SECTION

5

RADIANT WALLS AND CEILINGS

Although the majority of hydronic radiant heating systems are installed in floors, the walls and ceiling of a room can also make excellent radiant panels. This is possible because radiant energy travels equally well in any direction. Just as visible light travels downward and sideways from a ceiling fixture to illuminate the surfaces below, infrared light (e.g. radiant heat) will travel to warm the objects in the room below.

Experience with hydronic ceiling heating in North America dates back to the 1940s. Many systems were installed using both copper and iron tubing embedded in “plaster on lathe” ceilings. These systems demonstrated that radiant ceiling heating is not only feasible, but also able to create excellent comfort conditions. Some of these systems are still functioning today.

5-1 Advantages of Radiant Walls and Ceilings

Hydronically heated walls and ceilings offer several unique advantages compared to one or more of the floor heating options discussed in section 4. In circumstances where floor heating is not possible due to floor covering selections, heating load requirement (or other considerations) a heated wall or ceiling may be an ideal alternative. Keep the following advantages in mind as you evaluate your installation options.

- The output of heated walls and ceilings is not affected by floor coverings or furniture. Even a heated floor that’s initially installed with a low resistance covering may, at some future date, get covered with a high resistance finish floor that could substantially reduce its heat output. Most walls, and in particular ceilings, are unlikely to get more than a few coats of paint over the life of the system.
- Rooms such as bathrooms and kitchens often have a significant portion of their floor area occupied by base cabinets, islands, appliances or other objects that prevent the underling floor from being an effective heat emitter. In contrast, the ceilings of such spaces usually provide a virtually unobstructed surface from which radiant heat can be emitted. A radiant ceiling will also warm the countertop, floor

and tub surfaces below.

- In rooms where prolonged foot contact with the floor is likely, the maximum floor surface temperature should not exceed 85 deg. F. This limits the heat output from a heated floor to 35 to 40 Btu/hr/sq. ft. However, this temperature limit does not apply to heated walls and ceilings. A heated ceiling 8 feet above can be operated at temperatures as high as 100 deg. F. A 9 ft. tall ceiling can be operated as high as 110 deg. F. At these surface temperatures, heat outputs in excess of 70 Btu/hr/sqft are possible from either a heated wall or ceiling. Because of the higher outputs, the area of the radiant panel can often be reduced. This in turn reduces installation cost.
- Heated walls and ceilings typically have very low thermal mass and can respond quickly to changing load conditions. This is especially advantageous in rooms with significant solar gains or other sources of internal heat. This fast response is also beneficial for spaces that need to be quickly restored to normal comfort after prolonged setback periods.
- Heated walls and ceilings typically add very little weight to the structure and thus don't require structural alterations.
- Heated ceilings usually require less vertical space than most types of floor heating installations. This may be a significant advantage in retrofit situations, especially in basements with limited head room.
- Heated ceilings create very little air distubance in the room below. Approximately 95% of the output from a heated ceiling is in the form of radiant energy. Very little convection is created. The reduced air movement is especially desirable in rooms where dust movement and drafts need to be avoided.
- A radiant wall is an excellent addition to a walk-in shower. The warmed surface greatly improves the comfort over that of cold tile surfaces, especially if one or more walls are exposed to outdoor ambient conditions. The heated wall can be used to supplement the output of a heated floor. It also helps dry the shower walls quickly after a bath.
- Radiant walls make an excellent supplement to floor heating for indoor pool enclosures. In many cases, the amount of floor area available is limited due to the size of the pool. A low profile radiant wall will not only supplement the heat output, but will also significantly improve the comfort and help dry water splashed on the wall.

5-2 Radiant Wall Construction

Radiant walls can be constructed using a variation of the tube and plate system described in section 4. Figure 5-1 shows how the components go together.

In most rooms, it's neither necessary nor desirable to heat an entire wall from floor to ceiling. A better approach is to heat a low "perimeter band" along the wall. The heated area may extend 3 to 4 feet above the floor. This approach tends to direct the radiant energy into the lower (occupied) portion of the room.

A perimeter band can often be planned to run beneath the windowsill level to keep the tubing layout simple. Since the tubing is only installed in the lower portion of the wall, there's much less chance of it being struck by a nail (such as when a picture is hung on the wall). A "chair rail" molding often provides a convenient architectural divider for a transition between the heated lower portion of a wall and the unheated upper portion.

Installation:

If the tube and plates will be installed on the inside surface of an exterior wall, be sure that the wall is well insulated. To keep the outward heat loss comparable to that of a non-heated wall, the R-value of the wall insulation should be increased by about 50%. A vapor barrier should also be installed on the warm side of the insulation.

If the tube and plates will be installed on an inside partition, an R-11 fiberglass batt or other insulation with equivalent R-value should be installed behind the tube and plate system to steer the heat in the desired direction.

Begin by ripping 3/4" plywood sheets into strapping boards. The strapping boards, shown in figure 5-1, should have width 3/4" less than the tube spacing to be used. They can be nailed or screwed to the wall framing leaving a 3/4" gap between each adjacent row. These gaps accommodate the tube and trough portion of the heat dispersion plates.

Most walls require electrical outlets. When the wall will be clad with a tube and plate system, the junction box must extend an additional 3/4" out beyond the face of the wall studs to accommodate the added thickness of the strapping. It's usually easiest to install the necessary junction boxes before fastening the 3/4" plywood strapping to the wall. The tubing and aluminum heat dispersion plates should be kept at least 2" away from the junction boxes to minimize heat transfer to the box and the electrical device it contains.

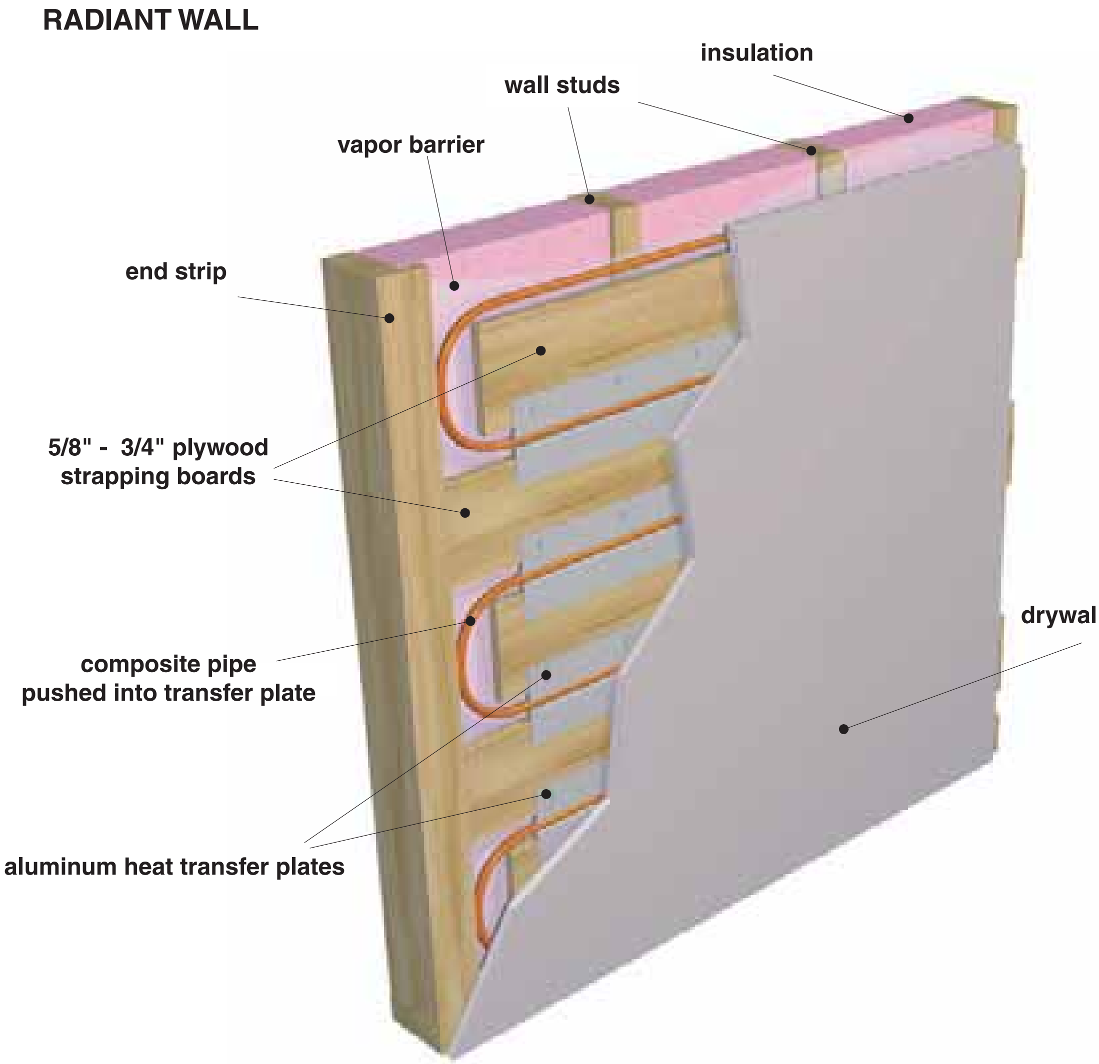


Figure 5-1

Where the tubing needs to form a return bend, hold the strapping short of the end of the wall by a distance approximately equal to the radius of the tube bend. A 1.5” x 3/4” plywood strip should be installed at the ends of the wall as a solid surface to which the wall finish can eventually be fastened. Be sure to plan where the tubing will enter and exit the wall. Figure 5-2 shows these details.

After the strapping is installed, the aluminum heat dispersion plates can be set in place and tacked using 2 or 3 staples through one wing of the plate. Be sure to pull the trough portion of the plate to one side of the strapping before stapling it. This creates a slight gap on the other side of the trough allowing the plate to expand slightly as the tube is pressed in place. Leave a gap of approximately 1 inch between ends of adjacent plates.

Uncoil the Kitec pipe and press it into the plates. Be sure to leave enough slack at the beginning and end of the serpentine pattern to connect the circuit to a manifold. A rubber-faced mason’s float makes an excellent tool for tapping the tubing into the plates without denting them.

After the circuits have been pressure tested, the wall can be covered with drywall or other panels. If the wall is to be finished with ceramic tile, the tubing and plates can be covered with a layer of cement board. The tile would then be bonded to the cement board with thin set mortar. Be sure not to drive fasteners through the tubing when installing the wall covering.

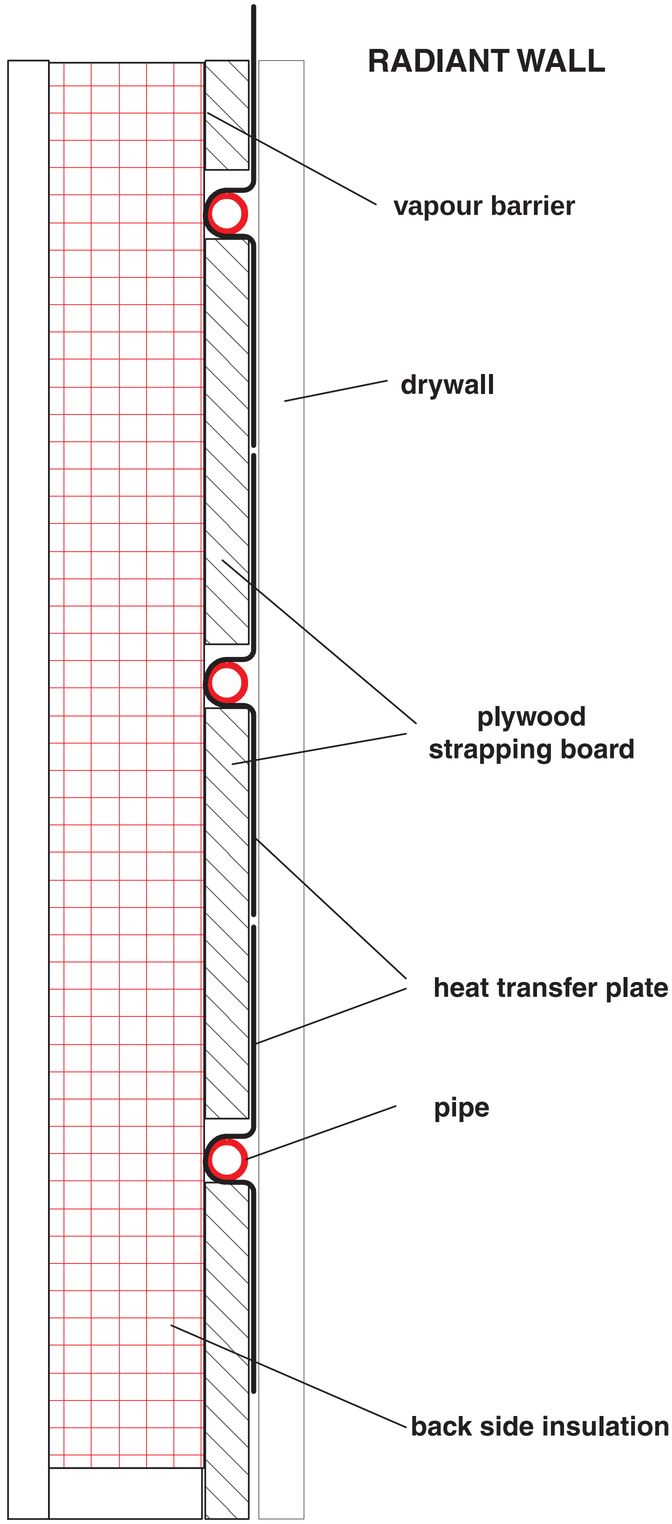

RADIANT WALL
vapour barrier
drywall
plywood
strapping board
heat transfer plate
pipe
back side insulation

Figure 5-1A

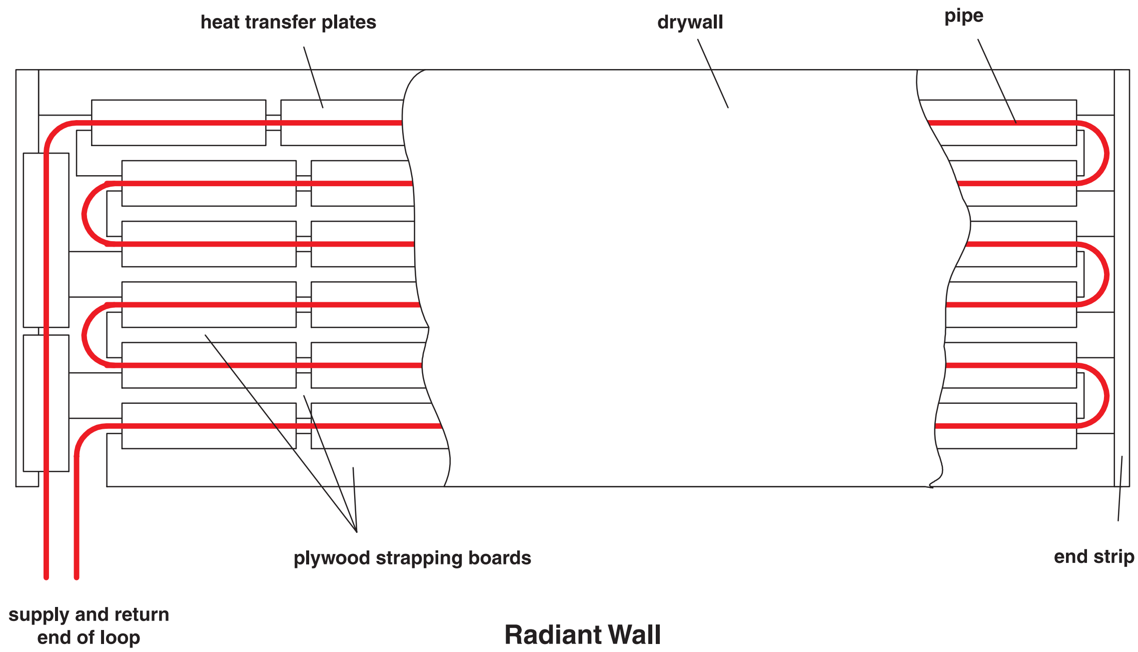


Figure 5-2

5-3 Radiant Ceilings Construction

The same tube and plate system used for a heated wall can also be used to create a radiant ceiling. Essentially the whole system is simply rotated by 90 degrees. The concept is shown in figure 5-3.

Installation:

Again, it is suggested that any electrical boxes on the ceiling be installed with an additional 3/4” projection below the ceiling framing prior to installing the strapping.

After the strapping is installed, the aluminum heat dispersion plates can be set in place and tacked using 2 or 3 staples on one side of the plate. Be sure to pull the trough portion of the plate to one side of the strapping before stapling it. This creates a slight gap on the other side of the trough, allowing the plate to expand slightly as the tube is pressed into place. Leave a gap of approximately 1 inch between ends of adjacent plates.

Uncoil the Kitec pipe and press it into the plates. A rubber-faced mason’s float makes an excellent tool for tapping the tubing into place without denting the plates. The slightly overbent shape of the heat dispersion plates will hold the tubing up after it is pushed tightly into place.

After the circuits have been pressure tested the ceiling can be drywalled. Leave some air pressure in the tubing as the drywall is installed. Because of the plywood strapping, additional screws and nails can be used if necessary to ensure the drywall is pulled tightly against the tubing and plates. Snap a chalk line halfway between the rows of piping and install the drywall fasteners along it. Be especially careful not to drive fasteners through the tubing near the return bends.

