	1	each	371.041
0115539	10" (250 mm) SDR 11 Flange Adapter	1	each	371.041
0115539BV	10" (250 mm) SDR 11 Flange Adapter BV	1	each	371.041
2915538	10" (250 mm) SDR 17.6 Flange Adapter	1	each	233.190
2915538BV	10" (250 mm) SDR 17.6 Flange Adapter BV	1	each	233.190
0115542	12" (315 mm) SDR 7.4 Flange Adapter	1	each	1,186.332
0115542BV	12" (315 mm) SDR 7.4 Flange Adapter BV	1	each	1,186.332
0115543	12" (315 mm) SDR 11 Flange Adapter	1	each	826.991
0115543BV	12" (315 mm) SDR 11 Flange Adapter BV	1	each	826.991
2915542	12" (315 mm) SDR 17.6 Flange Adapter	1	each	789.534
2915542BV	12" (315 mm) SDR 17.6 Flange Adapter BV	1	each	789.534
0115544	14" (355 mm) SDR 7.4 Flange Adapter	1	each	1,864.665
0115544BV	14" (355 mm) SDR 7.4 Flange Adapter BV	1	each	1,864.665
0115545	14" (355 mm) SDR 11 Flange Adapter	1	each	1,101.197
0115545BV	14" (355 mm) SDR 11 Flange Adapter BV	1	each	1,101.197
2915544	14" (355 mm) SDR 17.6 Flange Adapter	1	each	985.163

Notes

BV parts are for use with Butterfly Valves

Flange Adaptors - Continued

2915544BV	14" (355 mm) SDR 17.6 Flange Adapter BV	1	each	985.163
0115547	16" (400 mm) SDR 11 Flange Adapter	1	each	1,202.572
0115547BV	16" (400 mm) SDR 11 Flange Adapter BV	1	each	1,202.572
2915546	16" (400 mm) SDR 17.6 Flange Adapter	1	each	1,057.211
2915546BV	16" (400 mm) SDR 17.6 Flange Adapter BV	1	each	1,057.211
0115549	18" (450 mm) SDR 11 Flange Adapter	1	each	1,554.106
0115549BV	18" (450 mm) SDR 11 Flange Adapter BV	1	each	1,554.106
2915548	18" (450 mm) SDR 17.6 Flange Adapter	1	each	1,087.956
2915548BV	18" (450 mm) SDR 17.6 Flange Adapter BV	1	each	1,087.956
2915550	20" (500 mm) SDR 17.6 Flange Adapter	1	each	1,391.660
2915550BV	20" (500 mm) SDR 17.6 Flange Adapter BV	1	each	1,391.660
2915552	22" (560 mm) SDR 17.6 Flange Adapter	1	each	1,811.523
2915552BV	22" (560 mm) SDR 17.6 Flange Adapter BV	1	each	1,811.523
2915554	24" (630 mm) SDR 17.6 Flange Adapter	1	each	1,856.971
2915554BV	24" (630 mm) SDR 17.6 Flange Adapter BV	1	each	1,856.971

Flange Rings with ANSI bolt pattern

Item No.	Description	Packing Unit	Price Unit	List price each
3315712	1" (32 mm) Flange Ring	1	each	24.016
3315714	1 1/4" (40 mm) Flange Ring	1	each	32.343
3315716	1 1/2" (50 mm) Flange Ring	1	each	40.848
3315718	2" (63 mm) Flange Ring	1	each	48.909
3315720	2 1/2" (75 mm) Flange Ring	1	each	69.163
3315722	3" (90 mm) Flange Ring	1	each	80.613
3315724	3 1/2" (110 mm) Flange Ring	1	each	100.322
3315726	4" (125 mm) Flange Ring	1	each	109.718
3315730	6" (160 mm) Flange Ring	1	each	133.247
3315734	8" (200 mm) Flange Ring	1	each	177.125
3315738	10" (250 mm) Flange Ring	1	each	220.343
3315742	12" (315 mm) Flange Ring	1	each	239.156
3315744	14" (355 mm) Flange Ring	1	each	365.818
3315746	16" (400 mm) Flange Ring	1	each	423.678
3315748	18" (450 mm) Flange Ring	1	each	612.231
3315750	20" (500 mm) Flange Ring	1	each	600.820
3315752	22" (560 mm) Flange Ring	1	each	1,038.056
3315754	24" (630 mm) Flange Ring	1	each	847.986

Pump Flange Rings

Item No.	Description	Packing Unit	Price Unit	List price each
5515712	1" (32 mm) Pump Flange Adapter Ring	1	each	16.154
5515713	1 1/4" (40 mm) Pump Flange Adapter Ring	1	each	16.154
5515714	1 1/4" (40 mm) Pump Flange Adapter Ring	1	each	16.154

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Assembly Items

Item No.	Description	Packing Unit	Price Unit	List price each
9900015	Training kit	1	each	20.193
112130L	6" (160 mm) Green Pipe SDR 7.4 Elbow 90°	1	each	257.250
112131LB	6" (160 mm) SDR 11 Elbow 90° - 1ft Blue Pipe Extension	1	each	257.250
112131LG	6" (160 mm) SDR 11 Elbow 90° - 1ft Green Pipe Extension	1	each	257.250
112530L	6" (160 mm) Green SDR 7.4 Elbow 45° - 1ft Extension	1	each	255.150
112531LB	6" (160 mm) SDR 11 Elbow 45° - 1ft Blue Pipe Extension	1	each	255.150
112531LG	6" (160 mm) SDR 11 Elbow 45° - 1ft Green Pipe Extension	1	each	255.150
113130L	6" (160 mm) Green SDR 7.4 Tee - 1ft Extension	1	each	307.650
113131LB	6" (160 mm) SDR 11 Tee - 1ft Blue Extension	1	each	307.650
113131LG	6" (160 mm) SDR 11 Tee - 1ft Green Extension	1	each	307.650
113604L	6" x 6" x 4" (160 mm x 160 mm x 125 mm) Green SDR 7.4 Reducing Tee (inlet, outlet, branch)	1	each	339.150
113605LB	6" x 6" x 4" (160 mm x 160 mm x 125 mm) Blue SDR 11 Outlet Reducing Tee	1	each	339.150
113605LG	6" x 6" x 4" (160 mm x 160 mm x 125 mm) Green SDR 11 Outlet Reducing Tee	1	each	339.150
115530L	6" (160 mm) SDR 7.4 Flange Adapter - 1ft Extension	1	each	139.650
115531LB	6" (160 mm) SDR 11 Flange Adapter - 1ft Blue Extension	1	each	139.650
115531LG	6" (160 mm) SDR 11 Flange Adapter - 1ft Green Extension	1	each	139.650
ASK	Aquatherm Sales Kit	1	each	1,750.350

Unions and Electrofusion Couplings

Unions (with brass nut)

Item No.	Description	Packing Unit	Price Unit	List price each
0115812	1" (32 mm) Union with Brass Nut	1	each	110.836
0115814	1 1/4" (40 mm) Union with Brass Nut	1	each	173.634
0115816	1 1/2" (50 mm) Union with Brass Nut	1	each	176.071
0115818	2" (63 mm) Union with Brass Nut	1	each	286.769
0115820	2 1/2" (75 mm) Union with Brass Nut	1	each	376.858

Unions (with PP-R nut)

Item No.	Description	Packing Unit	Price Unit	List price each
0115838	1/2" (20 mm) Union with PP-R Nut	10	each	40.302
0115840	3/4" (25 mm) Union with PP-R Nut	10	each	44.348
0115842	1" (32 mm) Union with PP-R Nut	5	each	49.386
0115844	1 1/4" (40 mm) Union with PP-R Nut	5	each	91.061
0115846	1 1/2" (50 mm) Union with PP-R Nut	5	each	122.968
0115848	2" (63 mm) Union with PP-R Nut	1	each	146.172
0115850	2 1/2" (75 mm) Union with PP-R Nut	1	each	202.939