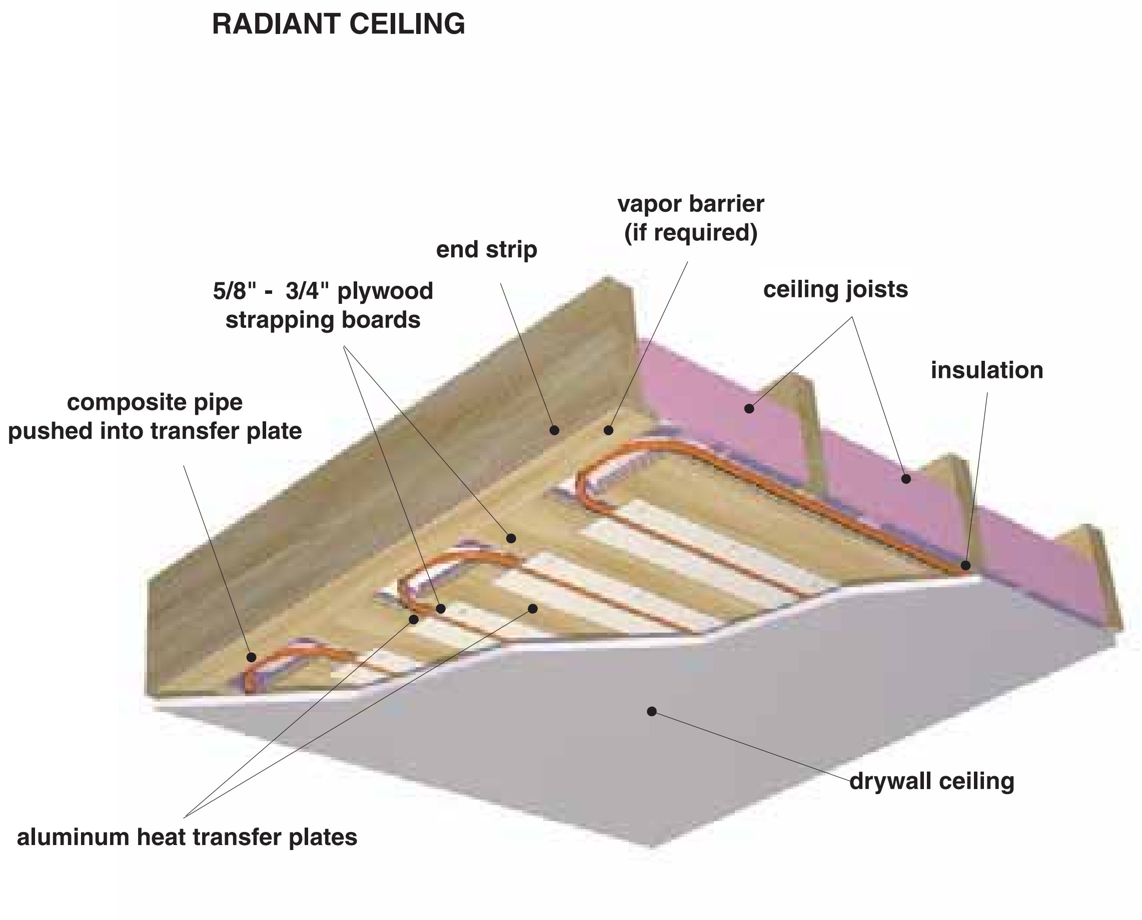


Figure 5-3

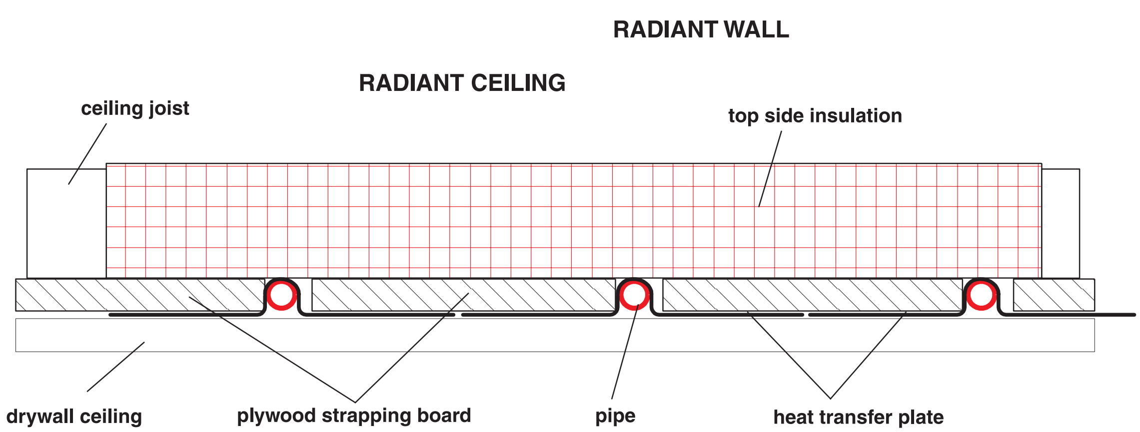


Figure 5-3A

SECTION

6

MANIFOLD SYSTEMS

6-1 Introduction

The vast majority of new hydronic radiant heating systems use one or more manifold stations as the connecting points for the tubing circuits.

All manifold stations consist of a supply manifold and a return manifold. The manifold station might be equipped with trims such as valve actuators, circuit flow meters, isolation valves and venting/draining components. The necessary trim is determined by how the system is intended to operate. For example, it's possible (although not always necessary) to operate each radiant panel circuit on the manifold station as an independent zone. A tubing circuit that heats the floor of the master bathroom could operate while the circuit(s) serving the bedroom adjacent to it remain off.

This section discusses the various manifold systems available from IPEX and suggests where each is appropriate.

6-2 Zoning Considerations

Hydronic heating has long been known for its ability to provide heat precisely when and where it's needed. If the building occupants desire a bathroom maintained at 75 deg. F., a child's bedroom at 65 deg. F., and an unused guest room at 55 degree F., hydronic heating can easily accommodate their needs.

Before planning the location of manifold stations, decisions need to be made on how the areas will be zoned.

One option is to treat the entire building as a single zone. This is appropriate when the following conditions are met:

- The occupants want to keep all rooms at similar and constant (although not necessarily identical) temperatures.
- All rooms have similar internal heat gains from sunlight, equipment, people and other sources.

- If temperature setback is used, all rooms will operate on the same setback schedule.
- There is relatively good air flow between rooms. The doors between individual rooms and interconnecting spaces are left open most of the time.

If these conditions are met, the entire building could be controlled as a single zone using a single thermostat (or other type of interior air temperature sensor). Since the control hardware is minimized, this approach will reduce installation cost.

When the conditions described above are not met, it's appropriate to plan the system for multiple zones.

When planning for multiple zones consider the following:

- What group of areas (if any) tend to have similar temperature requirements at the same time of day. For example, a home may have two or more bedrooms that are unoccupied during the daytime and thus could be kept at a reduced temperature to reduce fuel usage.
- What areas have similar internal heat gain patterns. For example on sunny days some rooms may receive enough direct solar heat gain to offset most of their heating load, even when it's very cold outside. A properly zoned system should allow the heat input from the hydronic system to these rooms to stop under such conditions. At the same time, other rooms that don't experience these heat gains should receive the necessary heat input to maintain their set temperatures.
- What areas have heat emitters with similar thermal mass. A room with a higher thermal mass system such as a heated concrete slab will not warm nor cool as fast as an otherwise identical room heated by fin-tube baseboard. If these two rooms were on the same zone, and that zone was operated with a temperature setback strategy, or experienced significant solar heat gain, the two rooms cannot respond comparably. The room heated by fin-tube baseboard could quickly interrupt heat input when solar heat gains occur, while the room with the heated slab would likely overheat due to the significant amount of heat stored in the slab.

A common misconception about zoning:

Some heating system designers feel that every room that may, at some point, need to be at a temperature different from that of other rooms, must be operated as an independent zone with its own thermostat. This is not true. It's possible under the right circumstances to maintain rooms at different air temperatures even though they are grouped together as a single zone and operated by a single thermostat.

One way to accomplish this is through the heat output capacity of the heat emitters. Imagine two identical rooms that have the same heating load. One has 10 feet of baseboard; the other contains 12 feet of the same baseboard. Water at the same temperature is supplied to both baseboards at the same time. Obviously there will be greater heat output into the room with the longer baseboard and thus it will attain a higher air temperature under all load conditions.

In the case of radiant panel heating, the output of the panel at a given water supply temperature can be altered by changing the amount of pipe used in the floor. The easiest way to achieve this is to vary the tube spacing. Again, imagine two identical rooms with a heated slab floor. In one room the tubing is spaced 9 inches on center. In the other the tubing is spaced 12 inches on center. Assuming both rooms are supplied with the same water temperature at the same time, the room with the closer tube spacing will receive more heat input and thus attain a higher air temperature.

Another method of controlling heat output, one that can be adjusted once the heat emitters are installed, is by varying the flow rate through individual heat emitters. Once again imagine two identical rooms with identical heating load, and identical heat emitters. Both rooms are controlled from a single thermostat, and have the same supply water temperature while operating. If the flow rate through one baseboard is reduced using a balancing valve, the average water temperature in that heat emitter will decrease as will its heat output. Thus the room operated at the lower flow rate will stabilize at a lower air temperature.

Understanding the above concepts and applying them when appropriate can reduce system costs. It also doesn't mandate the installation of individual room thermostats when they are not necessary.

6-3 Type of Manifolds

Manifold stations can be constructed using either valved or "valveless" manifold components.

Valved manifolds are either supplied with a shut-off valve for electrical actuator or balancing valve for each connected circuit. The valves allow the flow rate through individual tubing circuits to be adjusted, or completely stopped if necessary. Valveless manifolds, as their name implies, do not have this capability. They serve solely as a header for the attached circuits.

In situations where individual flow control of each circuit is desired a valveless manifold is installed as the supply manifold where each tubing circuit begins, and a valved manifold is installed as the return manifold where each circuit ends. This allows the optimal flow direction through the manifold valves.

Figure 6-1 shows a 4-circuit valved as well as valveless manifold.

A valveless manifold can also be combined with a zone valve as shown in figure 6-2 when several circuits are to be controlled from a single thermostat. This option is less expensive than installing several valve actuators on individual circuits and controlling them as a group.

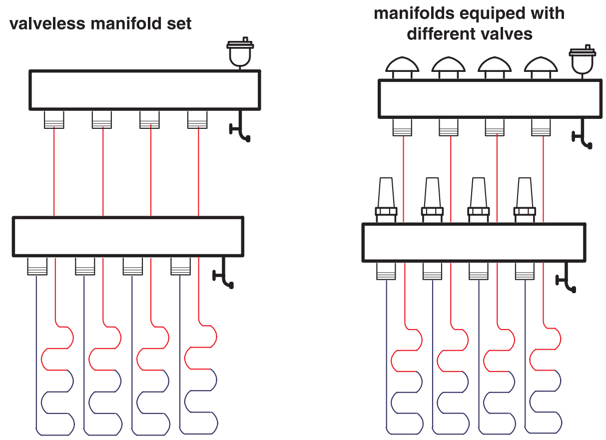


Figure 6-1

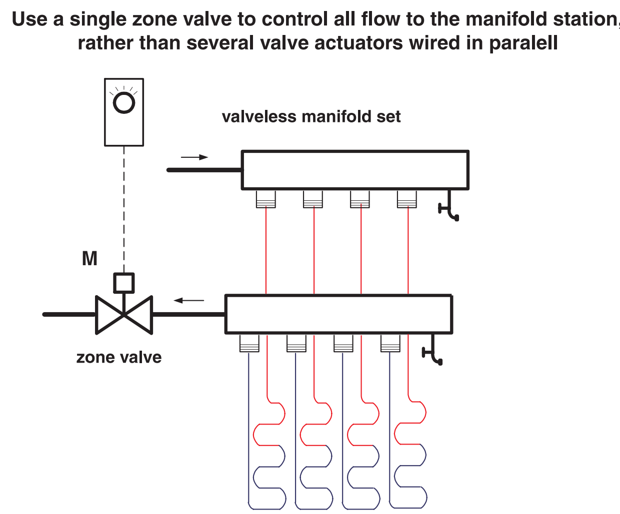


Figure 6-2

Valveless Manifold Systems

There are radiant panel heating applications where “valveless” manifold systems are well suited. Recognizing such situations often allows the installed cost of the system to be reduced.

An appropriate application for valveless manifolds is when a large building area is to be heated as a single zone. The large area requires several tubing circuits that all operate at the same time with the same supply water temperature. Provided that circuit lengths are kept within 10% of the same length, such circuits can be connected to a single valveless manifold.

The designer should recognize that circuits connected to valveless manifolds cannot be individually balanced or isolated. They also must be purged simultaneously when the system is filled. The designer should ensure that adequate means of high capacity purging are provided for each valveless manifold station. In most cases, the advantage of being able to isolate and shut down the loops far outweigh the cost saving by using valveless manifolds.

Valved Manifold Systems

In many hydronic systems including those supplying radiant panels as well as other types of heat emitters, the flow resistance of each connected circuit can vary considerably. For example, in the case of radiant floor heating, one tubing circuit my be 60 feet long while another, connected on the same manifold, may be 300 feet long.

If such circuits are connected to a valveless manifold station, the flow rates will be higher in the shorter circuits. This may not allow sufficient heat delivery in the areas served by the longer circuits.

A manifold station with circuit balancing valves on either the supply or return manifold allows the flow resistance of each circuit to be adjusted. This helps ensure that each circuit delivers the proper flow rate to its heat emitter.

Valved manifolds also allow the possibility of individually controlling each attached circuit. The most common approach is to attach an electric valve actuator to each valve bonnet on the manifold as shown in figure 6-3. As it's screwed onto the manifold valve, the actuator pushes the valve's stem to its fully closed position. When low voltage (24VAC) is applied to the actuator it retracts its stem allowing the spring inside the valve body to open the valve's plug.

The valve opens to its full position. The flow balancing is set on the balancing valve on the other manifold.

There are manifold types where the travel of the valve stem can be adjusted. The manifold valve only opens to its set balancing position when the actuator is powered up. This allows the valve to provide the proper balancing for the circuit when it's open as well as a means of on / off flow control when an actuator is attached.

In summary, the following manifold variations are used in hydronic systems;

Plain manifold

Manifold with plain shut off valves

Manifold with provision for electrical valve actuator

Manifold with flow rate indicator

Manifold with balancing valve

Manifold with balancing valve and flow rate indicator built-in

6-4 Locating Manifold Stations

The number and placement of manifold stations in a building depends on the following:

- Will all floor circuits operate at the same supply water temperature? A given manifold station can only supply one water temperature to all its circuits at one time. If the system requires more than one supply water temperature at a given temperature, it will need at least two manifolds (one for each water temperature).
- Can all floor circuits be routed from a single manifold without excessive "leader" lengths? Leader length is the portion of the circuit

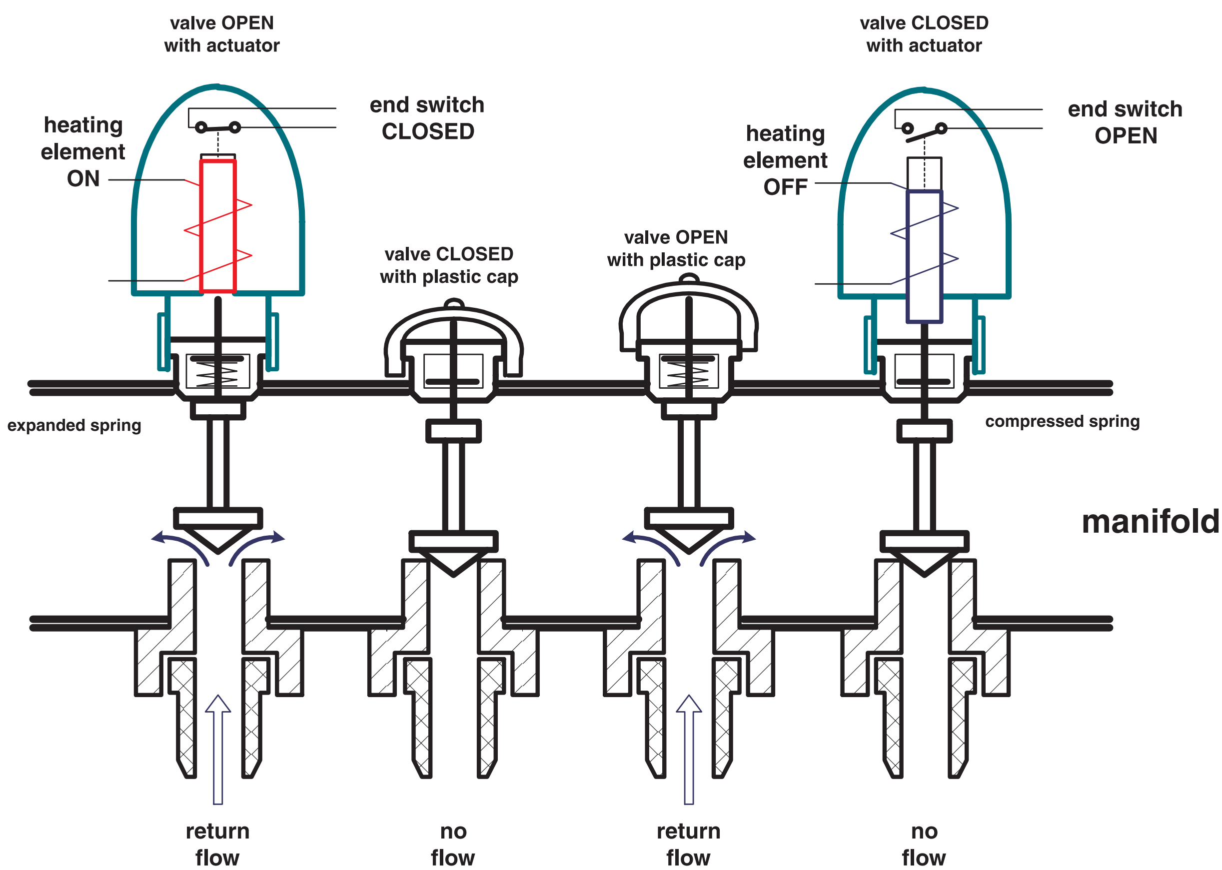


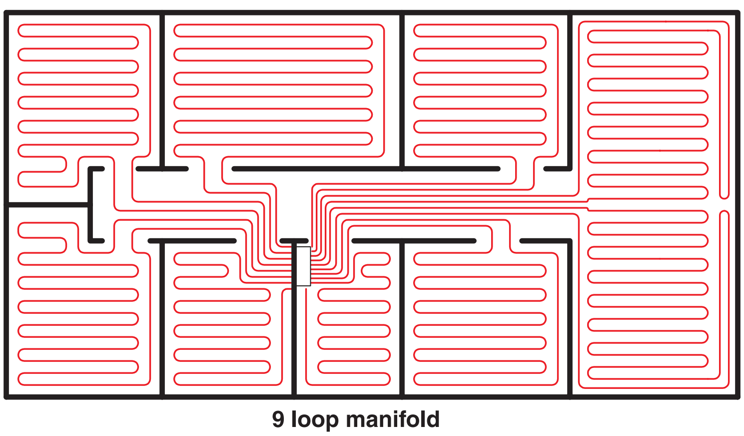
Figure 6-3

between the manifold station and the room where the circuit will release most of its heat. Such lengths should be kept to a minimum.

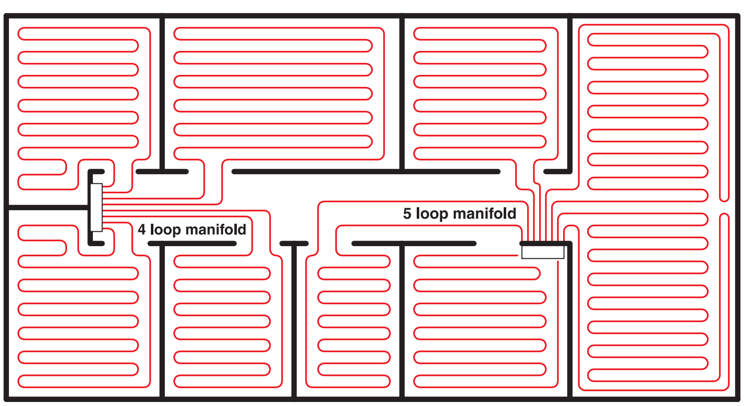
- Is the diameter of the manifolds sufficient to handle the entire system flow? To avoid noise and possible erosion due to high flow velocities, a 1" manifold should generally be limited to 11 circuits, and a 1.25" manifold limited to 15 circuits. Projects with a high number of circuits are usually better served by designing for multiple manifold stations.
- What locations are available for manifold stations? Manifold stations can be mounted both horizontally and vertically. In either case it is imperative to provide access to the manifold station. Try to avoid locations where furniture or other heavy or difficult to move objects would block such access. Try to find locations where the manifold access panel does not detract from the interior aesthetics of the building. In buildings with public access, the manifold stations are generally provided with "lockable" enclosures, or are located in areas where only authorized personnel have access.
- How many floor levels does the building have? It's often convenient to provide at least one manifold station on each floor level of a building. The reason is to minimize leader length in tubing circuits.
- Will some circuits be filled with an anti-freeze solution while others operate with water? Circuits operating with anti-freeze solutions must be supplied through different manifolds than those operating on water.

Whenever possible, manifold stations should be located so that circuits can be routed away from them in several directions. This typically reduces the length of circuit leaders.

In buildings with wide, spreadout floor plans, it is usually better to install two or more manifold stations (each with circuits clustered around it) rather than attempting to route all circuits back to a single location. The latter approach tends to create situations where tubing is closely packed along hallways that have very low heating requirements. Figure 6-4 shows an example of what can happen when the manifold station(s) are poorly placed. Note the concentration of tubing down the hallway.



Piping plan A:
note the long leader lengths and closely spaced tubing in the hallway.



Piping plan B:
note the shorter leader lengths and the reduced tubing in the hallway.

Figure 6-4

Manifold Mounting

Manifold stations are often mounted within the hollow cavity between wall studs. The lower manifold should be mounted 1.5 – 2 feet. The top manifold should be 2.5 – 3 feet above the floor to allow some flexibility in the tubing from where it penetrates the floor surface to where it connects to the manifold.

It's important that tubing penetrates the floor surface within the stud cavity. In the case of slab systems, the stud cavity doesn't exist at the time the manifold station is placed. Accurate measurements are essential to making sure the tubing penetrations remain inside where the wall will eventually be located.

For slab type floor heating systems, some installers make a wooden tubing template block that aligns the tubing where it penetrates the slab surface with the manifold connections above. The template block is supported on two driven stakes. The top of the block should be set at the same elevation at the top of the slab. The template block is typically the same width as the wall framing and remains in place after the slab is poured.

Other installers erect a temporary support for the manifold stations as shown in figure 6-5. This allows the tubing circuits to be connected to the manifold stations for pressure testing prior to the pour. After the walls are framed, the plywood backer can be removed and the manifold brackets secured to permanent framing.

All tubing should be sleeved where it enters and exits a slab surface. The sleeving protects the tubing from trowel edges when the slab is finished, as well as from other physical damage over the life of the system.

When the manifold station is to be mounted within a

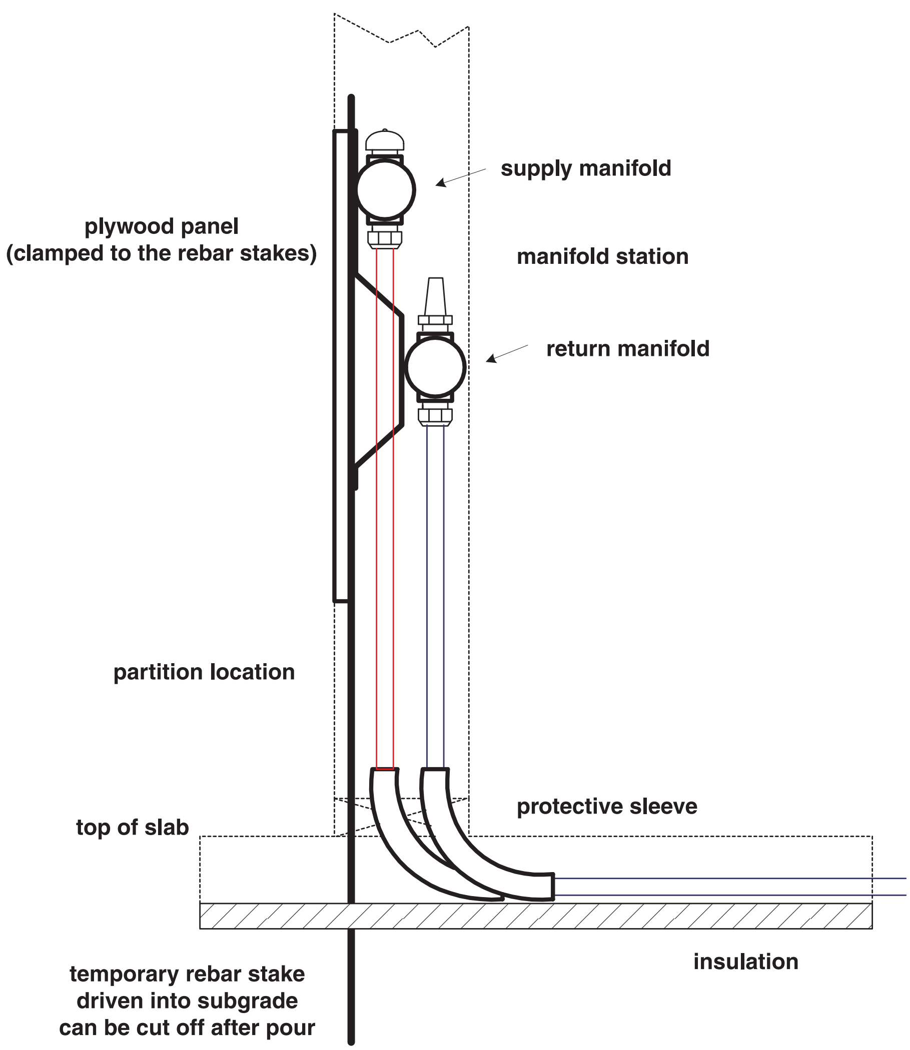


Figure 6-5

wall framing cavity, that cavity must be sufficiently deep. A 2x4-framed wall with a stud thickness of 3.5 inches is a bare minimum. A 2x6-stud cavity 5.5 inches deep provides an easier installation. The installer might also look for the opportunity to "fur out" the interior wall of a closet to provide a deeper mounting cavity.

The manifold mounting brackets should be secured to a solid wall, or a plywood panel that itself is secured directly to framing.

Be sure to make the access opening large enough to install valve actuators if they are planned at the present or may be added in the future.

Manifold stations can also be mounted horizontally. A good example is a manifold station secured to the underside of a framed floor deck as shown in figure 6-6. Tubing circuits from a thin-slab or tube & plate floor heating system can drop down through the sub floor and connect to the manifold station. Mounting one or more manifold stations to the underside of a framed floor with access from the basement eliminates the need for access panel in the finished space above.

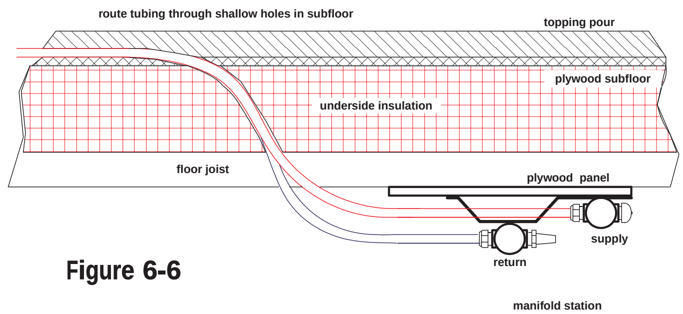


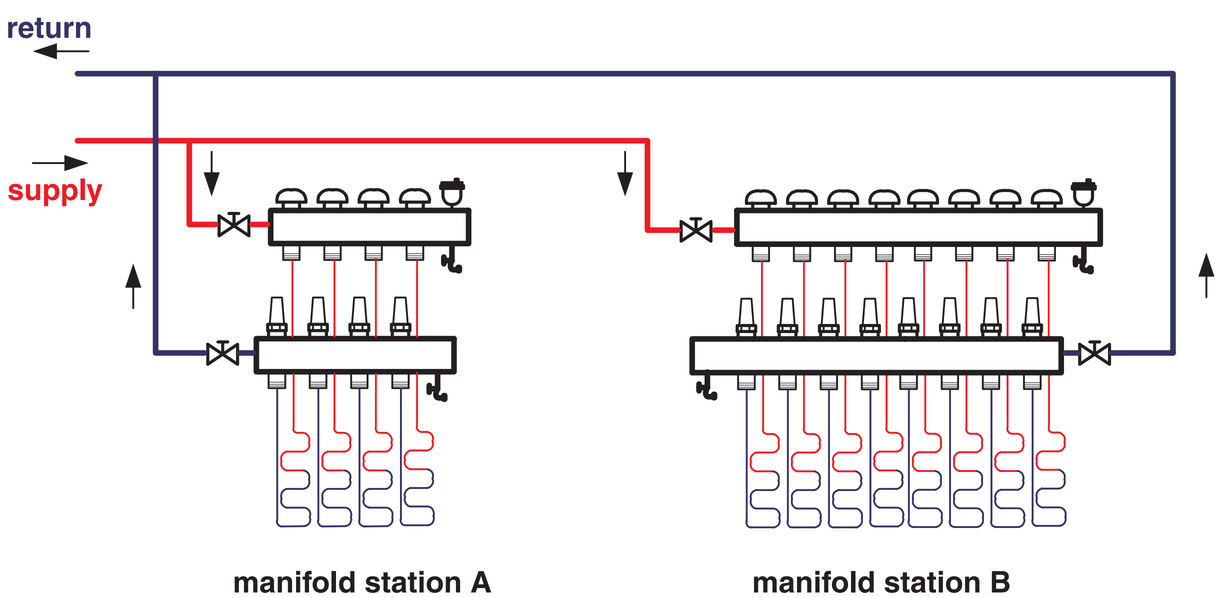
Figure 6-6

6-5 Manifold Piping Options

When multiple manifold stations will be operated at the same supply temperature, they should be piped in parallel as shown in figure 6-7.

Never connect multiple manifold stations in series with each other. The resulting pressure drop would be very large. The downstream manifold would also operate at a lower temperature and greatly reduced heat output.

Good hydronic piping design encourages the installation of valves that can isolate major system compo-



note: the supply and return piping to the manifold station A is on the same end of the manifolds. The piping to manifold station B is on *opposite* ends of the manifolds. Both configurations are acceptable.

Figure 6-7

nents from the balance of the system should they require service. Installing a pair of full port ball valves on the supply and return side of each manifold station to provide such isolation is considered good practice. IPEX offers such valves that thread directly to the manifolds.

IPEX manifolds can be configured with adapters allowing them to be supplied using either copper tubing or large diameter Kitec pipe. Distribution piping for multiple manifold systems can be set up several ways depending on the flow requirements and routing requirement. These methods include:

- Trunkline piping
- Homerun distribution piping
- Parallel primary / secondary piping

The concept of trunkline piping is shown in figure 6-8. Each manifold station taps into a common supply (trunk) pipe as well as a common return (trunk) pipe. Because this is a form of parallel piping, each manifold station receives the same water temperature (assuming minimal heat loss along the trunk piping).

Trunkline distribution piping can be constructed of

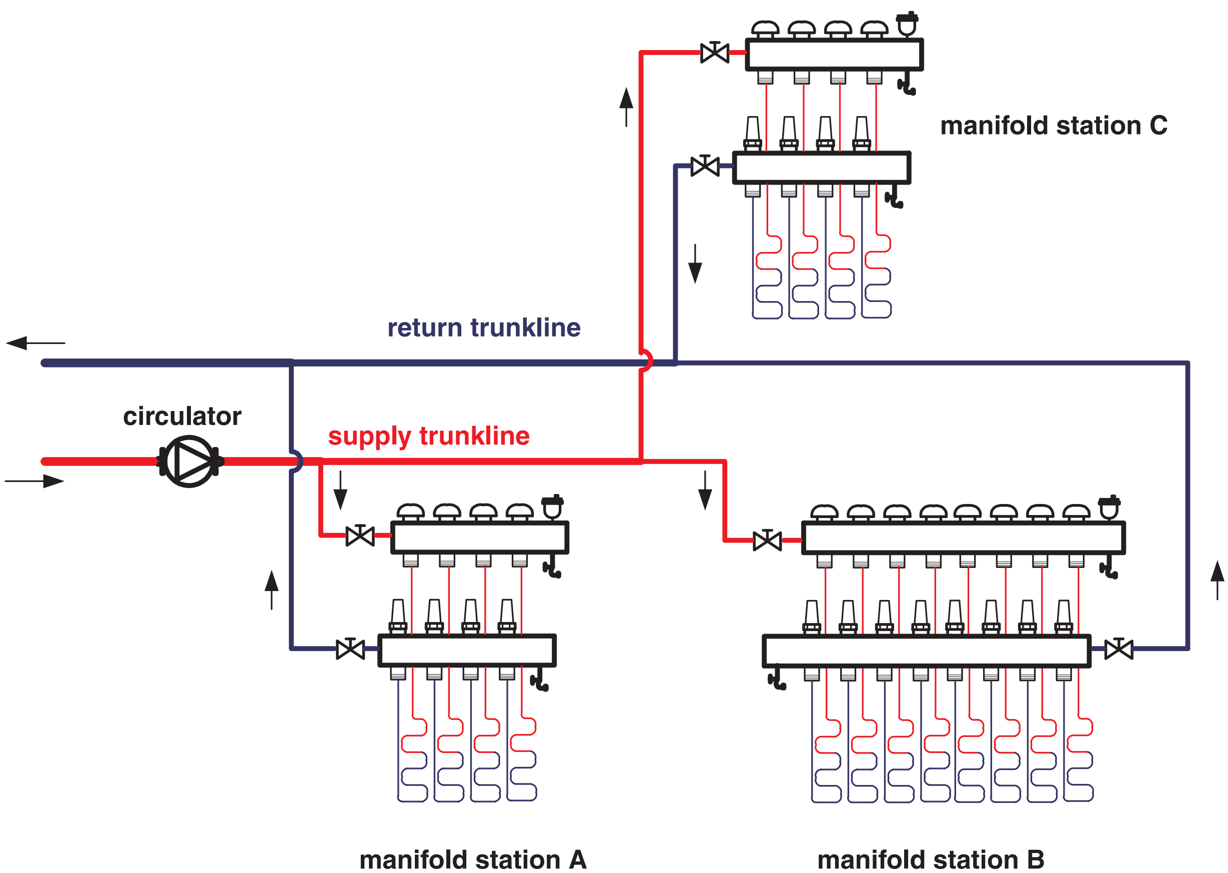


Figure 6-8

either rigid metal pipe or larger diameter Kitec pipe. It can be routed through the framing cavities of the building, in a mechanical chase above the ceiling, or even under the floor slab. In the latter case, flexible Kitec PEX-AL-PEX or PEX tubing is recommended. Portions of the trunkline piping may need to be insulated to minimize heat transmission to floor areas en route to the farther manifold stations. The size of the supply trunkline pipe can generally be reduced as flow is removed at each manifold station. Likewise, the piping size of the return trunkline is usually increased as return flow is added at each trunkline. The flow velocity at any point in the trunkline piping should not exceed than 4 feet per second to minimize flow noise.

Another option is to pipe each manifold as a "homerun" circuit as depicted in figure 6-9. A header is the mechanical room handling the supply and return flow to each manifold station. Homerun systems generally use small tubing than trunkline systems. Smaller diameter Kitec PEX-AL-PEX or PEX tubing is easier to route through confined building cavities smaller tubing, especially in retrofit applications. Homerun systems are another form of parallel piping and thus deliver the same water temperature to each manifold station.