Electrofusion Couplings

Item No.	Description	Packing Unit	Price Unit	List price each
0117208	1/2" (20 mm) Electrofusion Coupling	1	each	45.544
0117210	3/4" (25 mm) Electrofusion Coupling	1	each	47.325
0117212	1" (32 mm) Electrofusion Coupling	1	each	53.007
0117214	1 1/4" (40 mm) Electrofusion Coupling	1	each	53.855
0117216	1 1/2" (50 mm) Electrofusion Coupling	1	each	58.095
0117218	2" (63 mm) Electrofusion Coupling	1	each	84.217
0117220	2 1/2" (75 mm) Electrofusion Coupling	1	each	99.822
0117222	3" (90 mm) Electrofusion Coupling	1	each	127.386
0117224	3 1/2" (110 mm) Electrofusion Coupling	1	each	180.901
0117226	4" (125 mm) Electrofusion Coupling	1	each	227.679
0117230	6" (160 mm) Electrofusion Coupling	1	each	278.945
0117234	8" (200 mm) Electrofusion Coupling	1	each	473.184
0117238	10" (250 mm) Electrofusion Coupling	1	each	642.113

Mounting Devices

Threaded Back-plate Elbows

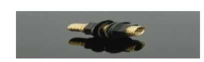
Item No.	Description	Packing Unit	Price Unit	List price each
0120108	1/2" x 1/2" F (20 mm x 1/2" F) Back Plate Elbow - Industrial Brass NPT	10	each	8.101
0120110	1/2" x 3/4" F (20 mm x 3/4" F) Back Plate Elbow - Industrial Brass NPT	10	each	12.119
0120112	3/4" x 3/4" F (25 mm x 3/4" F) Back Plate Elbow - Industrial Brass NPT	10	each	12.119
0120113	3/4" x 1/2" F (25 mm x 1/2" F) Back Plate Elbow - Industrial Brass NPT	10	each	8.101
0620108	1/2" x 1/2" F (20 mm x 1/2" F) Back Plate Elbow - Lead-free Brass NPT	10	each	11.848
0620110	1/2" x 3/4" F (20 mm x 3/4" F) Back Plate Elbow - Lead-free Brass NPT	10	each	17.725
0620112	3/4" x 3/4" F (25 mm x 3/4" F) Back Plate Elbow - Lead-free Brass NPT	10	each	17.725
0620113	3/4" x 1/2" F (25 mm x 1/2" F) Back Plate Elbow - Lead-free Brass NPT	10	each	11.848
0920108	1/2" x 1/2" F (20 mm x 1/2" F) Back Plate Elbow - Stainless Steel ISO	10	each	56.780
0920110	1/2" x 3/4" F (20 mm x 3/4" F) Back Plate Elbow - Stainless Steel ISO	10	each	64.720
0920112	3/4" x 3/4" F (25 mm x 3/4" F) Back Plate Elbow - Stainless Steel ISO	10	each	64.153
0920113	3/4" x 1/2" F (25 mm x 1/2" F) Back Plate Elbow - Stainless Steel ISO	10	each	55.859

Threaded Wing-back Elbows

Item No.	Description	Packing Unit	Price Unit	List price each
0120158	1/2" x 1/2" F (20 mm x 1/2" F) Wing Back 90° Elbow - Industrial Brass NPT	10	each	10.046
0620158	1/2" x 1/2" F (20 mm x 1/2" F) Wing Back 90° Elbow - Lead-free Brass NPT	10	each	14.692
0920158	1/2" x 1/2" F (20 mm x 1/2" F) Wing Back 90° Elbow - Stainless Steel ISO	10	each	56.213

Dry Construction Wall Fitting

Item No.	Description	Packing Unit	Price Unit	List price each
0120114	Dry construction wall fitting	10	each	21.452



ISO Plug for Pressure Tests

Item No.	Description	Packing Unit	Price Unit	List price each
0050708	1/2" (20 mm) ISO Plug for Pressure Tests with Gasket	1	each	1.378
0050710	3/4" (25 mm) ISO Plug for Pressure Tests with Gasket	1	each	1.782

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Mounting Plate

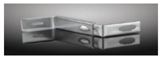
Item No.	Description	Packing Unit	Price Unit	List price each
0060010	7" / 4.75" / 2.75"-- 220 / 150 / 80 mm twin mounting unit for back-plate elbow	1	each	16.918

Mounting Plate

Item No.	Description	Packing Unit	Price Unit	List price each
0060110	3"/4"/6" -- 80/100/150 mm double mounting unit	1	each	48.874

Mounting Unit

Item No.	Description	Packing Unit	Price Unit	List price each
0060115	Single mounting unit	1	each	31.608



Mounting Unit with two transition elbows 0120208 with counternut, gasket, and tension rod

Item No.	Description	Packing Unit	Price Unit	List price each
0060150	Double mounting unit with two transition elbows (item 120208)	1	each	99.001

Mounting Unit with one transition elbows 0120208 with counternut, gasket, and tension rod

Item No.	Description	Packing Unit	Price Unit	List price each
0060155	Single mounting unit with one transition elbow (item 120208)	1	each	57.159

Transition pieces

Round FIP Transition Pieces

Item No.	Description	Packing Unit	Price Unit	List price each
0121008	1/2" x 1/2" F (20 mm x 1/2" F) Transition Piece - Industrial Brass NPT	10	each	6.935
0121010	1/2" x 3/4" F (20 mm x 3/4" F) Transition Piece - Industrial Brass NPT	10	each	9.138
0121011	3/4" x 1/2" F (25 mm x 1/2" F) Transition Piece - Industrial Brass NPT	10	each	6.935
0121012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Piece - Industrial Brass NPT	10	each	9.138
0121013	1" x 3/4" F (32 mm x 3/4" F) Transition Piece - Industrial Brass NPT	5	each	10.046
0621008	1/2" x 1/2" F (20 mm x 1/2" F) Transition Piece - Lead-free Brass NPT	10	each	10.143
0621010	1/2" x 3/4" F (20 mm x 3/4" F) Transition Piece - Lead-free Brass NPT	10	each	13.365
0621011	3/4" x 1/2" F (25 mm x 1/2" F) Transition Piece - Lead-free Brass NPT	10	each	10.143
0621012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Piece - Lead-free Brass NPT	10	each	13.365
0621013	1" x 3/4" F (32 mm x 3/4" F) Transition Piece - Lead-free Brass NPT	5	each	14.692
0921008	1/2" x 1/2" F (20 mm x 1/2" F) Transition Piece - Stainless Steel ISO	10	each	55.008
0921010	1/2" x 3/4" F (20 mm x 3/4" F) Transition Piece - Stainless Steel ISO	10	each	63.798
0921011	3/4" x 1/2" F (25 mm x 1/2" F) Transition Piece - Stainless Steel ISO	10	each	55.008
0921012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Piece - Stainless Steel ISO	10	each	63.373
0921013	1" x 3/4" F (32 mm x 3/4" F) Transition Piece - Stainless Steel ISO	5	each	64.578

Hex FIP Transition Pieces

Item No.	Description	Packing Unit	Price Unit	List price each
0121108	1/2" x 1/2" F (20 mm x 1/2" F) NPT Transition Piece - Industrial Brass NPT	10	each	10.882
0121110	1/2" x 3/4" F (20 mm x 3/4" F) NPT Transition Piece - Industrial Brass NPT	10	each	12.746
0121111	3/4" x 1/2" F (25 mm x 1/2" F) NPT Transition Piece - Industrial Brass NPT	10	each	10.882
0121112	3/4" x 3/4" F (25 mm x 3/4" F) NPT Transition Piece - Industrial Brass NPT	10	each	12.746
0121113	1" x 3/4" F (32 mm x 3/4" F) NPT Transition Piece - Industrial Brass NPT	5	each	14.683
0121114	1" x 1" F (32 mm x 1" F) NPT Transition Piece - Industrial Brass NPT	5	each	29.814
0121115	1 1/4" x 1" F (40 mm x 1" F) NPT Transition Piece - Industrial Brass NPT	5	each	31.303
0121116	1 1/4" x 1 1/4" F (40 mm x 1 1/4" F) NPT Transition Piece - Industrial Brass NPT	5	each	47.105
0121117	1 1/2" x 1 1/4" F (50 mm x 1 1/4" F) NPT Transition Piece - Industrial Brass NPT	5	each	48.670
0121118	1 1/2" x 1 1/2" F (50 mm x 1 1/2" F) NPT Transition Piece - Industrial Brass NPT	5	each	54.632
0121119	2" x 1 1/2" F (63 mm x 1 1/2" F) NPT Transition Piece - Industrial Brass NPT	1	each	59.849
0121120	2" x 2" F (63 mm x 2" F) NPT Transition Piece - Industrial Brass NPT	1	each	84.594
0121122	2 1/2" x 2" F (75 mm x 2" F) NPT Transition Piece - Industrial Brass NPT	1	each	88.321
0621108	1/2" x 1/2" F (20 mm x 1/2" F) NPT Transition Piece - Lead-free Brass NPT	10	each	15.915
0621110	1/2" x 3/4" F (20 mm x 3/4" F) NPT Transition Piece - Lead-free Brass NPT	10	each	18.641
0621111	3/4" x 1/2" F (25 mm x 1/2" F) NPT Transition Piece - Lead-free Brass NPT	10	each	15.915
0621112	3/4" x 3/4" F (25 mm x 3/4" F) NPT Transition Piece - Lead-free Brass NPT	10	each	18.641
0621113	1" x 3/4" F (32 mm x 3/4" F) NPT Transition Piece - Lead-free Brass NPT	5	each	21.474
0621114	1" x 1" F (32 mm x 1" F) NPT Transition Piece - Lead-free Brass NPT	5	each	43.602
0621115	1 1/4" x 1" F (40 mm x 1" F) NPT Transition Piece - Lead-free Brass NPT	5	each	45.781
0621116	1 1/4" x 1 1/4" F (40 mm x 1 1/4" F) NPT Transition Piece - Lead-free Brass NPT	5	each	68.891
0621117	1 1/2" x 1 1/4" F (50 mm x 1 1/4" F) NPT Transition Piece - Lead-free Brass NPT	5	each	71.179
0621118	1 1/2" x 1 1/2" F (50 mm x 1 1/2" F) NPT Transition Piece - Lead-free Brass NPT	5	each	79.899

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Hex FIP Transition Pieces continued

0621119	2" x 1 1/2" F (63 mm x 1 1/2" F) NPT Transition Piece - Lead-free Brass NPT	1	each	87.529
0621120	2" x 2" F (63 mm x 2" F) NPT Transition Piece - Lead-free Brass NPT	1	each	123.719
0621122	2 1/2" x 2" F (75 mm x 2" F) NPT Transition Piece - Lead-free Brass NPT	1	each	129.169
1121114	1" x 1" F (32 mm x 1" F) NPT Transition Piece - Stainless Steel ISO	5	each	179.768
1121115	1 1/4" x 1" F (40 mm x 1" F) NPT Transition Piece - Stainless Steel ISO	5	each	185.794
1121116	1 1/4" x 1 1/4" F (40 mm x 1 1/4" F) NPT Transition Piece - Stainless Steel ISO	5	each	232.863
1121117	1 1/2" x 1 1/4" F (50 mm x 1 1/4" F) NPT Transition Piece - Stainless Steel ISO	5	each	241.015
1121118	1 1/2" x 1 1/2" F (50 mm x 1 1/2" F) NPT Transition Piece - Stainless Steel ISO	5	each	262.919
1121119	2" x 1 1/2" F (63 mm x 1 1/2" F) NPT Transition Piece - Stainless Steel ISO	1	each	270.149

Round MIP Transition Pieces

Item No.	Description	Packing Unit	Price Unit	List price each
0121208	1/2" x 1/2" M (20 mm x 1/2" M) Transition Piece - Industrial Brass NPT	10	each	16.332
0121210	1/2" x 3/4" M (20 mm x 3/4" M) Transition Piece - Industrial Brass NPT	10	each	18.666
0121211	3/4" x 1/2" M (25 mm x 1/2" M) Transition Piece - Industrial Brass NPT	10	each	16.332
0121212	3/4" x 3/4" M (25 mm x 3/4" M) Transition Piece - Industrial Brass NPT	10	each	18.666
0121213	1" x 3/4" M (32 mm x 3/4" M) Transition Piece - Industrial Brass NPT	5	each	22.048
0621208	1/2" x 1/2" M (20 mm x 1/2" M) Transition Piece - Lead-free Brass NPT	10	each	23.886
0621210	1/2" x 3/4" M (20 mm x 3/4" M) Transition Piece - Lead-free Brass NPT	10	each	27.299
0621211	3/4" x 1/2" M (25 mm x 1/2" M) Transition Piece - Lead-free Brass NPT	10	each	23.886
0621212	3/4" x 3/4" M (25 mm x 3/4" M) Transition Piece - Lead-free Brass NPT	10	each	27.299
0621213	1" x 3/4" M (32 mm x 3/4" M) Transition Piece - Lead-free Brass NPT	5	each	32.245
0921208	1/2" x 1/2" M (20 mm x 1/2" M) Transition Piece - Stainless Steel ISO	10	each	70.745
0921210	1/2" x 3/4" M (20 mm x 3/4" M) Transition Piece - Stainless Steel ISO	10	each	79.534
0921211	3/4" x 1/2" M (25 mm x 1/2" M) Transition Piece - Stainless Steel ISO	10	each	70.745
0921212	3/4" x 3/4" M (25 mm x 3/4" M) Transition Piece - Stainless Steel ISO	10	each	79.534
0921213	1" x 3/4" M (32 mm x 3/4" M) Transition Piece - Stainless Steel ISO	5	each	83.151

Hex MIP NPT Transition Pieces

Item No.	Description	Packing Unit	Price Unit	List price each
0121308	1/2" x 1/2" M (20 mm x 1/2" M) NPT Transition Piece - Industrial Brass NPT	10	each	11.977
0121310	1/2" x 3/4"M (20 mm x 3/4"M) NPT Transition Piece - Industrial Brass NPT	10	each	13.688
0121312	3/4" x 3/4" M (25 mm x 3/4" M) NPT Transition Piece - Industrial Brass NPT	10	each	13.688
0121314	1" x 1" M (32 mm x 1" M) NPT Transition Piece - Industrial Brass NPT	5	each	22.943
0121316	1" (32 mm x 1 1/4" M) NPT Transition Piece - Industrial Brass NPT	5	each	38.627
0121317	1 1/4" (40 mm x 1" M) NPT Transition Piece - Industrial Brass NPT	5	each	23.786
0121318	1 1/4" (40 mm x 1 1/4" M) NPT Transition Piece - Industrial Brass NPT	5	each	41.090
0121319	1 1/2" x 1 1/4" M (50 mm x 1 1/4" M) NPT Transition Piece - Industrial Brass NPT	5	each	42.451
0121320	1 1/2" (50 mm x 1 1/2" M) NPT Transition Piece - Industrial Brass NPT	5	each	52.302
0121321	2" x 1 1/2" M (63 mm x 1 1/2" M) NPT Transition Piece - Industrial Brass NPT	1	each	61.959
0121322	2" x 2" M (63 mm x 2" M) NPT Transition Piece - Industrial Brass NPT	1	each	72.458
0121323	2 1/2" x 2" M (75 mm x 2" M) NPT Transition Piece - Industrial Brass NPT	1	each	74.208