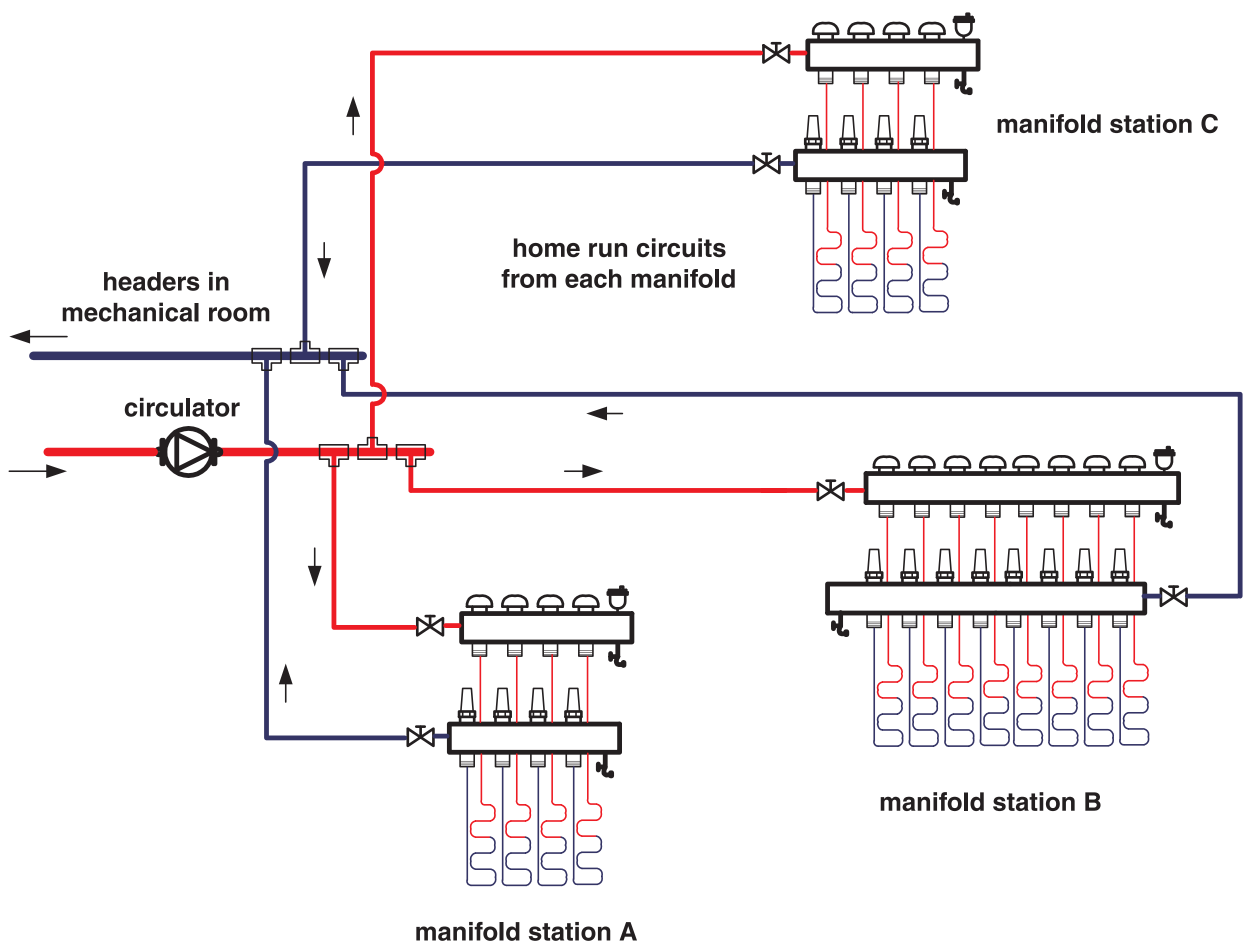


Figure 6-9

Another method of supplying multiple manifold systems with the same water temperature is primary/secondary piping. Figure 6-10 depicts the concept.

Note that each manifold station now has its own circulator. This circulator can be smaller than a single circulator that provides flow to the entire distribution system and all manifold stations. It can also be independently controlled if necessary.

A pair of closely spaced tees connects the manifold riser piping to a crossover bridge in the primary loop. This detail allows any of the manifold circulators to operate without interference with the circulator in the primary loop.

The use of primary/secondary piping to supply multiple manifold stations is generally not necessary in residential and light commercial systems. However, it does provide an option to a large central pump and numerous control valves in larger industrial systems.

See more details of piping systems in chapters 8 and 9.

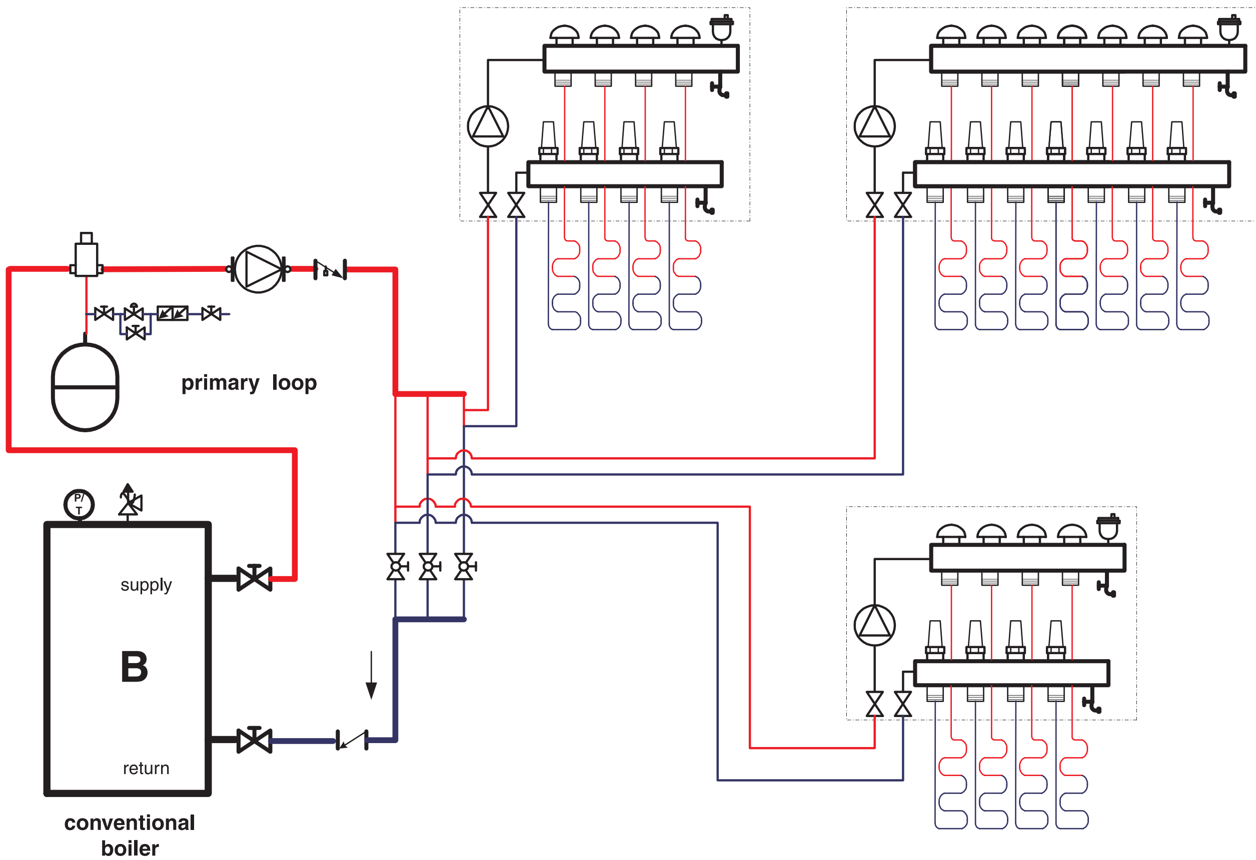


Figure 6-10

6-6 Manifold Accessories

IPEX also offer manifolds with built-in flow indicators / balancing valves. They allow the flow in each circuit to be read as well as adjusted. When a manifold with flow indicators / balancing valves is used, it should be installed as the return manifold. A valveless manifold can be used on the supply side. If valve actuators will also be installed, the other manifold must be valved to accommodate the loop valve actuator.

Manifold stations can also be equipped with air venting options as well as fill/drain valves. A float type air vent on the top manifold assists with air removal when the system is filled. When fill / drain valves are installed each manifold station can be individually purged. These accessories are shown in figures along this chapter.

SECTION

7

PRE-ASSEMBLED CONTROL PANELS

7-1.1 General

There is an endless variety of design options for hydronic systems. Every installation is designed as a specific project using a combination of pipe, manifolds and individual components to construct a heating system.

Depending on the project specifications and features and factoring in individual preferences, even similar projects can show major variations in design and components. Despite this, it is possible to find similarities and create "standard" assemblies that are versatile enough to cover these variations while using basic common principles. This is the fundamental goal of the IPEX Pre-assembled Control Panel concept.

7-1.2 Panel Design Process

IPEX analyzed the similarities and the likely variations in design based on a series of specific heating applications. The goal was to offer a number of pre-designed and pre-assembled control panels that installers can choose from to match the project at hand. By looking at the details of the heating application, the appropriate supply and return manifolds and controls can be selected and assembled in a professional enclosure.

The potential result would be time and money saving off-the-shelf solutions that put a professional finishing touch to almost any radiant heating application. In order to establish the final panel offering though, a number of design questions had to be addressed.

Will the hydronic system operate as a closed loop system or an open loop system? What pressures will the piping system operate under? Answering these two questions narrows the selection of components considerably. How will the heat input be controlled? Do we need to control every pipe loop independently? Would zone control be more appropriate? Again, answering these questions further defines the specific components necessary for the project.

The IPEX WarmRite Control Panel product line was developed using this process, in combination with valuable feedback from the North American market place. The result is the following eleven different Control Panels (CP)

Injection Mixing CP

Recirculating Zone CP

Recirculating Zone CP with Expansion Tank

CP with Heat Exchanger

Floor Warming CP

Multi Zone Manifold Station

Manifold Station with Circulator

Manifold Station

Snowmelt / Industrial CP

Injection Mixing Secondary CP

Isolation Module

Each control panel is described in this section. However, because the panels have numerous common elements, a review of their similarities is in order. For detailed information, application notes and installation / operation manuals are available for each panel.

7-1.3 Operating Principles

All panels are designed to control the average floor temperature required to compensate for ongoing heat loss. Each panel does this by cycling between heat input (on cycle) and no heat input (off cycle). During the on cycle, additional heat is added to the pipe loops to bring the floor temperature to its desired level. The ratio between the on and off cycle is proportional to the average heat needed in the floor. Simply put, if it is warm outside the heat loss is low. The on cycle is short and the off cycle is long. If the opposite is true and it is cold outside, the heat loss will be high causing the on cycle to be long and the off cycle to be short. In principle, radiant floor systems are designed so that on the coldest day of the year, the on cycle will operate 100% of the time.

7-1.4 Supply Water Temperature

Most panels operate on constant supply temperature. Only the Injection Mixing Control Panel modulates-changes continuously-the supply temperature based on outdoor reset. The Control Panel with Heat Exchanger and the Floor Warming Control Panel have a built-in tempering valve to set the supply temperature. These three panels control the floor supply temperature so no external supply water temperature control is needed. All other panels rely on receiving the calculated design water temperature.

7-1.5 Space Temperature Control

Most of the panels are primarily operated as a zone control mechanism. They can provide loop control if necessary, but one should always consider the way the building is used and clarify if zone control is appropriate, or if loop by loop control is needed. Loop by loop control always requires more hardware components than zone control.

Designers should consider how the building is used. Who is using it? What comfort level is required? How even and constant is the required indoor temperature? What level of accuracy is required from the control system? One must first identify what is really required and design accordingly.

7-1.6 Why zone control?

It is fair to say that the most fundamental requirement of every heating system is to provide constant temperature in the heated space. There are exceptions of course, but mostly a set temperature is desired throughout the heating season. The opposite of this occurs if a building needs to be heated only for a short time, then cooled and heated again. In most cases, high mass radiant floor may not be the best option for this type of heating pattern. Where radiant heating thrives is in constant temperature environments. This being the case, the fundamental requirement is to be able to set a desired temperature and allow the system to maintain it - this is what zone control does best. To clarify, zone control means that all pipe loops (or heat emitters) connected to a manifold are controlled by one thermostat or sensor. However, this does not mean that the temperature must be the same in all areas covered by the loops from a single manifold. Different temperatures can be set within the zone by adjusting the balancing valve on each loop. Adjusting the flow rate loop results in different temperatures in the areas covered by the loops.

7-1.7 Setting the Temperature

All panels have a balancing valve for each pipe loop fitted on the return manifold. Most panels also have flow rate indicators on the return manifold. The desired temperature relationship can be set easily and with no additional hardware-i.e. a thermostat in every room and an actuator on every loop. This approach to temperature control works very well as long as the preference is for a consistent temperature pattern which is not often altered. The temperature difference between the areas will remain the same unless the balancing valves are readjusted.

Naturally there are applications when the temperature setting has to be changed more frequently - such as a motel where guests change every day, and with them so do individual comfort requirements. Perhaps in our own home there is a guest bedroom that is only used sporadically. In these cases, separate thermostats are required. The pipe loops serving these spaces will have valve actuators connected to the appropriate room thermostat. When the room is occupied and that thermostat calls for heat, valves open on those loops until the appropriate setting is satisfied. The provision for individual loop valves is available on all WarmRite Floor control panels designed for residential or office environments.

Industrial and Secondary Injection Mixing Control Panels differ from the others in that the environments they are designed for rarely require loop by loop control. In large areas, the flow adjustment in a single loop has virtually no effect on the overall heat output. There are no sophisticated balancing or actuated valves in these panels because they are not required. All of the other control panels have been designed to accommodate individual loop by loop control when required.

Every panel designed for closed loop systems has an automatic air vent on the supply manifold and a fill/drain valve on both manifolds. Each is equipped with a pressure gauge on the return manifold and two temperature gauges: one for supply and one for return water temperature. The temperature drop in the system characterizes best how the unit is operating.

7-1.8 Protection from Overheating

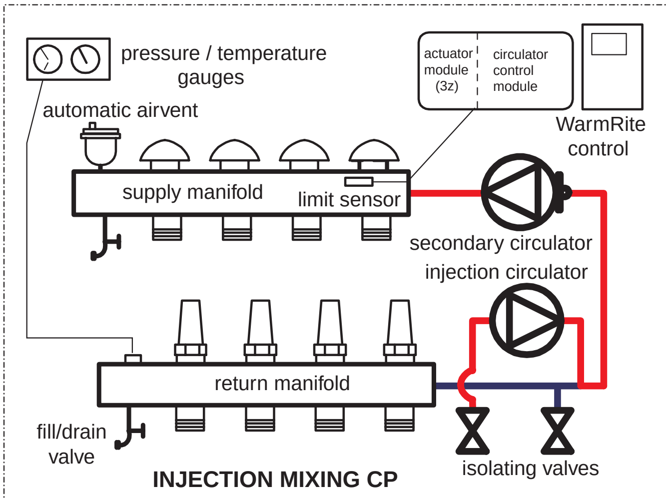
All panels - except the manifold station - are fitted with a limit thermostat to protect the floor from overheating. Floor surface temperature should be less than 85 deg. F. for human comfort. The limit thermostat monitors the supply water temperature which is proportional to the floor surface temperature. If the supply temperature reaches the setpoint, the limit thermostat turns off the heat input. This is a factory setting based on typical concrete slab installations. When higher supply temperatures are required, it can be readjusted accordingly. See the Application Notes and Installation / Operation Manual supplied with each panel for more details.

7-2 CONTROL PANELS

Injection Mixing Control Panel

Operation:

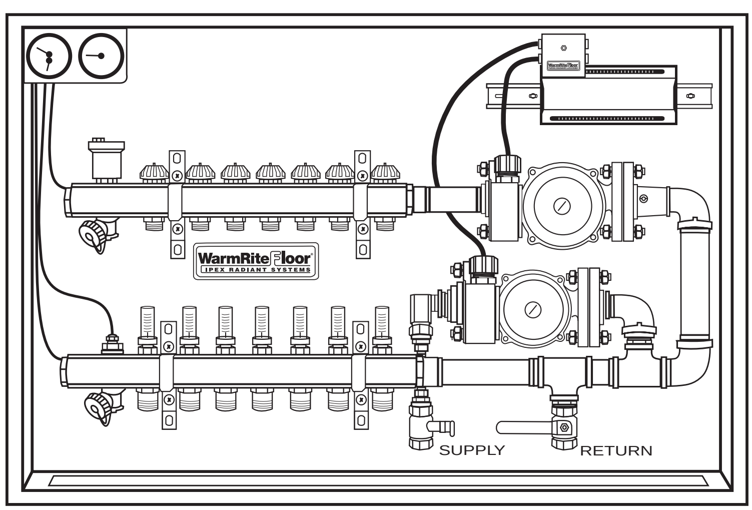
This panel is designed to control supply fluid temperature by injection mixing. The WarmRite Control provides variable speed operation of an injection circulator based on outdoor air temperature. This panel is ideal when supply temperature control is required. The application of this panel is extended to control the return water temperature for conventional boilers by installing the return water temperature sensor.



When the control is in the outdoor reset mode, the speed of the injection circulator is varied to maintain a target fluid temperature in the supply manifold based on outdoor air temperature. The control can alternately be used as a set point control. In this mode, the speed of the injection circulator is varied to maintain a user adjustable supply fluid temperature. A room thermostat monitors the desired room temperature and turns the mixing control off when the zone(s) is satisfied.

The panel is operated as a single zone system by using the thermostat to activate the control. The secondary circulator operates continuously providing even heat distribution during the heat up and cool down cycles. The panel can be operated with subzones set up on a single zone panel. The system thermostat is operating the main heat input while the subzone thermostats operate the loops fitted with valve actuators. The sub zoning should not exceed more than 50% of the loops. The panel can be operated as a multiple zone system. The on/off valves located on the supply manifold are fitted with optional electrical valve actuators to control individual loops in the system. In this application, every actuator is connected to a thermostat located in the area served by the loop. When the thermostat calls for heat, the actuator opens the loop allowing flow. When all loops are satisfied, the secondary circulator is shut down and the injection control is disabled.

The panel operation is controlled by closure of a dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, integrated building controls, etc. Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary. The optional actuators and thermostats must be ordered separately according to the project specifications.



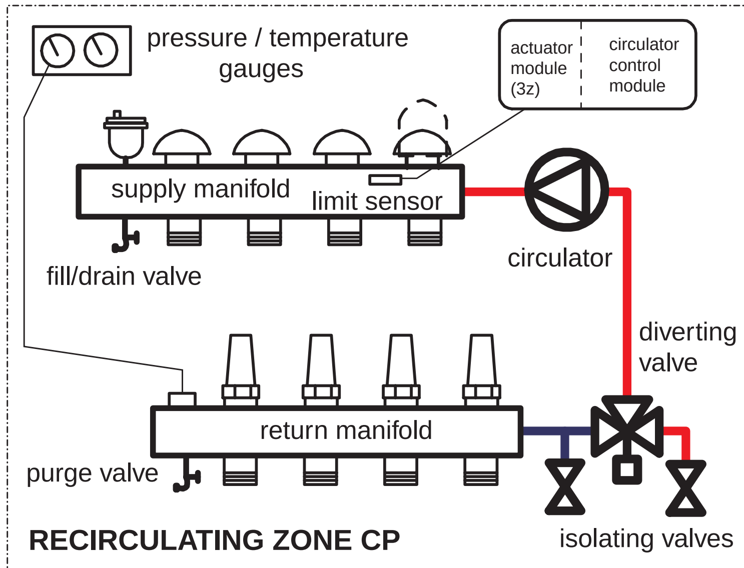
The panel operation is controlled by closure of a dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, integrated building controls, etc.