Hex MIP NPT Transition Pieces

0121324	2 1/2" x 2 1/2" M (75 mm x 2 1/2" M) NPT Transition Piece - Industrial Brass NPT	1	each	111.086
0121325	3" x 3" M (90 mm x 3" M) NPT Transition Piece - Industrial Brass NPT	1	each	173.239
0121327	3 1/2" x 4" M (110 mm x 4" M) NPT Transition Piece - Industrial Brass NPT	1	each	355.162
0621308	1/2" x 1/2" M (20 mm x 1/2" M) NPT Transition Piece - Lead-free Brass NPT	10	each	17.516
0621310	1/2" x 3/4"M (20 mm x 3/4"M) NPT Transition Piece - Lead-free Brass NPT	10	each	20.019
0621312	3/4" x 3/4" M (25 mm x 3/4" M) NPT Transition Piece - Lead-free Brass NPT	10	each	20.019
0621314	1" x 1" M (32 mm x 1" M) NPT Transition Piece - Lead-free Brass NPT	5	each	33.555
0621316	1" (32 mm x 1 1/4" M) NPT Transition Piece - Lead-free Brass NPT	5	each	56.492
0621317	1 1/4" (40 mm x 1" M) NPT Transition Piece - Lead-free Brass NPT	5	each	34.787
0621318	1 1/4" (40 mm x 1 1/4" M) NPT Transition Piece - Lead-free Brass NPT	5	each	60.095
0621319	1 1/2" x 1 1/4" M (50 mm x 1 1/4" M) NPT Transition Piece - Lead-free Brass NPT	5	each	62.085
0621320	1 1/2" (50 mm x 1 1/2" M) NPT Transition Piece - Lead-free Brass NPT	5	each	76.492
0621321	2" x 1 1/2" M (63 mm x 1 1/2" M) NPT Transition Piece - Lead-free Brass NPT	1	each	90.616
0621322	2" x 2" M (63 mm x 2" M) NPT Transition Piece - Lead-free Brass NPT	1	each	105.971
0621323	2 1/2" x 2" M (75 mm x 2" M) NPT Transition Piece - Lead-free Brass NPT	1	each	108.529
0621324	2 1/2" x 2 1/2" M (75 mm x 2 1/2" M) NPT Transition Piece - Lead-free Brass NPT	1	each	162.463
0621325	3" x 3" M (90 mm x 3" M) NPT Transition Piece - Lead-free Brass NPT	1	each	253.363

Transition FIP Elbows

Item No.	Description	Packing Unit	Price Unit	List price each
0123008	1/2" x 3/4" F (20 mm x 3/4" F) Transition Elbow - Industrial Brass NPT	10	each	12.119
0123010	1/2" x 1/2" F (20 mm x 1/2" F) Transition Elbow - Industrial Brass NPT	10	each	8.101
0123012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Elbow - Industrial Brass NPT	10	each	12.119
0123014	3/4" x 1/2" F (25 mm x 1/2" F) Transition Elbow - Industrial Brass NPT	10	each	8.101
0123016	1" x 3/4" F (32 mm x 3/4" F) Transition Elbow - Industrial Brass NPT	5	each	13.416
0123018	1" x 1" F (32 mm x 1" F) Transition Elbow - Industrial Brass NPT	5	each	29.035
0623008	1/2" x 3/4" F (20 mm x 3/4" F) Transition Elbow - Lead-free Brass NPT	10	each	17.725
0623010	1/2" x 1/2" F (20 mm x 1/2" F) Transition Elbow - Lead-free Brass NPT	10	each	11.848
0623012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Elbow - Lead-free Brass NPT	10	each	17.725
0623014	3/4" x 1/2" F (25 mm x 1/2" F) Transition Elbow - Lead-free Brass NPT	10	each	11.848
0623016	1" x 3/4" F (32 mm x 3/4" F) Transition Elbow - Lead-free Brass NPT	5	each	19.621
0623018	1" x 1" F (32 mm x 1" F) Transition Elbow - Lead-free Brass NPT	5	each	42.464
1123018	1/2" x 1/2" x 1/2" F (20 mm x 20 mm x 1/2") Transition Elbow - Stainless Steel NPT	5	each	166.584
0923008	1/2" x 3/4" F (20 mm x 3/4" F) Transition Elbow - Stainless Steel ISO	10	each	67.413
0923010	1/2" x 1/2" F (20 mm x 1/2" F) Transition Elbow - Stainless Steel ISO	10	each	58.410
0923012	3/4" x 3/4" F (25 mm x 3/4" F) Transition Elbow - Stainless Steel ISO	10	each	67.413
0923014	3/4" x 1/2" F (25 mm x 1/2" F) Transition Elbow - Stainless Steel ISO	10	each	58.410
0923016	1" x 3/4" F (32 mm x 3/4" F) Transition Elbow - Stainless Steel ISO	5	each	65.003

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Transition m/f x FIP NPT Elbows

Item No.	Description	Packing Unit	Price Unit	List price each
0123208	1/2" x 1/2" F (20 mm x 1/2" F) NPT Transition Street Elbow M/F - Industrial Brass NPT	10	each	8.101
0623208	1/2" x 1/2" F (20 mm x 1/2" F) NPT Transition Street Elbow M/F - Lead-free Brass NPT	10	each	11.848

Transition MIP Elbows

Item No.	Description	Packing Unit	Price Unit	List price each
0123506	1/2" x 1/2" M (20 mm x 1/2" M) Transition Elbow - Industrial Brass NPT	10	each	10.110
0123508	1/2" x 3/4" M (20 mm x 3/4" M) Transition Elbow - Industrial Brass NPT	10	each	11.406
0123510	3/4" x 3/4" M (25 mm x 3/4" M) Transition Elbow - Industrial Brass NPT	10	each	11.406
0123512	1" x 3/4" M (32 mm x 3/4" M) Transition Elbow - Industrial Brass NPT	5	each	14.906
0123514	1" x 1" M (32 mm x 1" M) Transition Elbow - Industrial Brass NPT	5	each	26.508
0623506	1/2" x 1/2" M (20 mm x 1/2" M) Transition Elbow - Lead-free Brass NPT	10	each	14.786
0623508	1/2" x 3/4" M (20 mm x 3/4" M) Transition Elbow - Lead-free Brass NPT	10	each	16.682
0623510	3/4" x 3/4" M (25 mm x 3/4" M) Transition Elbow - Lead-free Brass NPT	10	each	16.682
0623512	1" x 3/4" M (32 mm x 3/4" M) Transition Elbow - Lead-free Brass NPT	5	each	21.801
0623514	1" x 1" M (32 mm x 1" M) Transition Elbow - Lead-free Brass NPT	5	each	38.768
0923506	1/2" x 1/2" M (20 mm x 1/2" M) Transition Elbow - Stainless Steel ISO	1	each	72.092
0923508	1/2" x 3/4" M (20 mm x 3/4" M) Transition Elbow - Stainless Steel ISO	1	each	82.441
0923510	3/4" x 3/4" M (25 mm x 3/4" M) Transition Elbow - Stainless Steel ISO	1	each	82.441
0923512	1" x 3/4" M (32 mm x 3/4" M) Transition Elbow - Stainless Steel ISO	1	each	84.497

Transition MIP Piece with counternut, gasket, and tension washer

Item No.	Description	Packing Unit	Price Unit	List price each
0120204	1/2" x 1/2" F x 3/4" M (20 mm x 1/2" F x 3/4" M) ISO Transition Piece	10	each	17.693

Transition MIP Elbow with counternut, gasket, and tension washer

Item No.	Description	Packing Unit	Price Unit	List price each
0120208	1/2" x 1/2" F x 3/4" M (20 mm x 1/2" F x 3/4" M) ISO Transition Elbow	10	each	22.618
0120209	3/4" x 1/2" F x 3/4" M (25 mm x 1/2" F x 3/4" M) ISO Transition Elbow	10	each	22.618

Transition Elbow for Plasterboard

Item No.	Description	Packing Unit	Price Unit	List price each
0120210	1/2" x 1/2" F x 3/4" M (20 mm x 1/2" F x 3/4" M) ISO Transition Elbow	10	each	22.618