Recirculating Zone Control Panel

Operation:

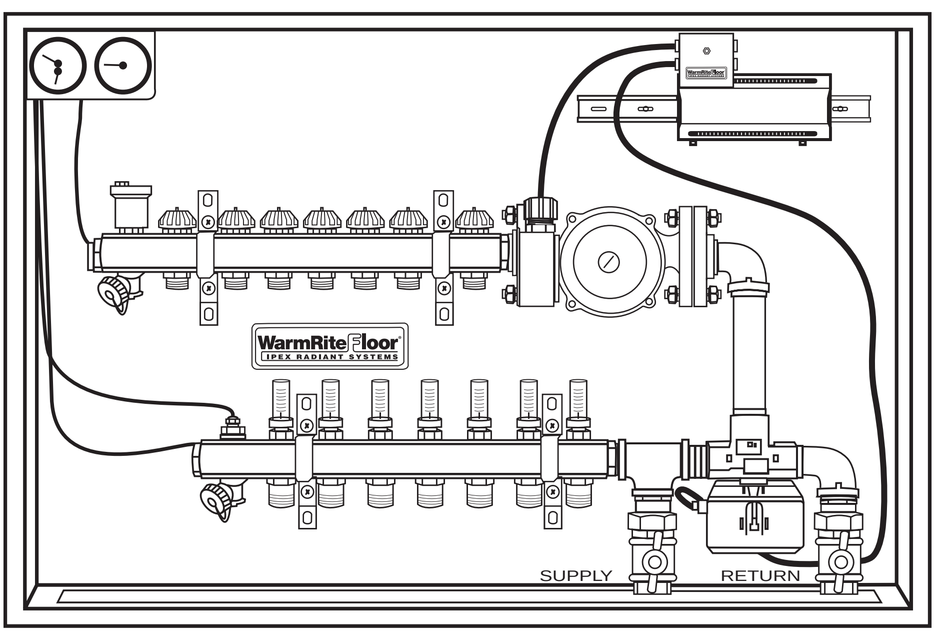
This panel is designed as a manifold station that provides constant circulation in the distribution system. There is no supply water temperature control in the panel.

The panel operates primarily as a single zone system maintaining the average space temperature. A thermostat and a diverting valve control the heat input. It cycles the heat-input on/off to match the average heat load requirement in the zone. Fluid circulates from the heat source to the panel and through the floor piping. When the zone is satisfied, the diverting valve closes the path to the heat source and removes the external enable signal. The fluid continuously circulates in the floor piping, providing even heat distribution both on heat up and cool down cycles.



Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary.

The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.



Recirculating Zone Control Panel with Expansion Tank

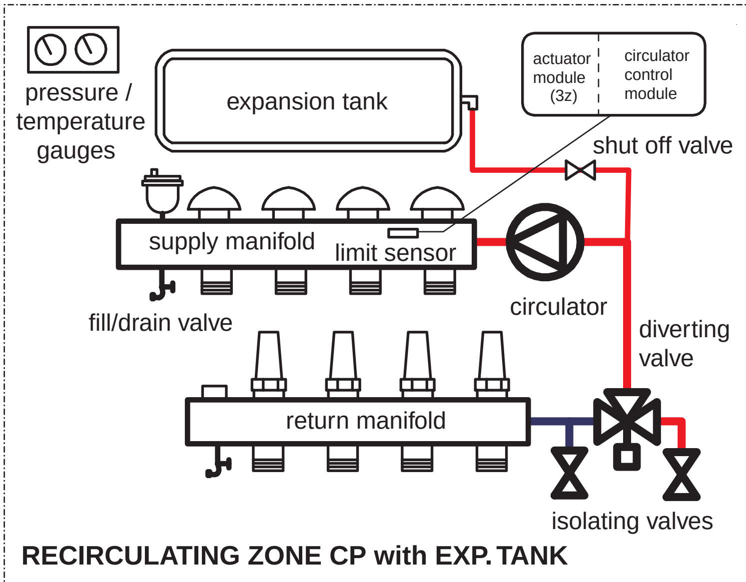
Operation:

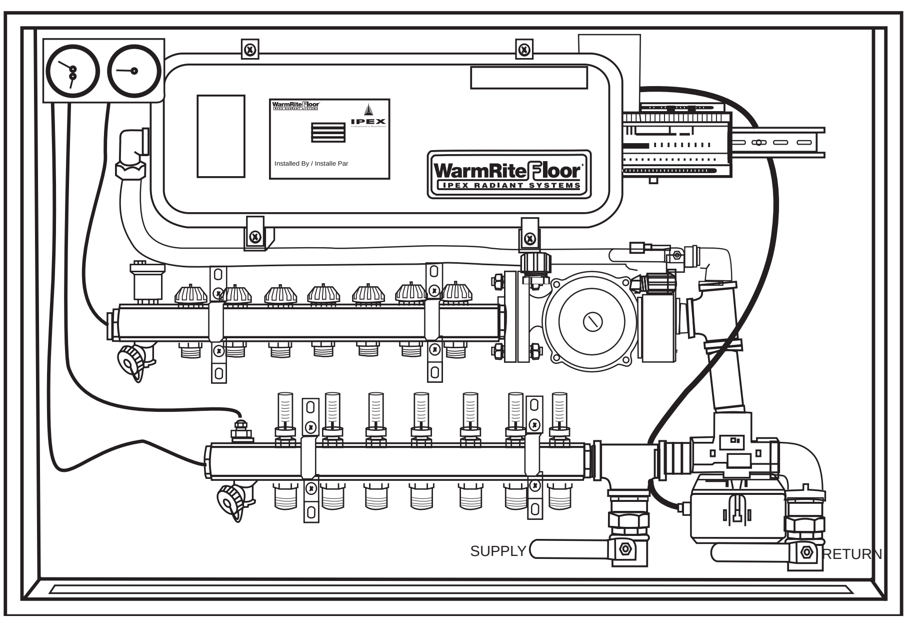
This panel is designed as a manifold station that provides constant circulation in the distribution system. There is no supply water temperature control in the panel.

The panel operates primarily as a single zone system maintaining the average space temperature. A thermostat and a diverting valve control the heat input. It cycles the heat-input on/off to match the average heat load requirement in the zone. Fluid circulates from the heat source to the panel and through the floor piping. When the zone is satisfied, the diverting valve closes the path to the heat source and removes the external enable signal. The fluid continuously circulates in the floor piping, providing even heat distribution both on heat up and cool down cycles.

Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary.

The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.





Control Panel with Heat Exchanger

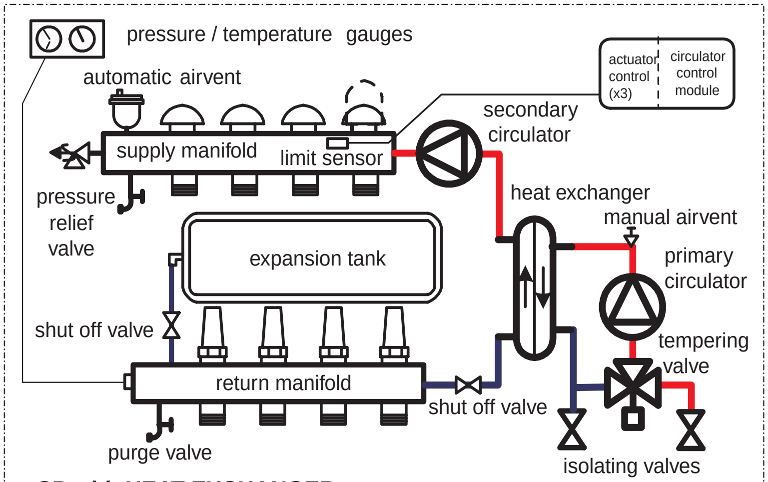
Operation:

This panel is designed to separate the secondary system fluid from the primary system fluid by utilizing a plate heat exchanger, and is recommended for applications that use an open loop system as the heat source or in applications where a water/glycol mixture is used in the secondary heating loop.

The secondary system is filled during installation and operates as a closed loop circuit. The panel comes with an expansion tank and relief valve for the secondary side of the system. The design supply fluid temperature in the primary loop is set with a tempering valve.

The panel is operated as a single zone system by using a thermostat to activate the primary circulator. The secondary circulator operates continuously providing even heat distribution during the heat up and cool down cycles.

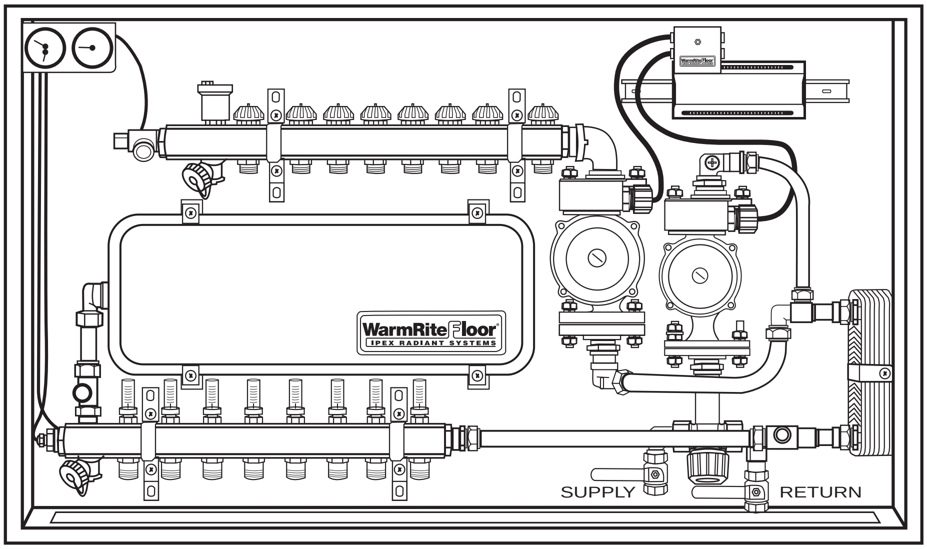
The panel can also be operated as a multiple zone system. The on/off valves located on the supply manifold can be fitted with optional electrical valve actuators to control individual loops in the system. In this application, every actuator is connected to a thermostat located in the area served by the loop. When the thermostat calls for heat, the actuator opens the loop allowing flow. When all loops are satisfied, the primary and secondary circulators are shut down.



CP with HEAT EXCHANGER

Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rate of each loop. The circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary. The optional actuators and thermostats must be ordered separately according to project specifications.

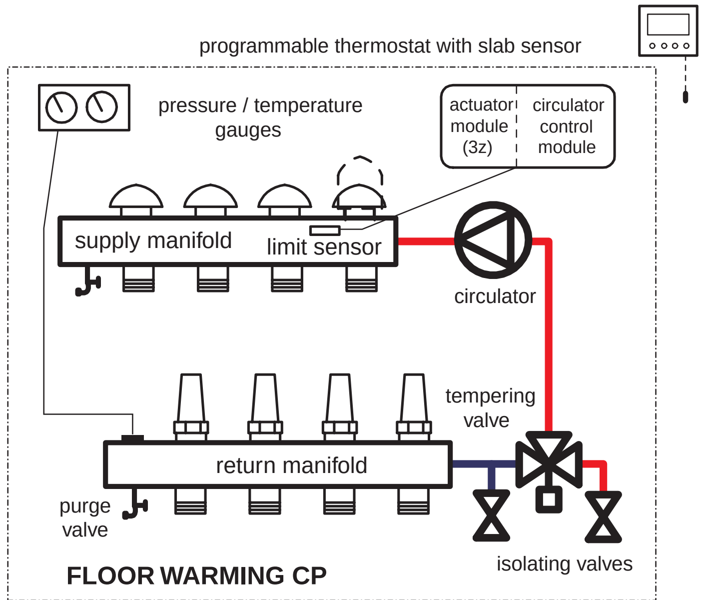
The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.



Floor Warming Control Panel

Operation:

This panel is designed to operate floor warming and basic heating systems. This panel incorporates non-ferrous components to allow use with the domestic water supply where permitted.



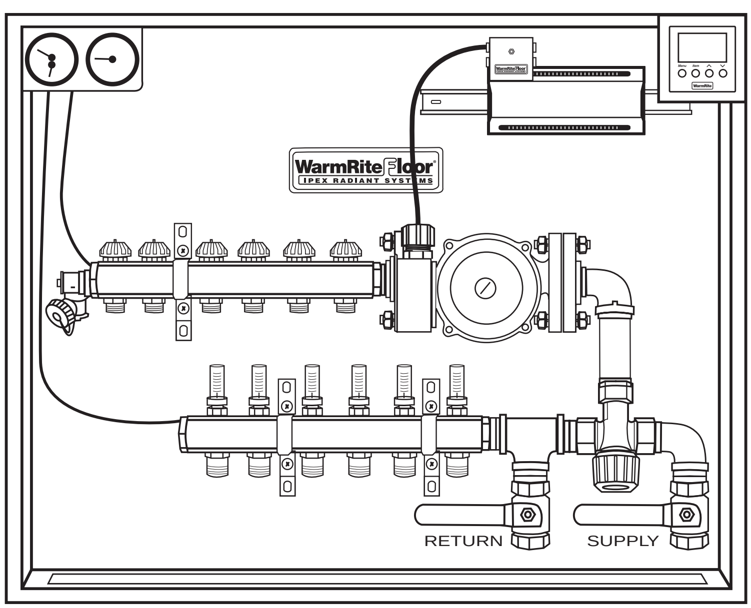
The panel is supplied with a programmable thermostat to sense slab temperature or air temperature depending on the application. In a floor warming application the thermostat is programmed to sense slab temperature. In a space heating application it is programmed to sense air temperature, or optionally air and slab temperature.

The thermostat can be programmed to circulate the water throughout the year to prevent stagnation when utilizing a domestic water heat source. A built in tempering valve allows control of supply water temperature.

The panel is operated as a single zone system by using the thermostat to activate the circulator. The panel can be operated as a multiple zone system. The on/off valves located on the supply manifold can be fitted with optional electrical valve actuators to control individual loops in the system. In this application every actuator is connected to a thermostat located in the area served by the loop. If periodic circulation to avoid stagnation is required, all thermostats on the system must be programmable thermostats with timer capabilities.

Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rate of each loop. The circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit that prevents the supply water from exceeding the desired temperature. Valves on both the supply and return manifolds allow for isolation of the loop when necessary.

The panel operation is controlled by closure of a 24V dry contact. The panel comes complete with a programmable thermostat, but also may be controlled by devices such as: two and three wire room thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.



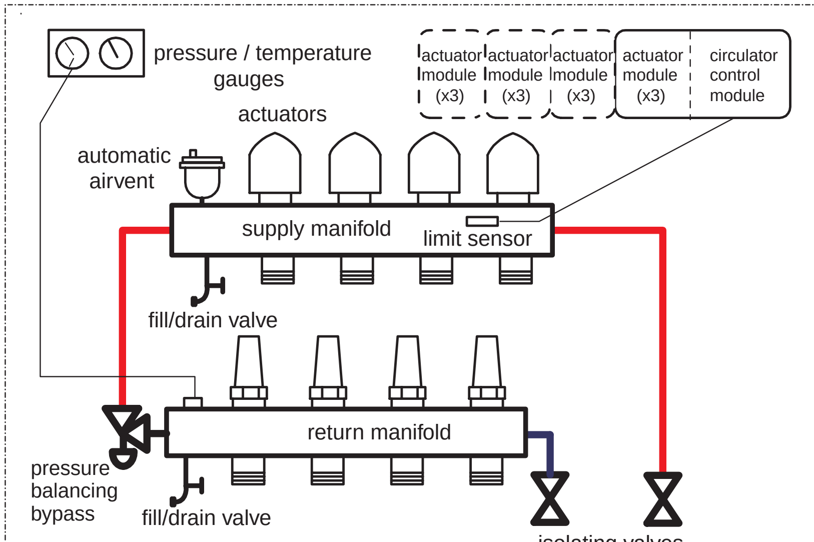
Multi Zone Manifold Station

Operation:

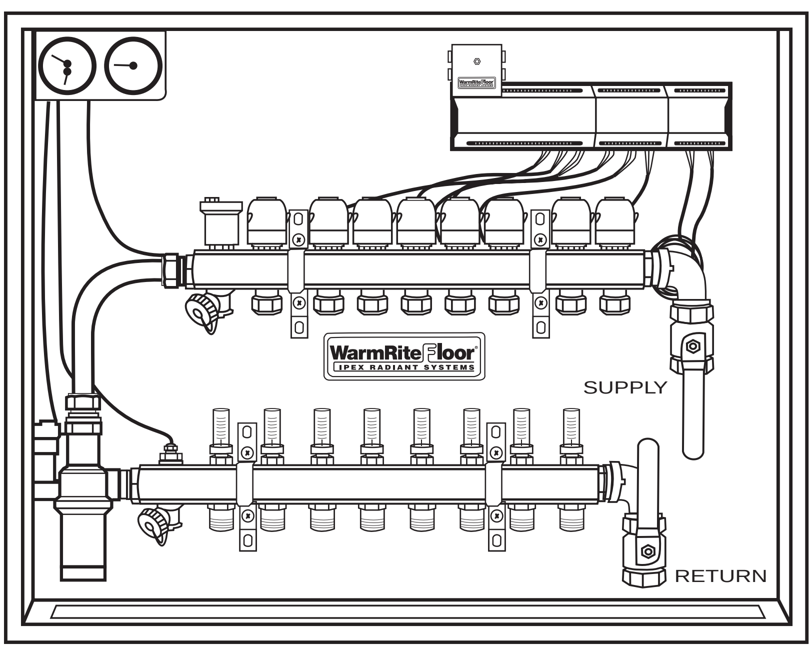
This panel is used as multiple zone system. The on/off valves located on the supply manifold are fitted with electrical valve actuators to control individual loops in the system. Every actuator must be connected to a thermostat located in the area served by the loop(s). When the thermostat calls for heat, the actuator opens the loop allowing flow. The pressure balancing bypass valve equalizes the changing head loss conditions as various loops open and close. When all loops are satisfied the dry contact in the circulator control module opens.

Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary. The thermostats must be ordered separately according to the project specifications.

Each actuator's operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, integrated building controls, etc.



MULTI ZONE MANIFOLD STATION



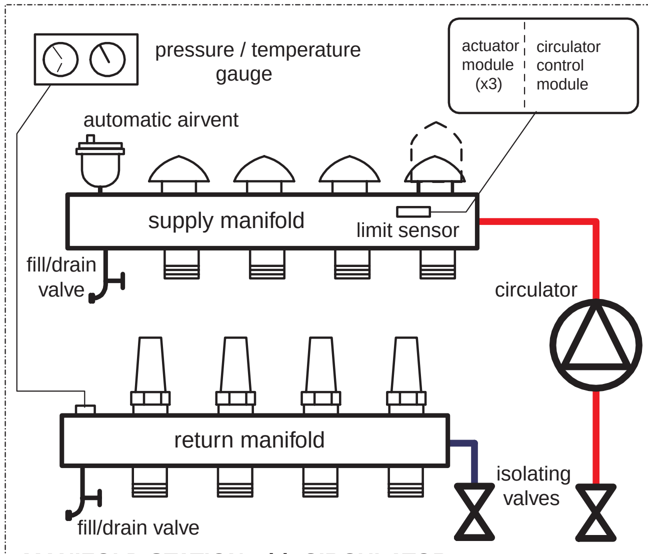
Manifold Station with Circulator

Operation:

This panel is designed as a basic manifold station.