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Transition FIP Tees

Item No.	Description	Packing Unit	Price Unit	List price each
0125006	1/2" x 1/2" x 1/2" F (20 mm x 20 mm x 1/2") Transition Tee - Industrial Brass NPT	10	each	9.592
0125008	1/2" x 1/2" x 3/4" F (20 mm x 20 mm x 3/4") Transition Tee - Industrial Brass NPT	10	each	12.768
0125010	3/4" x 3/4" x 1/2" F (25 mm x 25 mm x 1/2") Transition Tee - Industrial Brass NPT	10	each	9.592
0125012	3/4" x 3/4" x 3/4" F (25 mm x 25 mm x 3/4") Transition Tee - Industrial Brass NPT	10	each	12.768
0125013	1" x 1" x 1/2" F (32 mm x 32 mm x 1/2") Transition Tee - Industrial Brass NPT	5	each	14.906
0125014	1" x 1" x 3/4" F (32 mm x 32 mm x 3/4") Transition Tee - Industrial Brass NPT	5	each	14.906
0125016	1" x 1" x 1" F (32 mm x 32 mm x 1") Transition Tee - Industrial Brass NPT	5	each	29.165
0125022	1 1/2" x 1 1/2" x 1" F (50 mm x 50 mm x 1") Transition Tee - Industrial Brass NPT	5	each	32.834
0625006	1/2" x 1/2" x 1/2" F (20 mm x 20 mm x 1/2") Transition Tee - Lead-free Brass NPT	10	each	14.028
0625008	1/2" x 1/2" x 3/4" F (20 mm x 20 mm x 3/4") Transition Tee - Lead-free Brass NPT	10	each	18.673
0625010	3/4" x 3/4" x 1/2" F (25 mm x 25 mm x 1/2") Transition Tee - Lead-free Brass NPT	10	each	14.028
0625012	3/4" x 3/4" x 3/4" F (25 mm x 25 mm x 3/4") Transition Tee - Lead-free Brass NPT	10	each	18.673
0625014	1" x 1" x 3/4" F (32 mm x 32 mm x 3/4") Transition Tee - Lead-free Brass NPT	5	each	21.801
0625016	1" x 1" x 1" F (32 mm x 32 mm x 1") Transition Tee - Lead-free Brass NPT	5	each	42.654
0625022	1 1/2" x 1 1/2" x 1" F (50 mm x 50 mm x 1") Transition Tee - Lead-free Brass NPT	5	each	48.020
1125016	1" x 1" x 1" F (32 mm x 32 mm x 1") Transition Tee - Stainless Steel NPT	5	each	176.579
0925006	1/2" x 1/2" x 1/2" F (20 mm x 20 mm x 1/2") Transition Tee - Stainless Steel ISO	10	each	55.575
0925008	1/2" x 1/2" x 3/4" F (20 mm x 20 mm x 3/4") Transition Tee - Stainless Steel ISO	10	each	66.208
0925010	3/4" x 3/4" x 1/2" F (25 mm x 25 mm x 1/2") Transition Tee - Stainless Steel ISO	10	each	56.213
0925012	3/4" x 3/4" x 3/4" F (25 mm x 25 mm x 3/4") Transition Tee - Stainless Steel ISO	10	each	66.208
0925014	1" x 1" x 3/4" F (32 mm x 32 mm x 3/4") Transition Tee - Stainless Steel ISO	5	each	65.145

Transition MIP NPT Tees

Item No.	Description	Packing Unit	Price Unit	List price each
0125506	1/2" x 1/2" M (20 mm x 1/2" M) NPT Transition Tee - Industrial Brass NPT	10	each	11.730
0625506	1/2" x 1/2" M (20 mm x 1/2" M) NPT Transition Tee - Lead-free Brass NPT	5	each	17.156

Compression fitting Stub-out

Item No.	Description	Packing Unit	Price Unit	List price each
0099013	1/2" PPR to 1/2" Compression (20 mm to 20 mm) Transition to Compression Fitting (PP-R to brass)	10	each	19.205

PEX Adaptors - Crimp

Item No.	Description	Packing Unit	Price Unit	List price each
0099840	1/2" (20 mm) PEX Adapter (crimp)	1	each	11.253
0099841	3/4" (25 mm) PEX Adapter (crimp)	1	each	20.524
0099842	1" (32 mm) PEX Adapter (crimp)	1	each	27.812

PEX Adaptors - Compression

Item No.	Description	Packing Unit	Price Unit	List price each
0098840	1/2" (20 mm x 1/2") PEX Adapter (compression)	1	each	18.000
0098841	3/4" (25 mm x 3/4") PEX Adapter (compression)	1	each	22.500
0098842	1" (32 mm x 1") PEX Adapter (compression)	1	each	27.000

Grooved Transition

Item No.	Description	Packing Unit	Price Unit	List price each
0627060	2.5" to 2" (75 mm x 63 mm) PP-R to Grooved Pipe Transition	1	each	217.485

Straight Copper Stubouts

Item No.	Description	Packing Unit	Price Unit	List price each
AQ638P211	1/2" (20 mm) Straight Stub Out (PP-R to copper)	25	each	14.810
AQ638P311	3/4" (25 mm) Straight Stub Out (PP-R to copper)	25	each	26.620
AQ638P418	1" (32 mm) Straight Stub Out (PP-R to copper)	10	each	47.230

Elbow Copper Stubouts

Item No.	Description	Packing Unit	Price Unit	List price each
AQ630P248E	1/2" (20 mm) Stub Out (PP-R to copper)	25	each	14.805
AQ630P368E	3/4" (25 mm) Stub Out (PP-R to copper)	25	each	32.307
AQ630P41110	1" (32 mm) Stub Out (PP-R to copper)	10	each	59.231

Fusion Outlets FIP

Item No.	Description	Packing Unit	Price Unit	List price each
0128214	1 1/4" x 3/4" x 1/2" F (40 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128216	1 1/2" x 3/4" x 1/2" F (50 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128218	2" x 3/4" x 1/2" F (63 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128220	2 1/2" x 3/4" x 1/2" F (75 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128222	3" x 3/4" x 1/2" F (90 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128224	3 1/2" x 3/4" x 1/2" F (110 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128226	4" x 3/4" x 1/2" F (125 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128230	6" x 3/4" x 1/2" F (160 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128232	8 to 10" x 3/4" x 1/2" F (200 mm to 250 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.926
0128234	1 1/4" x 3/4" x 3/4" F (40 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128236	1 1/2" x 3/4" x 3/4" F (50 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128238	2" x 3/4" x 3/4" F (63 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128240	2 1/2" x 3/4" x 3/4" F (75 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128242	3" x 3/4" x 3/4" F (90 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128244	3 1/2" x 3/4" x 3/4" F (110 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128246	4" x 3/4" x 3/4" F (125 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	17.062
0128250	6" x 3/4" x 3/4" F (160 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	16.988
0128254	8 to 10" x 3/4" x 3/4" F (200 mm to 250 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	16.988
0128260	2 1/2" x 1" x 1" F (75 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	24.730
0128262	3" x 1" x 1" F (90 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	24.730
0128264	3 1/2" x 1" x 1" F (110 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	24.730
0128266	4" x 1" x 1" F (125 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	24.730
0128270	6" x 1" x 1" F (160 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	24.730
0128274	8 to 10" x 1" x 1" F (200 mm to 250 mm x 32 mm x 1") NPT Fusion Outlet - Industrial Brass NPT	5	each	33.351
0628214	1 1/4" x 3/4" x 1/2" F (40 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628216	1 1/2" x 3/4" x 1/2" F (50 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628218	2" x 3/4" x 1/2" F (63 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628220	2 1/2" x 3/4" x 1/2" F (75 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628222	3" x 3/4" x 1/2" F (90 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628224	3 1/2" x 3/4" x 1/2" F (110 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628226	4" x 3/4" x 1/2" F (125 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628230	6" x 3/4" x 1/2" F (160 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628232	8 to 10" x 3/4" x 1/2" F (200 mm to 250 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.441
0628234	1 1/4" x 3/4" x 3/4" F (40 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628236	1 1/2" x 3/4" x 3/4" F (50 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628238	2" x 3/4" x 3/4" F (63 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628240	2 1/2" x 3/4" x 3/4" F (75 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628242	3" x 3/4" x 3/4" F (90 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628244	3 1/2" x 3/4" x 3/4" F (110 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953
0628246	4" x 3/4" x 3/4" F (125 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.953

Fusion outlets require welding heads 50614-50699 and drill bits 50940-50958

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Fusion Outlets FIP continued

0628250	6" x 3/4" x 3/4" F (160 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.845
0628254	8 to 10" x 3/4" x 3/4" F (200 mm to 250 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	24.845
0628260	2 1/2" x 1" x 1" F (75 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	36.167
0628262	3" x 1" x 1" F (90 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	36.167
0628264	3 1/2" x 1" x 1" F (110 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	36.167
0628266	4" x 1" x 1" F (125 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	36.167
0628270	6" x 1" x 1" F (160 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	36.167
0628274	8 to 10" x 1" x 1" F (200 mm to 250 mm x 32 mm x 1") NPT Fusion Outlet - Lead-free Brass NPT	1	each	48.776
0928214	1 1/4" x 3/4" x 1/2" F (40 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928216	1 1/2" x 3/4" x 1/2" F (50 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928218	2" x 3/4" x 1/2" F (63 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928220	2 1/2" x 3/4" x 1/2" F (75 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928222	3" x 3/4" x 1/2" F (90 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928224	3 1/2" x 3/4" x 1/2" F (110 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928226	4" x 3/4" x 1/2" F (125 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928230	6" x 3/4" x 1/2" F (160 mm x 25 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.210
0928232	8 to 10" x 3/4" x 1/2" F (200 mm to 250 mm x 1/2") NPT Fusion Outlet - Stainless Steel ISO	5	each	75.636
0928234	1 1/4" x 3/4" x 3/4" F (40 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928236	1 1/2" x 3/4" x 3/4" F (50 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928238	2"x3/4" (63 mm x 25 mm) NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928240	2 1/2" x 3/4" x 3/4" F (75 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928242	3" x 3/4" x 3/4" F (90 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928244	3 1/2" x 3/4" x 3/4" F (110 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928246	4" x 3/4" x 3/4" F (125 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928250	6" x 3/4" x 3/4" F (160 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	100.304
0928254	8 to 10" x 3/4" x 3/4" F (200 mm to 250 mm x 25 mm x 3/4") NPT Fusion Outlet - Stainless Steel ISO	5	each	107.393

Fusion Outlets MIP

Item No.	Description	Packing Unit	Price Unit	List price each
0128314	1" x 3/4" x 1/2" M (40 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.730
0128316	1 1/2" x 3/4" x 1/2" M (50 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.730
0128318	2" x 3/4" x 1/2" M (63 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.730
0128320	2 1/2" x 3/4" x 1/2" M (75 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.148
0128322	3" x 3/4" x 1/2" M (90 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	11.148
0128324	3 1/2" x 3/4" x 1/2" M (110 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	14.064
0128326	4" x 3/4" x 1/2" M (125 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	14.064
0128330	6" x 3/4" x 1/2" M (160 mm x 25 mm x 1/2") NPT Fusion Outlet - Industrial Brass NPT	5	each	15.036
0128334	1" x 3/4" x 3/4" M (40 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	15.822
0128336	1 1/2" x 3/4" x 3/4" M (50 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	15.822
0128338	2" x 3/4" x 3/4" M (63 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749
0128340	2 1/2" x 3/4" x 3/4" M (75 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749
0128342	3" x 3/4" x 3/4" M (90 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749
0128344	3 1/2" x 3/4" x 3/4" M (110 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749
0128346	4" x 3/4" x 3/4" M (125 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749
0128350	6" x 3/4" x 3/4" M (160 mm x 25 mm x 3/4") NPT Fusion Outlet - Industrial Brass NPT	5	each	22.749

Notes

Fusion outlets require welding heads 50614-50699 and drill bits 50940-50958

Fusion Outlets MIP

0628314	1" x 3/4" x 1/2" M (40 x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.156
0628316	1 1/2" x 3/4" x 1/2" M (50 x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.156
0628318	2" x 3/4" x 1/2" M (63 x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	17.156
0628320	2 1/2" x 3/4" x 1/2" M (75 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	16.304
0628322	3" x 3/4" x 1/2" M (90 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	16.304
0628324	3 1/2" x 3/4" x 1/2" M (110 x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	20.569
0628326	4" x 3/4" x 1/2" M (125 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	20.569
0628330	6" x 3/4" x 1/2" M (160 mm x 25 mm x 1/2") NPT Fusion Outlet - Lead-free Brass NPT	1	each	21.991
0628334	1" x 3/4" x 3/4" M (40 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	23.140
0628336	1 1/2" x 3/4" x 3/4" M (50 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	23.140
0628338	2" x 3/4" x 3/4" M (63 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
0628340	2 1/2" x 3/4" x 3/4" M (75 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
0628342	3" x 3/4" x 3/4" M (90 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
0628344	3 1/2" x 3/4" x 3/4" M (110 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
0628346	4" x 3/4" x 3/4" M (125 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
0628350	6" x 3/4" x 3/4" M (160 mm x 25 mm x 3/4") NPT Fusion Outlet - Lead-free Brass NPT	1	each	33.270
1128260	2 1/2" x 1" x 1" F (75 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	159.353
1128262	3" x 1" x 1" F (90 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	159.353
1128264	3 1/2" x 1" x 1" F (110 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	159.353
1128266	4" x 1" x 1" F (125 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	159.353
1128270	6" x 1" x 1" F (160 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	159.353
1128274	8 to 10" x 1" x 1" F (200 mm to 250 mm x 32 mm x 1") NPT Fusion Outlet - Stainless Steel NPT	5	each	176.437

Distributors and Accessories

Distribution Block Plumbing

Item No.	Description	Packing Unit	Price Unit	List price each	Notes
0130115	3/4" x 1/2" (25 mm x 20 mm) Distribution Block Plumbing	1	each	32.313	includes one plug and two fastening nails

Distribution Block Plumbing (with insulation)

Item No.	Description	Packing Unit	Price Unit	List price each
0130130	3/4" x 1/2" (25 mm x 20 mm) Distribution Block Plumbing (with insulation block)	1	each	45.459

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Flow Meter Well

Item No.	Description	Packing Unit	Price Unit	List price each
0628480	2" to 2 1/2" x 1 1/4" x 1 1/4" F (63 mm to 75 mm x 40 mm x 40 mm F) Flow Meter Well	1	each	75.753
0628500	4" x 1 1/2" x 1 1/2" F (125 mm x 50 mm x 50 mm F) Flow Meter Well	1	each	91.062
0628520	4" to 6" x 2" x 2" F (125 mm to 160 mm x 63 mm x 63 mm F) Flow Meter Well	1	each	147.879

Notes

may also be used for a thermometer well

Distribution Pipe

Item No.	Description	Packing Unit	Price Unit	List price each
0130604	1" x 1/2" (32 mm x 20 mm) Distribution Pipe	1	each	14.842

Notes

Manifold End Piece with Female Thread

Item No.	Description	Packing Unit	Price Unit	List price each
0130804	1" (32 mm) Distributor End Piece (female thread) NPT	2	each	12.807

Pipe Bags

Item No.	Description (pipe size given in O.D.)	Packing Unit - meters	Packing Unit - feet	List price per meter	List price per foot
0001444	9" (220 mm) plastic bag for greenpipe	300 m	925 ft	1.121	0.345
0001445	10" (250 mm) plastic bag for greenpipe	300 m	925 ft	1.336	0.411
0001446	10.5" (270 mm) plastic bag for greenpipe	300 m	925 ft	1.336	0.411
0001447	12" (300 mm) plastic bag for greenpipe	300 m	925 ft	1.336	0.411
0001448	14" (350 mm) plastic bag for greenpipe	300 m	925 ft	1.589	0.489
0002211	9" 220 mm) plastic bag for climatherm pipe	300 m	925 ft	1.001	0.308
0002212	10" (250 mm) plastic bag for climatherm pipe	300 m	925 ft	1.138	0.350
0002213	10.5" (270 mm) plastic bag for climatherm pipe	300 m	925 ft	1.229	0.378
0002214	12" (300 mm) plastic bag for climatherm pipe	300 m	925 ft	1.365	0.420
0002215	14" (350 mm) plastic bag for climatherm pipe	300 m	925 ft	1.593	0.490

Accessories

Item No.	Description	Packing Unit	Price Unit	List price each
0001111	Green Depth Gauge	1	each	1.176
0001112	Blue Depth Gauge	1	each	1.176
0050195	Heat Resistant Gloves	1	each	64.596

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Valves

Screw-down Stop Globe Valves

Item No.	Description	Packing Unit	Price Unit	List price each
0140808	1/2" (20 mm) Screw-Down Stop Globe Valve	1	each	23.355
0140810	3/4" (25 mm) Screw-Down Stop Globe Valve	1	each	23.355
0140812	1" (32 mm) Screw-Down Stop Globe Valve	1	each	43.918
0140814	1 1/4" (40 mm) Screw-Down Stop Globe Valve	1	each	72.969