The panel is operated as a single zone system by using a thermostat to activate the circulator.

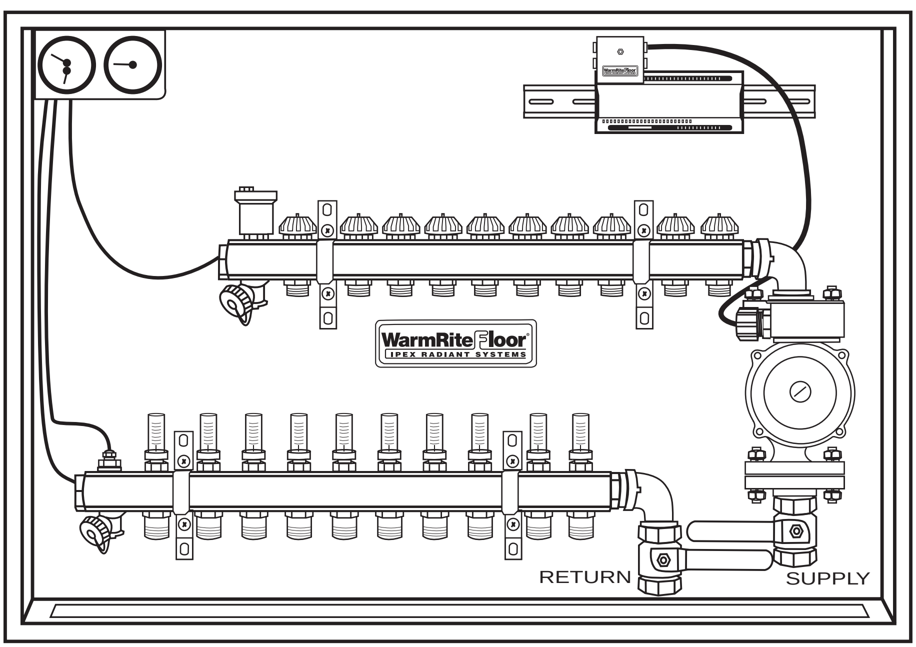
The panel can also be used as multiple zone system. The on/off valves located on the supply manifold can be fitted with optional electrical valve actuators to control individual loops in the system. In this application, every actuator is connected to a thermostat located in the area served by the loop. When the thermostat calls for heat, the actuator opens the loop allowing flow. When all loops are satisfied the circulator is shut down.



MANIFOLD STATION with CIRCULATOR

Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary. The optional actuators and thermostats must be ordered separately according to the project specifications.

The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.



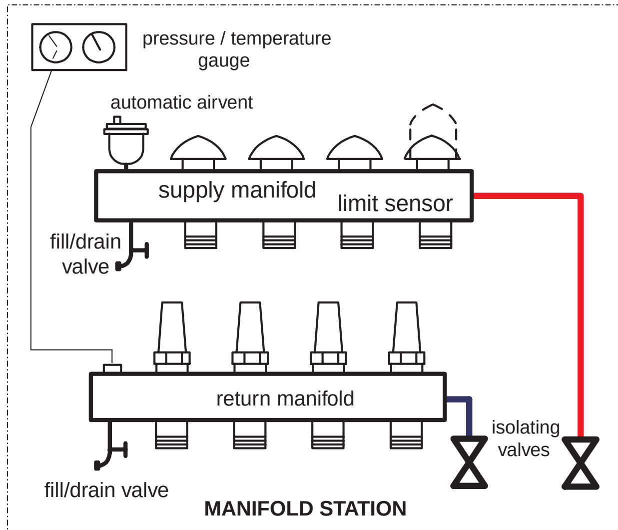
Manifold Station

Operation:

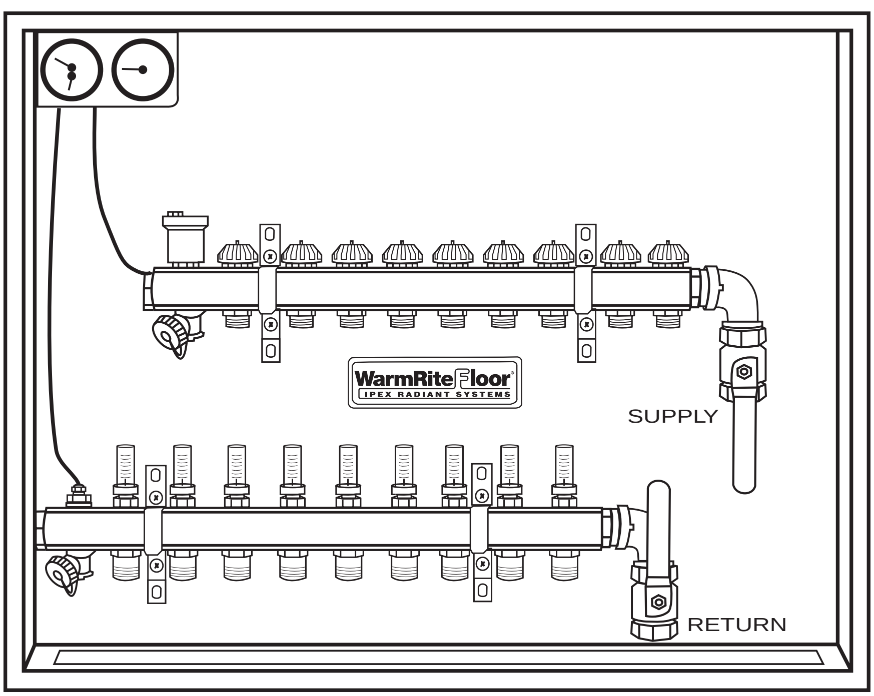
This panel is designed as a basic manifold station.

The panel is operated as a single zone system by using a thermostat to activate the external zone valve or a circulator.

The panel can also be used with limited number of subzones. The on/off valves located on the supply manifold can be fitted with optional electrical valve actuators to control individual loops in the system. In this application, every actuator is connected to a thermostat located in the area served by the loop. When the thermostat calls for heat, the actuator opens the loop allowing flow.



Balancing valves with flow indicators on the return manifold allow the user to adjust and visually monitor the flow rates of each loop. The unit has no integral zone control device. When a zone valve or circulator is attached to the manifold station a Circulator Control Module has to be fitted in the system. This controls the zone valve or circulator and the loop valve actuators for the subzones. The circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature. Valves on the supply and return manifolds allow each loop to be isolated when necessary. The optional actuators and thermostats must be ordered separately according to the project specifications.



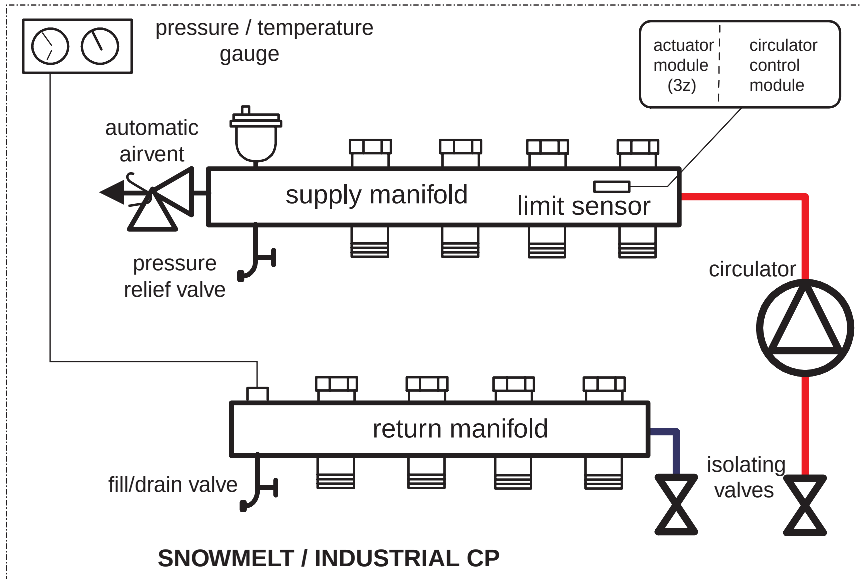
Snowmelt / Industrial Control Panel

Operation:

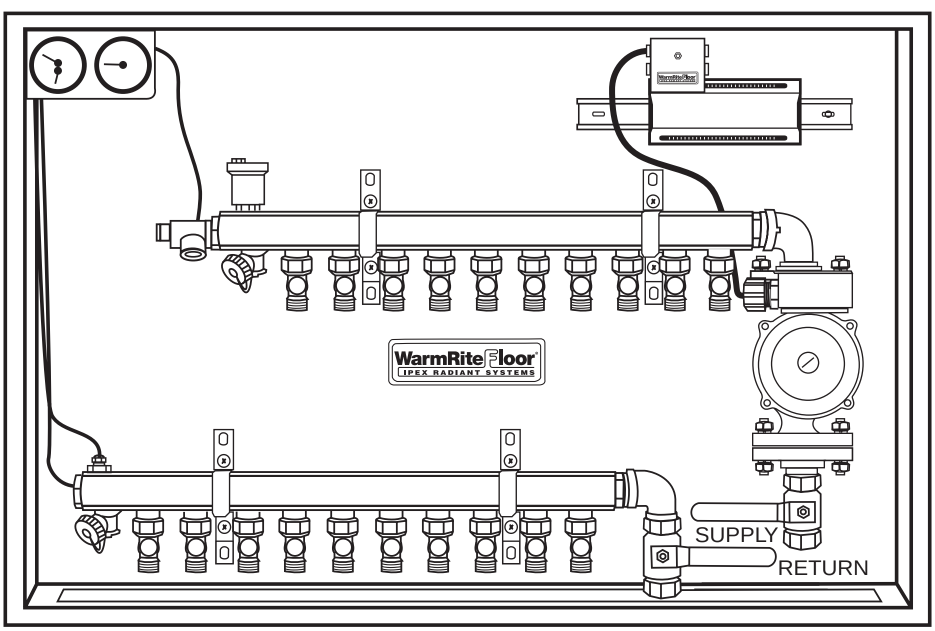
This panel is designed to operate snowmelt or industrial heating systems, which are usually designed with pipe loops of equal length.

In these circumstances individual loop flow rate adjustment is not required, nor is recirculation necessary. An external control turns the circulator on when heat is required.

Valves on the supply and return manifolds are used if flow rate compensation is required. They may also be used to isolate each loop for installation and servicing ease. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature.



The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, snow melt controls, integrated building controls, etc.



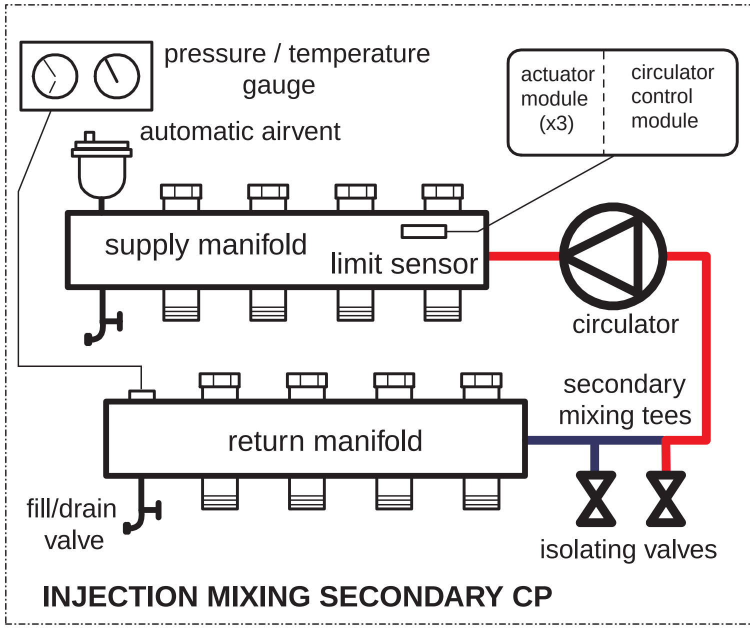
Injection Mixing Secondary Control Panel

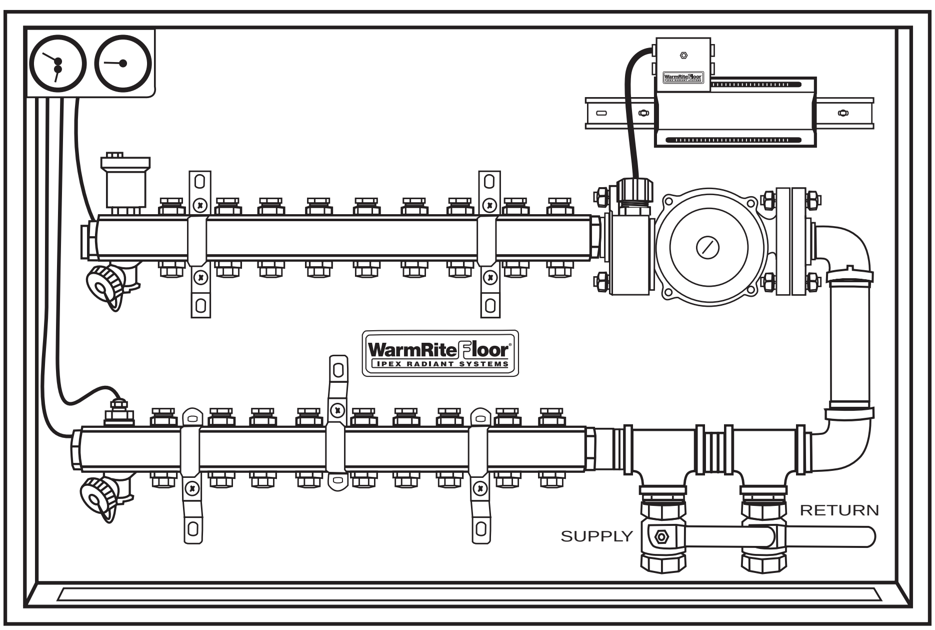
Operation:

This panel is designed to function as a remote secondary circuit of an injection mixing system to heat large commercial/industrial spaces. This design concept takes advantage of the high temperature drop across the injection bridge which allows for low flow rates. The reduced flow rates in turn allow the use of smaller pipe sizes from the boiler room to the remotely mounted panel. Large commercial/industrial spaces often require multiple remotely mounted manifolds. This panel allows a single WarmRite Control and injection circulator to provide the required temperature fluid to all panels, eliminating the need for multiple controls.

The secondary circuit in the panel constantly circulates the fluid in the floor loops. The room thermostat provides a call for heat to the centrally located WarmRite control.

Balancing valves on the supply and return manifolds are used if flow rate compensation is required. They may also be used to isolate a loop when necessary. A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit which prevents the supply fluid from exceeding the desired temperature.





Isolation Module

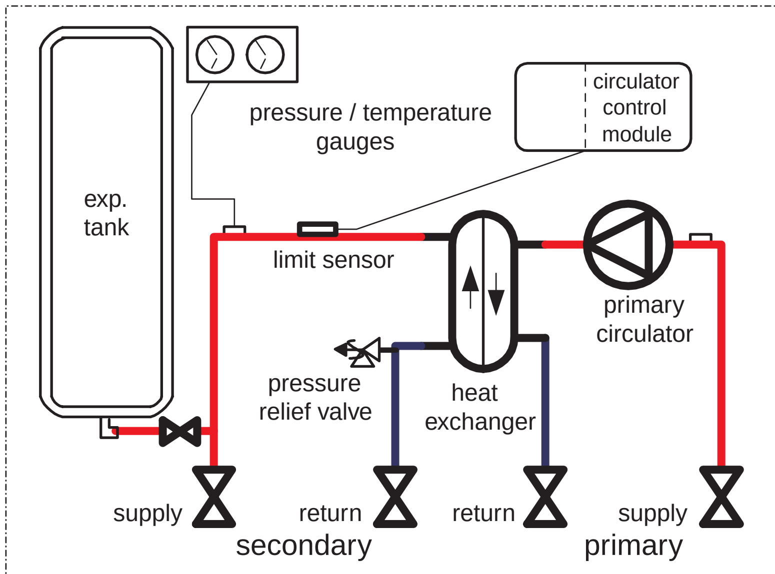
Operation:

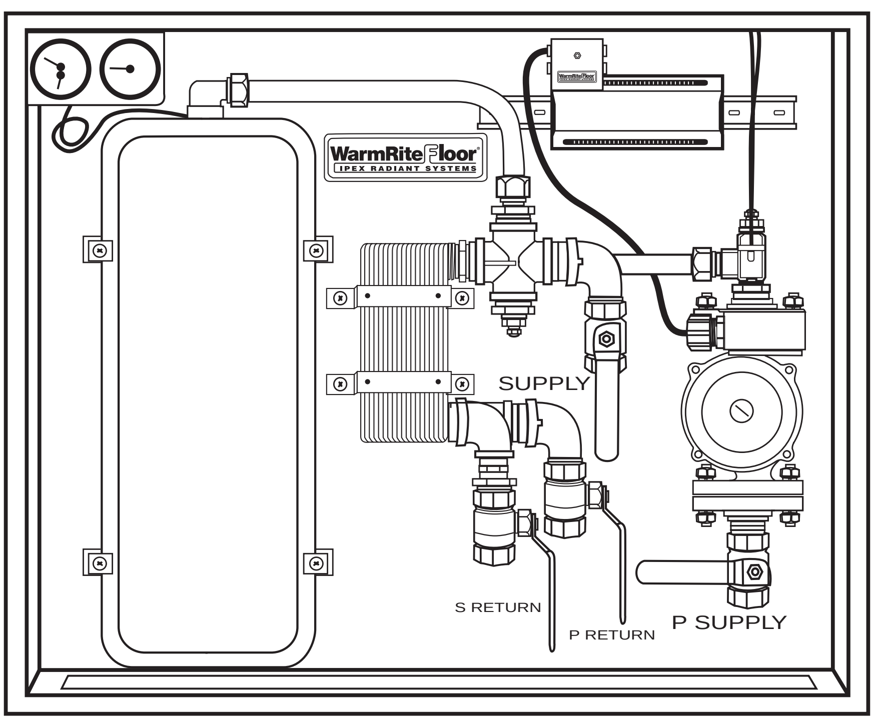
This module is designed to isolate the liquid used in the heating loop from the liquid used in the heat source. For example, a snowmelt system operating with water-glycol mixture is connected to a heat source operating with water or separating a heating system from a domestic water heat source.