Concealed Valves

Item No.	Description	Packing Unit	Price Unit	List price each
0140858	1/2" (20 mm) Concealed Valve	1	each	50.241
0140860	3/4" (25 mm) Concealed Valve	1	each	50.241
0140862	1" (32 mm) Concealed Valve	1	each	84.361

Concealed Valves (for deep construction)

Item No.	Description	Packing Unit	Price Unit	List price each
0140878	1/2" (20 mm) Concealed Valve	1	each	54.677
0140880	3/4" (25 mm) Concealed Valve	1	each	54.677
0140882	1" (32 mm) Concealed Valve	1	each	88.463

Notes

flexible for building depths 55-100mm

Concealed Valves (tamper-proof)

Item No.	Description	Packing Unit	Price Unit	List price each
0140868	1/2" (20 mm) Concealed Valve (short design)	1	each	44.567
0140870	3/4" (25 mm) Concealed Valve (short design)	1	each	44.029
0140872	1" (32 mm) Concealed Valve (short design)	1	each	71.292

Concealed Valves (tamper-proof; for deep contruction)

Item No.	Description	Packing Unit	Price Unit	List price each
0140888	1/2" (20 mm) Concealed Valve	1	each	46.538
0140890	3/4" (25 mm) Concealed Valve	1	each	46.538
0140892	1" (32 mm) Concealed Valve	1	each	107.146

Notes

flexible for building depths up to 60mm

Extensions for Concealed Valves

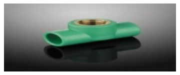
Item No.	Description	Packing Unit	Price Unit	List price each
0140900	(3.5" -- 92 mm length) concealed valve extension	1	each	22.965
0140902	(5" -- 132 mm length) concealed valve extension	1	each	32.603

Notes

for valves 140858-140862

Stop Valve Bodies

Item No.	Description	Packing Unit	Price Unit	List price each
0140908	1/2" -- 20 mm X 3/4" FIP stop valve body	1	each	8.687
0140910	3/4" -- 25 mm X 3/4" FIP stop valve body	1	each	8.687
0140912	1" -- 32 mm X 1" FIP stop valve body	1	each	16.598
0140914	1.25" -- 40 mm X 1.25" FIP stop valve body	1	each	35.518



Inclined Valves

Item No.	Description	Packing Unit	Price Unit	List price each
0141108	1/2" (20 mm) Inclined Valve	1	each	47.564
0141110	3/4" (25 mm) Inclined Valve	1	each	47.564
0141112	1" (32 mm) Inclined Valve	1	each	62.431
0141114	1 1/4" (40 mm) Inclined Valve	1	each	98.032

Combination / Check Valves

Item No.	Description	Packing Unit	Price Unit	List price each
0141208	1/2" (20 mm) Inclined Check Valve	1	each	58.842
0141210	3/4" (25 mm) Inclined Check Valve	1	each	58.842
0141212	1" (32 mm) Inclined Check Valve	1	each	70.462
0141214	1 1/4" (40 mm) Inclined Check Valve	1	each	127.995

Ball Valves (with brass ball)

Item No.	Description	Packing Unit	Price Unit	List price each
0041308	1/2" (20 mm) PP/Brass Ball Valve	1	each	53.079
0041310	3/4" (25 mm) PP/Brass Ball Valve	1	each	59.763
0041312	1" (32 mm) PP/Brass Ball Valve	1	each	72.962
0041314	1 1/4" (40 mm) PP/Brass Ball Valve	1	each	110.335
0041316	1 1/2" (50 mm) PP/Brass Ball Valve	1	each	168.650
0041318	2" (63 mm) PP/Brass Ball Valve	1	each	269.739

Extensions for Ball Valves

Item No.	Description	Packing Unit	Price Unit	List price each	Notes
0141378	1/2" to 3/4" x 1 1/3" (20 mm to 25 mm x 35 mm) Extension for Ball Valve	1	each	30.304	for valves 141308-141310
0141382	1" to 1 1/4" x 1 1/3" (32 mm to 40 mm x 35 mm) Extension for Ball Valve	1	each	30.361	for valves 141312-141314
0141386	1 1/2" to 2" x 1 4/5" (50 mm to 63 mm x 46 mm) Extension for Ball Valve	1	each	33.779	for valves 141316-141318

Ball Valves (with PP-R ball)

Item No.	Description	Packing Unit	Price Unit	List price each
0041488	1/2" (20 mm) PP Ball Valve	1	each	68.242
0041490	3/4" (25 mm) PP Ball Valve	1	each	71.545
0041492	1" (32 mm) PP Ball Valve	1	each	86.071
0041494	1 1/4" (40 mm) PP Ball Valve	1	each	109.880
0041496	1 1/2" (50 mm) PP Ball Valve	1	each	144.058
0041498	2" (63 mm) PP Ball Valve	1	each	169.976
0041400	2 1/2" (75 mm) PP Ball Valve	1	each	501.270

Ball Valves (with PP-R ball and ISO flange connections)

Item No.	Description	Packing Unit	Price Unit	List price each
0041602	3" (90 mm) PP Ball Valve (ISO bolt pattern)	1	each	710.597
0041604	3 1/2" to 4" (110 mm to 125 mm) PP Ball Valve (ISO bolt pattern)	1	each	717.373
0041607	6" (160 mm) PP Ball Valve (ISO bolt pattern)	1	each	1,785.505

Draining Branches

Item No.	Description	Packing Unit	Price Unit	List price each
0141408	1/2" (20 mm) Draining Branch	1	each	18.173
0141410	3/4" (25 mm) Draining Branch	1	each	18.173
0141412	1" (32 mm) Draining Branch	1	each	20.096
0141414	1 1/4" (40 mm) Draining Branch	1	each	20.096
0141416	1 1/2" (40 mm) Draining Branch	1	each	21.771
0141418	2" (63 mm) Draining Branch	1	each	24.687

Tools

Aquatherm is no longer offering hand-held welding irons, butt-fusion equipment or peeling tools. Please consult your local distributor or local Aquatherm Sales Representative for information on approved tool manufacturers.

Pipe Cutters

Item No.	Description	Packing Unit	Price Unit	List price each
0050104	3/8" - 1 1/4" (16 mm - 40 mm) Pipe Cutter	1	each	163.966

Welding Accessories

Socket Welding Heads

Item No.	Description	Packing Unit	Price Unit	List price each
0050208	1/2" (20 mm) Welding Head	1	each	111.943
0050210	3/4" (25 mm) Welding Head	1	each	114.912
0050212	1" (32 mm) Welding Head	1	each	129.825
0050214	1 1/4" (40 mm) Welding Head	1	each	163.136
0050216	1 1/2" (50 mm) Welding Head	1	each	185.345
0050218	2" (63 mm) Welding Head	1	each	222.401
0050220	2 1/2" (75 mm) Welding Head	1	each	266.881
0050222	3" (90 mm) Welding Head	1	each	287.216
0050224	3 1/2" (110 mm) Welding Head	1	each	498.254
0050226	4" (125 mm) Welding Head	1	each	606.066

Welding Head for Repair Plug

Item No.	Description	Packing Unit	Price Unit	List price each
0050307	1/4" (7 mm) Repair Set	1	each	140.865
0050311	7/16" (11 mm) Repair Set	1	each	140.865

Repair Plug

Item No.	Description	Packing Unit	Price Unit	List price each
0060600	7/16" x 1/4" (11 mm - 7 mm) Repair Plug	10	each	3.855

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Saddle Welding Heads (for fusion outlets)