The primary side of the heat exchanger is connected to the heat source. The primary circulator and the isolating valves are included in the panel. The secondary side contains an expansion tank, pressure relief valve, and isolating valves. Each circuit is monitored with a pressure / temperature gauge.

A circulator control module contains a 24V transformer, a circulator relay, a dry contact enable, and an adjustable high limit that prevents the supply fluid from exceeding the desired temperature.

The panel operation is controlled by closure of a 24V dry contact. An example of devices that can provide this are: two and three wire room thermostats, programmable thermostats, set point controls, indoor/outdoor reset controls, integrated building controls, etc.





SECTION

8

Distribution Systems for Hydronic Heating

There are several methods of transporting water from a hydronic heat source to one or more heat emitters. The method used depends on:

- How much water has to be moved?
- Can the heat emitters operate properly at different water temperatures?
- Do some portions of the piping system need to operate as different zones?
- Are there several circulators that must operate simultaneously?
- What type of pipe will be used to convey heated water to the heat emitters?

This section examines several “classic” hydronic distribution system configurations. It also discusses several unique ways to use PEX-AL-PEX pipe to create distribution systems that are easy and fast to install, as well as efficient to operate.

8-1 Series Loop Systems

The simplest way of connecting two or more hydronic heat emitters is in a series loop. Heated water flows into the first heat emitter, gives up some heat, exits that heat emitter and enters the next one in the loop. An example of a series piping loop using composite piping to connect several fin-tube baseboards together is shown in Figure 8-1.

Series piping circuits, although simple to build do have a number of limitations. Chief among these limitations is the lack of individual heat output control for each heat emitter. Series loops should be limited to a building area that can be controlled as a single zone. Avoid series circuits if one or more of the heat emitters is located in a room with high internal heat gains compared to other rooms.

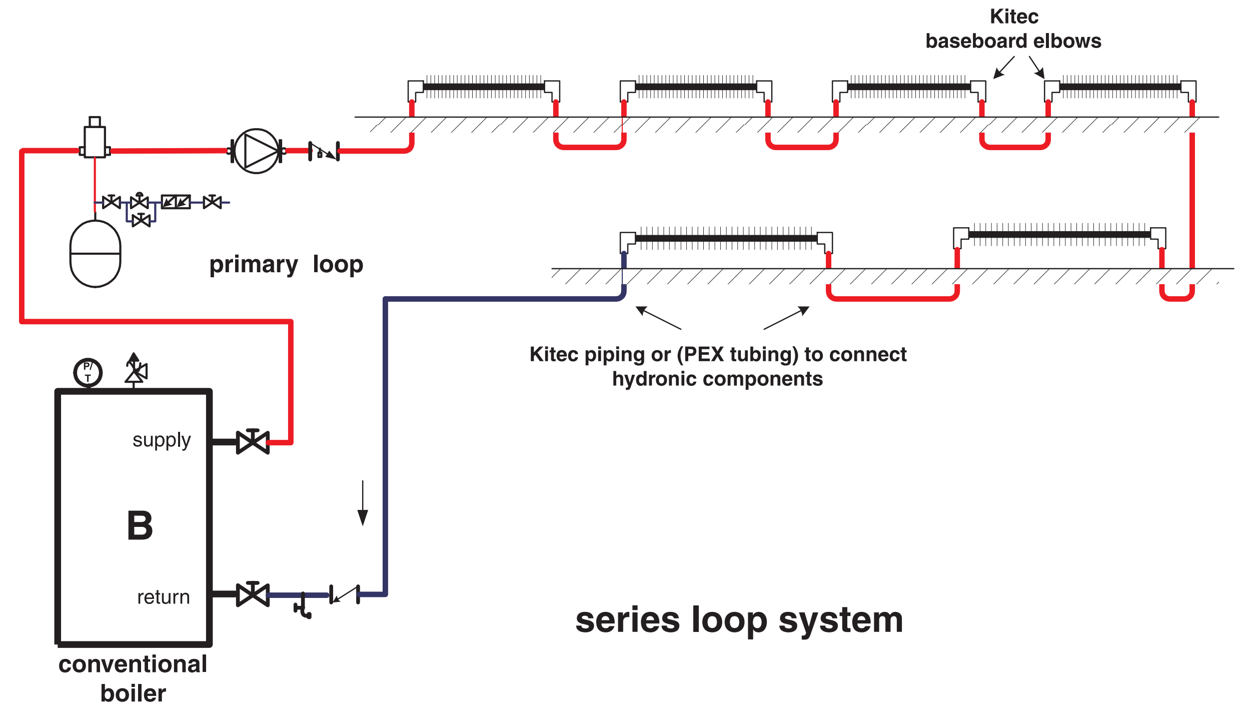


Figure 8-1

If the water temperature supplied to a series loop is changed to increase or decrease the heat output of one heat emitter, the output of all other heat emitters on the loop will be effected. This also holds true if one attempts to adjust heat output by changing the flow rate through the loop.

Another potential limitation of series loop is excessive head loss (e.g. pressure drop). In a series loop the head losses (pressure drops) of each heat emitter and interconnecting piping add together. Too many heat emitters in series could lead to high pressure drops and low flow rates. This often shows up as under heated rooms near the end of the loop.

Series loops containing several heat emitters should be designed to accommodate the drop in water temperature from one heat emitter to the next. If the flow rate in the circuit is known, the temperature drop across each heat emitter can be determined using formula 8-1:

Formula 8-1

$$\Delta T = \frac{Q}{500 \times f}$$

Where:

ΔT = Temperature drop across the heat emitter (deg. F)

Q = Rate of heat output by the heat emitter (Btu/hr)

f = Flow rate in the circuit (in gpm)

500 a constant for water (use 479 for 30% and 450 for 50% glycol)

For example: Assume water enters a length of fin-tube baseboard at 170 deg. F. and 2 gpm. The baseboard releases heat at a rate of 10,000 Btu/hr. What is the outlet temperature from the baseboard?

$$\Delta T = \frac{Q}{500 \times f} = \frac{10{,}000}{500 \times 2} = 10^{o}F$$

Solution:

Therefor the water exits at 170-10 = 160 deg. F.

Formula 8-1 can be used sequentially to determine the temperature drop from one heat emitter to the next. Remember that as the water temperature drops in the downstream direction the size (or length) of the heat emitter needed for a given heat output increases.

8-2 Home Run Distribution Systems

The ability of PEX-AL-PEX extends far beyond radiant panel heating systems. Its ability to handle relatively high water temperatures combined with ease of installation makes it ideal for piping traditional hydronic heat emitters such as fin-tube baseboard, cast-iron radiators and baseboard, and panel radiators.

The concept for a “home run” piping system is shown in figure 8-2. It employs the same piping and manifold components used for radiant panel systems.

The difference is that the tubing circuits are not part of the heat emitter. Instead, they carry heated water to and from individual heat emitters.

In a home run system each heat emitter has its own supply and return tube. This allows each heat emitter to be supplied with approximately the same water temperature. The drop in water temperature associated with a series loop system is no longer an issue. Each heat emitter connected to the manifold can be sized at the same water temperature. Since the heat emitters don’t have to be “up sized” to compensate for reduced water temperature the overall cost of the heat emitters selected may be reduced.

Homerun systems also allow each circuit to be controlled as an independent zone. When each room is served by its own homerun circuit the temperature of each room can be adjusted as desired. Unoccupied rooms can be set at low temperatures to conserve fuel. Heat output to a room that experience solar heat gains can be interrupted when necessary without compromising comfort in other rooms. The temperature in bedrooms can be reduced during sleeping hours if desired, while bathrooms can remain warm for showers and baths.

One way of providing room-by-room zone control is by adding low voltage electric valve actuators to the valves on the manifold. These actuators are controlled by the thermostats in each room. When the room thermostat calls for heat it sends a 24 volt AC signal to the associated actuator. The actuator then opens the manifold valve to which it is attached. An isolated end switch with the valve actuator provides a contact that is used to turn on the circulator and heat source.

Non-electric thermostatic radiator valves (TRVs) can also be used in conjunction with a homerun distribution system to provide individual temperature control in each room. TRVs adjust the flow rate of heated water through the heat emitters to regulate heat output. They do not have the ability to signal for circulator or boiler operation. In this type of distribution system the circu-

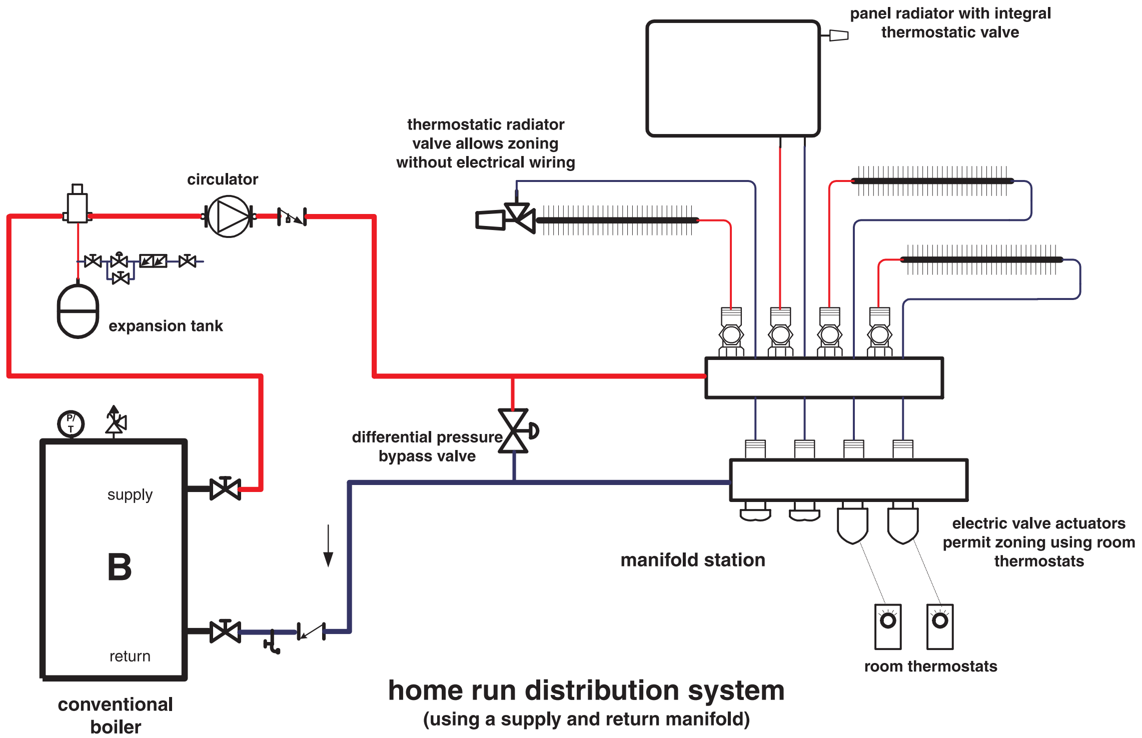


Figure 8-2

lator runs continuously throughout the heating season. The water temperature supplied to the heat emitters is often regulated by an outdoor reset control. The colder it is outside the warmer the water temperature.

Still another benefit of homerun distribution systems is the reduced pressure drops they create in comparison to a series piping loop. Lower pressure drops often allow a smaller, less power consuming circulator to be used. This saves not only on installation cost, but also on operating cost over the long life of the system.

When designing a homerun distribution system keep in mind that some hydronic heat emitters such as panel radiators and lengths of fin-tube baseboard can be sized to operate with temperature drops as high as 40 deg. F. under design load conditions. Such high temperature drops allow significant reductions in the flow rate supplied to the heat emitters. This in turn can allows the use of small tubing such as 3/8" Kitec PEX-AL-PEX for the homerun circuits.

For example, a panel radiator delivering 10,000 Btu/hr with 180 deg. F inlet, and 140 deg. F. outlet water temperature only needs about 0.5 gpm of flow. This could easily be handled by 3/8" tubing.

Such small diameter tubing is easily routed through framing cavities, even cavities that are closed off. In general, if a piece of electrical cable can be pulled through the building from one location to another, so can a length of small diameter composite tubing. This makes the homerun approach ideal for retrofit jobs where framing cavities may have limited access.

When individual circuit control is used, a differential bypass valve should be installed across the manifold as shown in figure 8-2. It provides a flow bypass that prevents the circulator from "dead heading" when all the manifold valves are closed. Adjust the knob on the differential pressure bypass valve so it just begins bypassing flow when all the zone circuits are on, then increase the pressure setting slightly. As the individual homerun circuits close off the bypass valve will take an increasing percentage of the manifold flow and prevent the circulator from imposing a high pressure differential on the circuits that remain active.

8-3 Parallel ("2-pipe") Distribution Systems

Another hydronic distribution system that supplies approximately the same water temperature to each heat emitter is called a parallel (or "2-pipe") system. In this type of system, each heat emitter is piped into a crossover bridge that crosses from a supply main to a return main.

Direct Return Piping:

One form of a parallel (2-pipe) distribution system is specifically called a direct return system. An example of the piping arrangement is shown in figure 8-3.

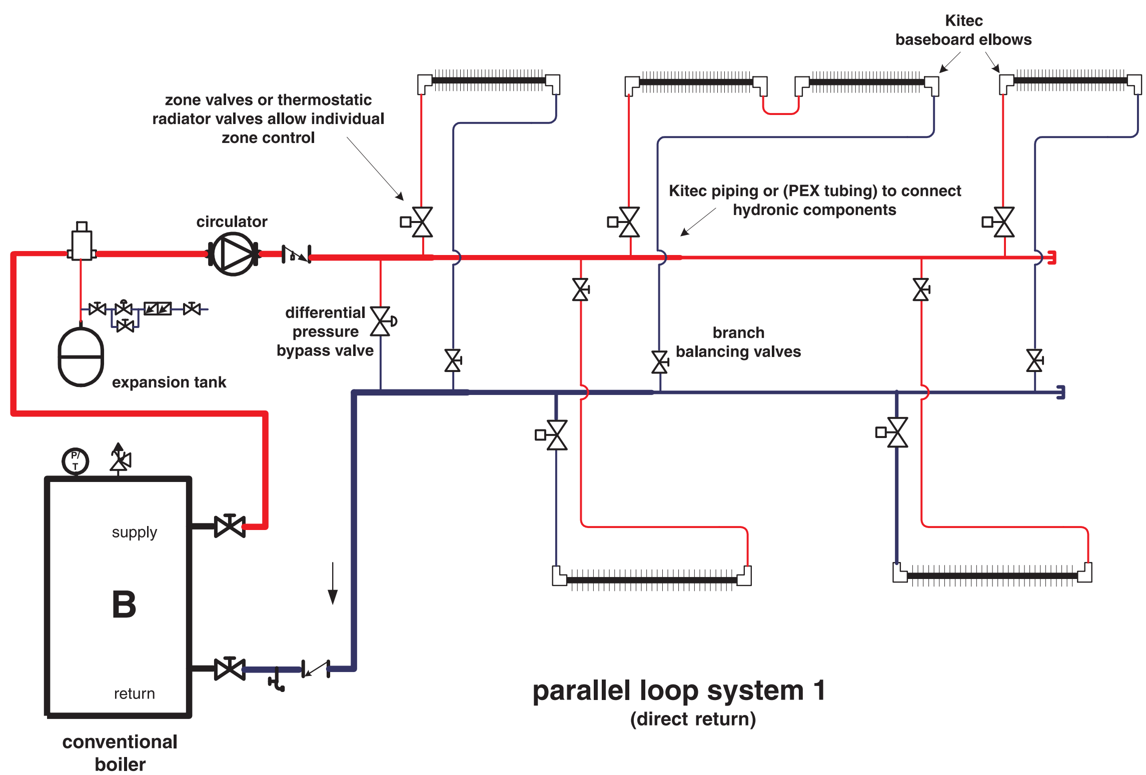


Figure 8-3

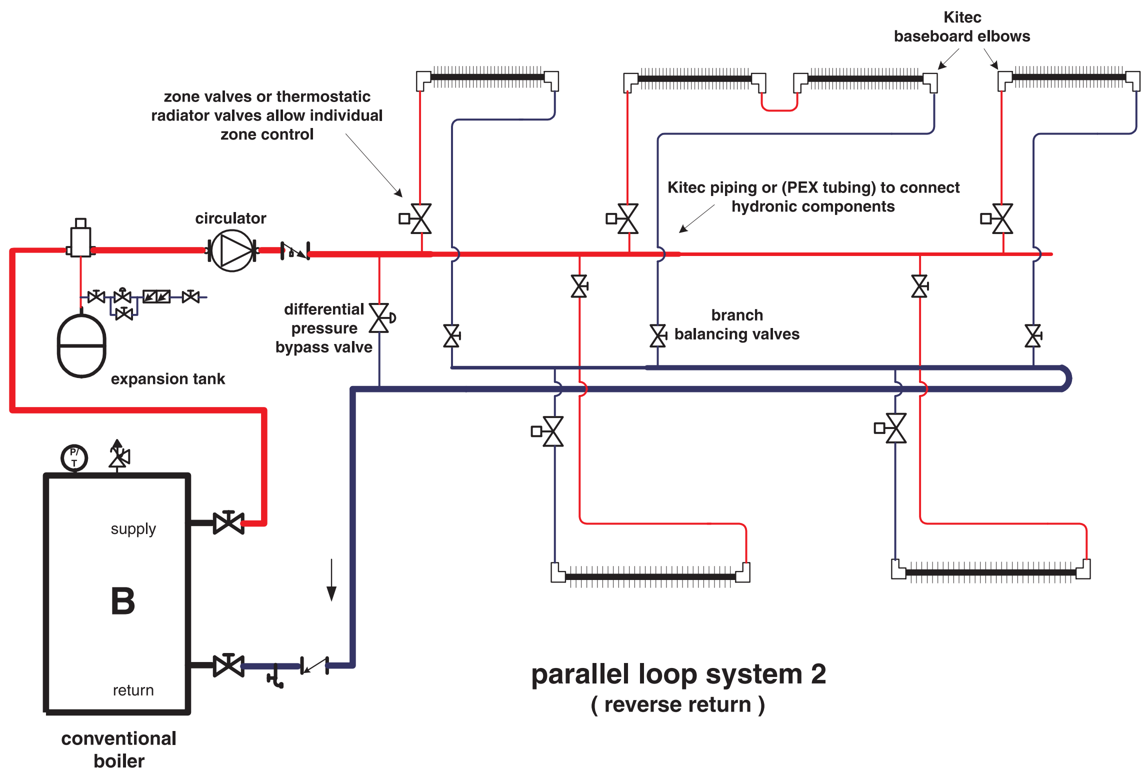


Figure 8-4

Notice that the crossover bridge closest to the supply side of the heat source and circulator is also the closest to the return end of the system. The farther out the other crossover bridges are the longer the flow path of the circulating water. To obtain the proper flow rate through each heat emitter a flow balancing valve must be installed in each crossover bridge. The amount each balancing valve is closed depends on the intended flow rate through each heat emitter as well as its position on the mains. Although it is possible to calculate the necessary Cv setting of each balancing valve this is seldom done. Instead, the valves are set through a trial and error process until the heat outputs of all heat emitters are acceptable.