Item No.	Description	Packing Unit	Price Unit	List price each
0050614	1 1/4" x 1/2" & 3/4" (40 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050616	1 1/2" x 1/2" & 3/4" (50 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050619	2" x 1/2" & 3/4" (63 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050620	2" x 1" (63 mm x 32 mm) Fusion Outlet Welding Head	1	each	226.081
0050623	2 1/2" x 1/2" & 3/4" (75 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050624	2 1/2" x 1" (75 mm x 32 mm) Fusion Outlet Welding Head	1	each	226.081
0050625	2 1/2" x 1 1/4" (75 mm x 40 mm) Fusion Outlet Welding Head	1	each	226.145
0050627	3" x 1/2" & 3/4" (90 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050628	3" x 1" (90 mm x 32 mm) Fusion Outlet Welding Head	1	each	226.081
0050629	3" x 1 1/4" (90 mm x 40 mm) Fusion Outlet Welding Head	1	each	226.081
0050631	3 1/2" x 1/2" & 3/4" (110 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050632	3 1/2" x 1" (110 mm x 32 mm) Fusion Outlet Welding Head	1	each	226.081
0050634	3 1/2" x 1 1/4" (110 mm x 40 mm) Fusion Outlet Welding Head	1	each	226.081
0050635	3 1/2" x 1 1/2" (110 mm x 50 mm) Fusion Outlet Welding Head	1	each	347.157
0050636	4" x 1/2" & 3/4" (125 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	226.081
0050638	4" x 1" (125 mm x 32 mm) Fusion Outlet Welding Head	1	each	226.081
0050640	4" x 1 1/4" (125 mm x 40 mm) Fusion Outlet Welding Head	1	each	226.081
0050642	4" x 1 1/2" (125 mm x 50 mm) Fusion Outlet Welding Head	1	each	355.047
0050644	4" x 2" (125 mm x 63 mm) Fusion Outlet Welding Head	1	each	403.010
0050648	6" x 1/2" & 3/4" (160 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	224.461
0050650	6" x 1" (160 mm x 32 mm) Fusion Outlet Welding Head	1	each	267.259
0050652	6" x 1 1/4" (160 mm x 40 mm) Fusion Outlet Welding Head	1	each	306.278
0050654	6" x 1 1/2" (160 mm x 50 mm) Fusion Outlet Welding Head	1	each	481.194
0050656	6" x 2" (160 mm x 63 mm) Fusion Outlet Welding Head	1	each	566.152
0050657	6" x 2 1/2" (160 mm x 75 mm) Fusion Outlet Welding Head	1	each	716.354
0050658	6" x 3" (160 mm x 90 mm) Fusion Outlet Welding Head	1	each	841.494
0050660	8" x 1/2" & 3/4" (200 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	301.219
0050662	8" x 1" (200 mm x 32 mm) Fusion Outlet Welding Head	1	each	300.987
0050664	8" x 1 1/4" (200 mm x 40 mm) Fusion Outlet Welding Head	1	each	354.252
0050666	8" x 1 1/2" (200 mm x 50 mm) Fusion Outlet Welding Head	1	each	449.967
0050667	8" x 2 1/2" (200 mm x 75 mm) Fusion Outlet Welding Head	1	each	734.556
0050668	8" x 2" (200 mm x 63 mm) Fusion Outlet Welding Head	1	each	551.207
0050669	8" x 3" (200 mm x 90 mm) Fusion Outlet Welding Head	1	each	884.118
0050670	8" x 3 1/2" (200 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,115.324
0050671	8" x 4" (200 mm x 125 mm) Fusion Outlet Welding Head	1	each	1,278.552
0050672	10" x 1/2" & 3/4" (250 mm x 20 mm & 25 mm) Fusion Outlet Welding Head	1	each	302.382
0050674	10" x 1" (250 mm x 32 mm) Fusion Outlet Welding Head	1	each	314.885
0050676	10" x 1 1/4" (250 mm x 40 mm) Fusion Outlet Welding Head	1	each	352.217
0050678	10" x 1 1/2" (250 mm x 50 mm) Fusion Outlet Welding Head	1	each	456.248
0050680	10" x 2" (250 mm x 63 mm) Fusion Outlet Welding Head	1	each	550.335
0050682	10" x 2 1/2" (250 mm x 75 mm) Fusion Outlet Welding Head	1	each	734.556
0050684	10" x 3" (250 mm x 90 mm) Fusion Outlet Welding Head	1	each	884.118
0050686	10" x 3 1/2" (250 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,115.324
0050688	10" x 4" (250 mm x 125 mm) Fusion Outlet Welding Head	1	each	1,278.552
0050690	12" x 2" (315 mm x 63 mm) Fusion Outlet Welding Head	1	each	1,085.900
0050692	12" x 2 1/2" (315 mm x 75 mm) Fusion Outlet Welding Head	1	each	1,226.275

Saddle Welding Heads (for fusion outlets) continued

0050694	12" x 3" (315 mm x 90 mm) Fusion Outlet Welding Head	1	each	1,441.024
0050696	12" x 3 1/2" (315 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,752.186
0050698	12" x 4" (315 mm x 125 mm) Fusion Outlet Welding Head	1	each	2,168.311
0050699	12" x 6" (315 mm x 160 mm) Fusion Outlet Welding Head	1	each	2,550.766
0050712	14"x 2" (355 mm x 63 mm) Fusion Outlet Welding Head	1	each	1,111.079
0050714	14" x 2 1/2" (355 mm x 75 mm) Fusion Outlet Welding Head	1	each	1,255.175
0050716	14" x 3" (355 mm x 90 mm) Fusion Outlet Welding Head	1	each	1,468.646
0050718	14" x 3 1/2" (355 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,778.296
0050720	14" x 4" (355 mm x 125 mm) Fusion Outlet Welding Head	1	each	2,215.005
0050722	14" x 6" (355 mm x 160 mm) Fusion Outlet Welding Head	1	each	2,652.761
0050724	14" x 8" (355 mm x 200 mm) Fusion Outlet Welding Head	1	each	3,301.312
0050726	16" - 24" x 2" (400 mm - 630 mm x 63 mm) Fusion Outlet Welding Head	1	each	1,111.058
0050728	16" - 20" x 2 1/2" (400 mm - 500 mm x 75 mm) Fusion Outlet Welding Head	1	each	1,255.149
0050730	22" - 24" x 2 1/2" (560 mm - 630 mm x 75 mm) Fusion Outlet Welding Head	1	each	1,255.149
0050732	16" - 20" x 3" (400 mm - 500 mm x 90 mm) Fusion Outlet Welding Head	1	each	1,468.614
0050734	22" - 24" x 3" (560 mm - 630 mm x 90 mm) Fusion Outlet Welding Head	1	each	1,468.614
0050736	16" - 18" x 3 1/2" (400 mm - 450 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,778.259
0050738	20" - 22" x 3 1/2" (500 mm - 560 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,778.259
0050740	24" x 3 1/2" (630 mm x 110 mm) Fusion Outlet Welding Head	1	each	1,778.259
0050742	16" x 4" (400 mm x 125 mm) Fusion Outlet Welding Head	1	each	1,964.214
0050744	18" - 1/2" x 4" (450 mm - 500 mm x 125 mm) Fusion Outlet Welding Head	1	each	1,964.214
0050746	22" - 24" x 4" (560 mm - 630 mm x 125 mm) Fusion Outlet Welding Head	1	each	1,964.214

Drill Bits (for fusion outlets)

Item No.	Description	Packing Unit	Price Unit	List price each
0050940	1/2" & 3/4" (for pipes 1 1/4"-6") (20 mm & 25 mm (for p) Drill Bit	1	each	209.166
0050941	1/2" & 3/4" (20 mm & 25 mm) Drill Bit	1	each	212.489
0050942	1" (32 mm) Drill Bit	1	each	231.761
0050944	1 1/4" (40 mm) Drill Bit	1	each	254.421
0050946	1 1/2" (50 mm) Drill Bit	1	each	447.706
0050948	2" (63 mm) Drill Bit	1	each	577.080
0050950	2 1/2" (75 mm) Drill Bit	1	each	601.245
0050952	3" (90 mm) Drill Bit	1	each	680.206
0050954	3 1/2" (110 mm) Drill Bit	1	each	910.121
0050956	4" (125 mm) Drill Bit	1	each	1,004.836
0050958	6" (160 mm) Drill Bit	1	each	1,737.719
0050960	8" (200 mm) Drill Bit	1	each	1,942.637

Drill bits 50950-50960 are NOT COMPATIBLE with hand-held drills, and must be used in fixed drilling machines.

These bits have a Morse-taper shank and no pilot bit.

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