Parallel direct-return distribution systems can be constructed of Kitec PEX-AL-PEX pipe. Larger diameter composite piping can be used to create the mains, while small pipe sizes can be used to create the rungs. Notice how the pipe size of the mains decreases as the distribution system expands away from the mechanical room.

Reverse Return Piping:

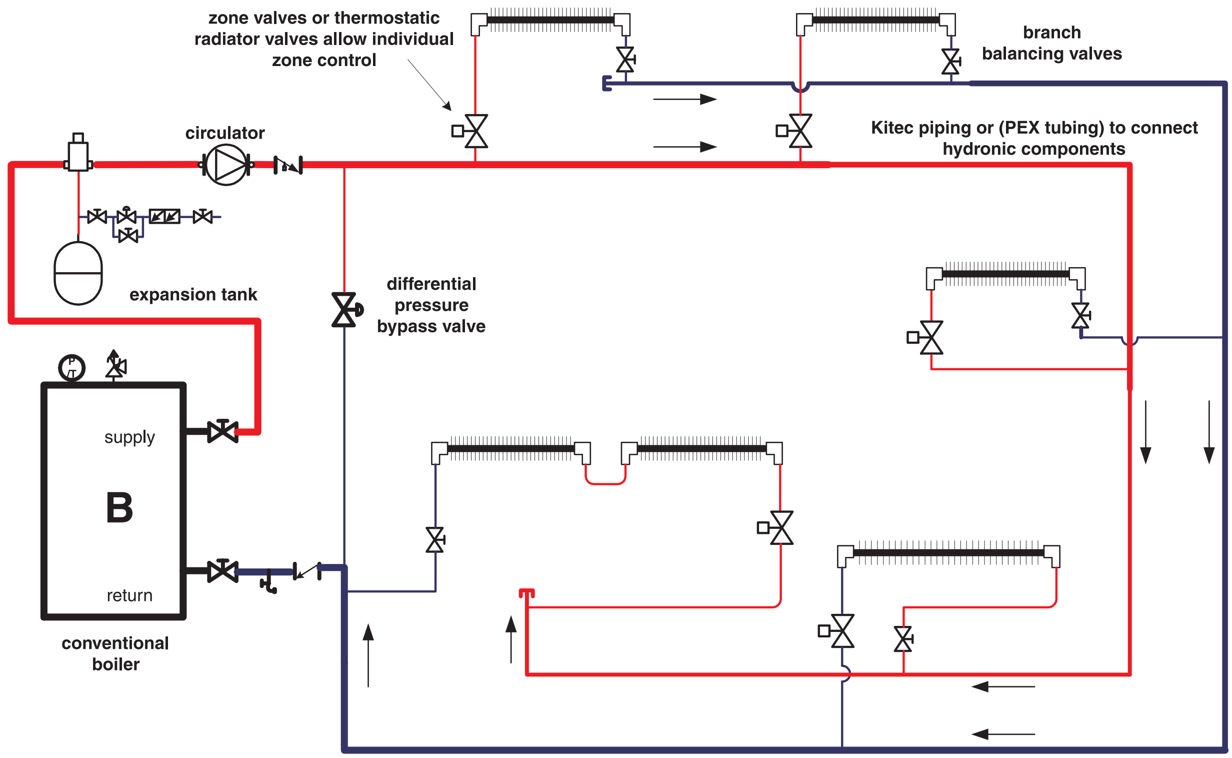
Another variation on the parallel piping concept is called a reverse return system. An example is shown in figure 8-4.

In a reverse return system the first crossover bridge attached to the supply main is, in effect, the last to be attached to the return main. This arrangement helps equalize the piping path length through each heat emitter. This in turn help naturally balance flow through the system, especially with the attached heat emitters have similar flow resistance. Because of its ability to be self balancing reverse return systems are often preferred over direct return systems.

The optimal arrangement of a parallel reverse return circuit within a building is shown in figure 8-5. Notice that the distribution system makes a loop around the building rather than a “dead end” at the farthest point out.

8-4 Primary/Secondary Distribution Systems

The concept of primary / secondary (P/S) piping dates back to the 1950s when it was applied mostly for larger commercial systems, especially chilled water cooling applications. However, renewed interest in radiant floor heating, combined with increasingly sophisticated residential and light commercial applica-



parallel loop system 3 (building loop)
(reverse return)

Figure 8-5

tions prompted designers to look for a piping method more flexible and forgiving than the standard 2-pipe system. They soon rediscovered the elegant simplicity of primary / secondary piping, and were able to successfully integrated with modern controls. Today method of piping is rapidly becoming the standard setter as the backbone upon which to build modern multi-load / multi-temperature hydronic systems.

The fundamental concept of a P/S system is to uncouple the pressure differential established by any given circulator, from that established by other circulators in the same system. P/S piping allows each circulator in the system to operate with virtually no tendency to induce flow, or even disturb flow, in circuits other than it's own. In effect each circulator "thinks" it's circuit is the only circuit in the system. This allows a number of circulators with different head and flow rate characteristics to operate simultaneously without interfering with each other.

The Primary Loop:

All primary /secondary systems have a primary loop that serves as the hot water "bus bar" for one or more secondary circuits. An example of a simple primary circuit is shown in figure 8-6.

The function of the primary circuit is to deliver hot water to each of the secondary circuit attached to it.

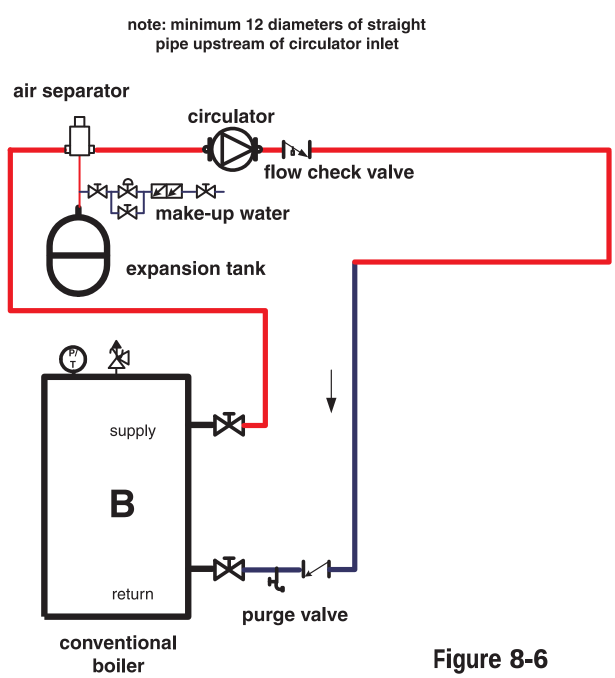


Figure 8-6

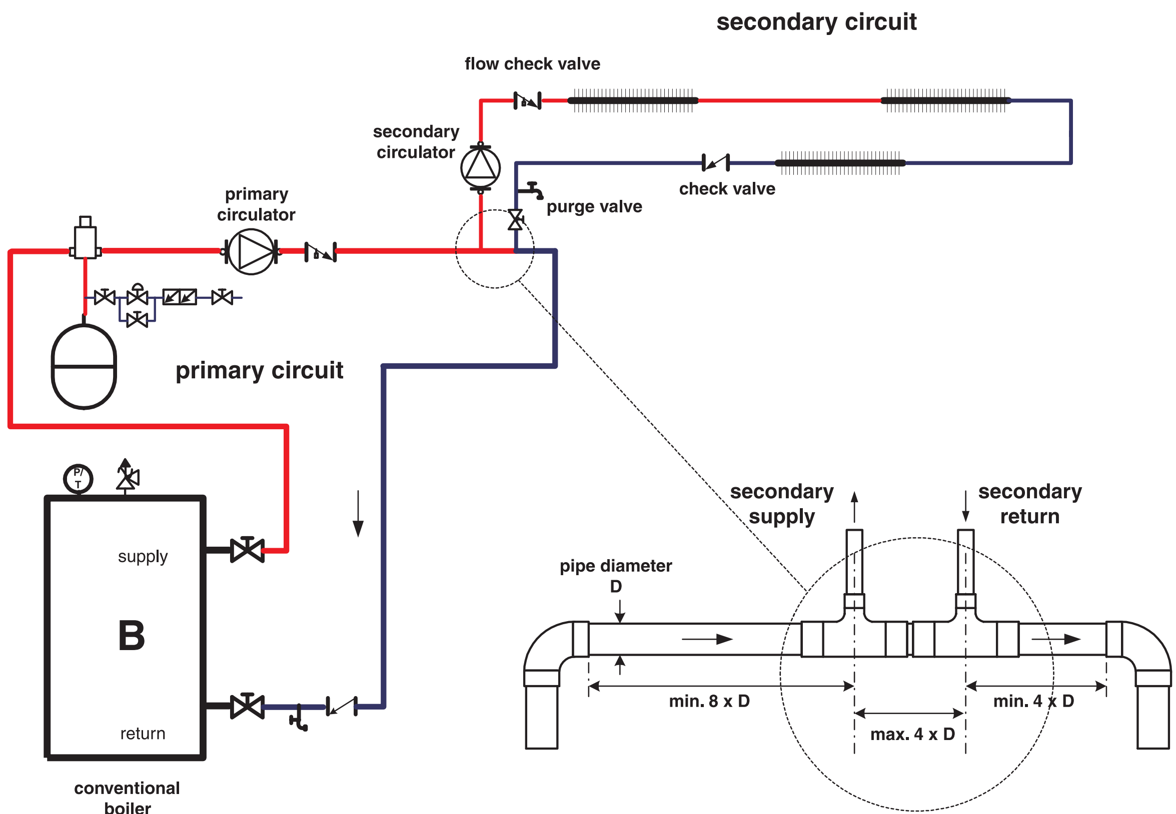


Figure 8-7

The primary circulator produces flow in the primary loop only, and is NOT intended to create or even assist with flow in any of the secondary circuits.

Each secondary circuit is attached to the primary circuit using a pair of closely spaced tees as shown in figure 8-7.

Since the pressure drop between the closely spaced tees is almost zero, there's virtually no tendency for flow in the primary circuit to create flow in the secondary circuit.

When a secondary circulator is turned on, it establishes its own pressure differential in its secondary circuit. This in turn draws flow from the upstream tee in the primary loop, sends the flow through the secondary circuit, and returns it to the downstream tee in the primary loop. The primary loop functions as the source of hot water as well as a return path, instead of direct piping connections to the heat source itself.

The primary loop also becomes the pressure reference point for the secondary circuits. It acts as the point of connection to an expansion tank for each of the secondary circuits. Because of this, it's important that each secondary circulator pumps into its associated secondary circuit, (e.g. away from the expansion tank reference point). This allows the pressure in the secondary circuit to increase when the secondary circulator operates.

Series Primary Loops:

A series primary loop is created when two or more secondary circuits are arranged in sequence along the primary loop as shown in figure 8-8.

When designing a series primary loop it's necessary to account for the temperature drop associated with each operating secondary circuit. Formula 8-1, repeated below, can be used for this purpose.

Formula 8-1

$$\Delta T = \frac{Q}{500 \times f}$$

Where:

ΔT = Temperature drop in the primary loop across the tees of an operating secondary circuit (deg. F)

Q = Rate of heat delivery to the secondary circuit (Btu/hr)

f = Flow rate in the primary circuit (in gpm)

500 a constant for water (use 479 for 30% and 450 for 50% glycol)

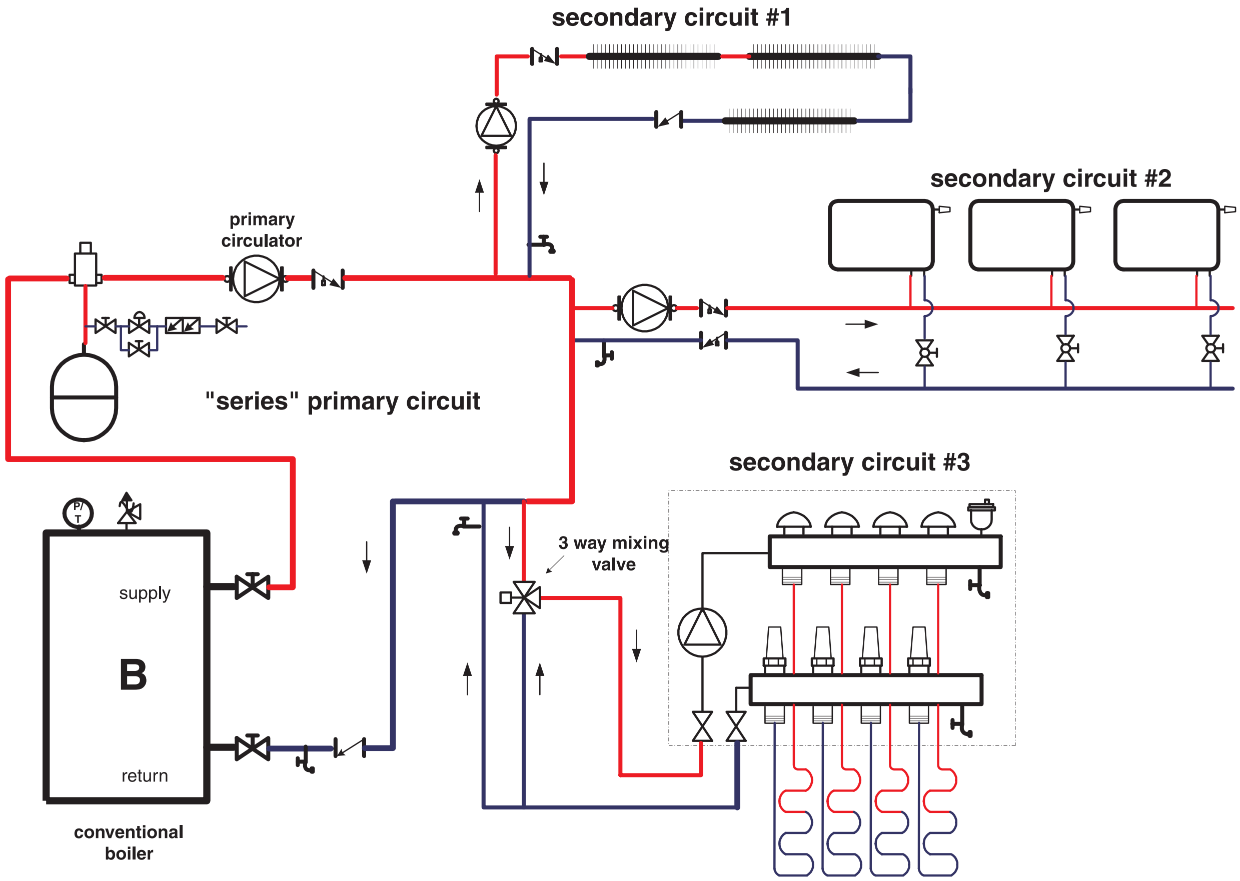


Figure 8-8

The heat emitters in the various secondary circuits need to be sized for the water temperature available to them based on where they connect to the primary circuit. The farther downstream a given secondary circuit connects to the primary loop, the lower the water temperature it has available (assuming the upstream secondary circuits are operating).

It's usually best to place secondary circuits with higher temperature requirements near the beginning of the primary circuit, and those that can work with lower water temperatures near the end.

If a conventional boiler is used as the heat source always check that the water temperature at the end of the primary loop (when all loads are operating) is above the dew point of the boiler's exhaust gases. Minimum return temperatures of 130 deg. F. for gas-fired boilers, and 150 deg. F. for oil-fired boilers are often suggested.

Preventing Heat Migration:

It's very important to protect secondary circuits from off-cycle heat migration (e.g. the undesirable flow of hot water into a secondary circuit when its circulator is off). This migration is causes by two factors.

First there's the natural tendency of hot water to "thermosiphon" through an unblocked piping loop located above the heat source. Hot water is lighter than cool water. Given an unblocked piping path that rises above the heat source this difference in buoyancy will maintain a weak, but persistent flow. Under such conditions the piping loop and any heat emitter it contains serves as a heat dissipater that could easily overheat spaces that simply don't need any heat input at the time.

Another factor that causes heat migration is the fact that the pressure drop between the closely-spaced tees where the secondary circuit connects to the primary loop is not quite zero. The slightly higher pressure at the upstream tee will try to push some hot water into the secondary circuit.

Every secondary circuit in a P/S system must include detailing to prevent heat migration when its circulator is off. One method is to install a flow-check valve (which has a weighted plug) on both supply and return risers of the secondary circuit. The opening pressure of these valves is about 1/4 psi. This is sufficient to prevent buoyancy forces from setting up a thermosiphon flow pattern when the secondary circulator is off. A spring-loaded check valve is an acceptable alternative to a flow-check in these locations. These details are shown in figure 8-9.

Two other options exist for the return riser of a secondary circuit. One is the under slung thermal trap shown in figure 8-9. Another is a swing check. Neither of these can stop forward flow caused by buoyancy forces and therefore should only be used on the return side of a secondary circuit.

Purging:

The closely spaced tees connecting a secondary circuit to the primary circuit make it difficult to purge the secondary circuits by forcing water around the primary loop. The solution is to install separate purging valves on the return side of each secondary circuit as shown in figure 8-9. During purging the ball valve is closed forcing pressurized make-up water in the desired direction through the secondary circuit as air is blown out through the open hose bib.

Sizing the Primary Circulator:

Every circulator in a P/S system functions as if it were installed in an isolated circuit. The primary circulator does not assist in moving flow through any of the secondary circuits, or vice versa. The function of the primary loop is simply to convey hot water from the heat source around the primary loop. In the process the water temperature drops by some intended design ΔT.

The flow rate necessary to deliver the output of the

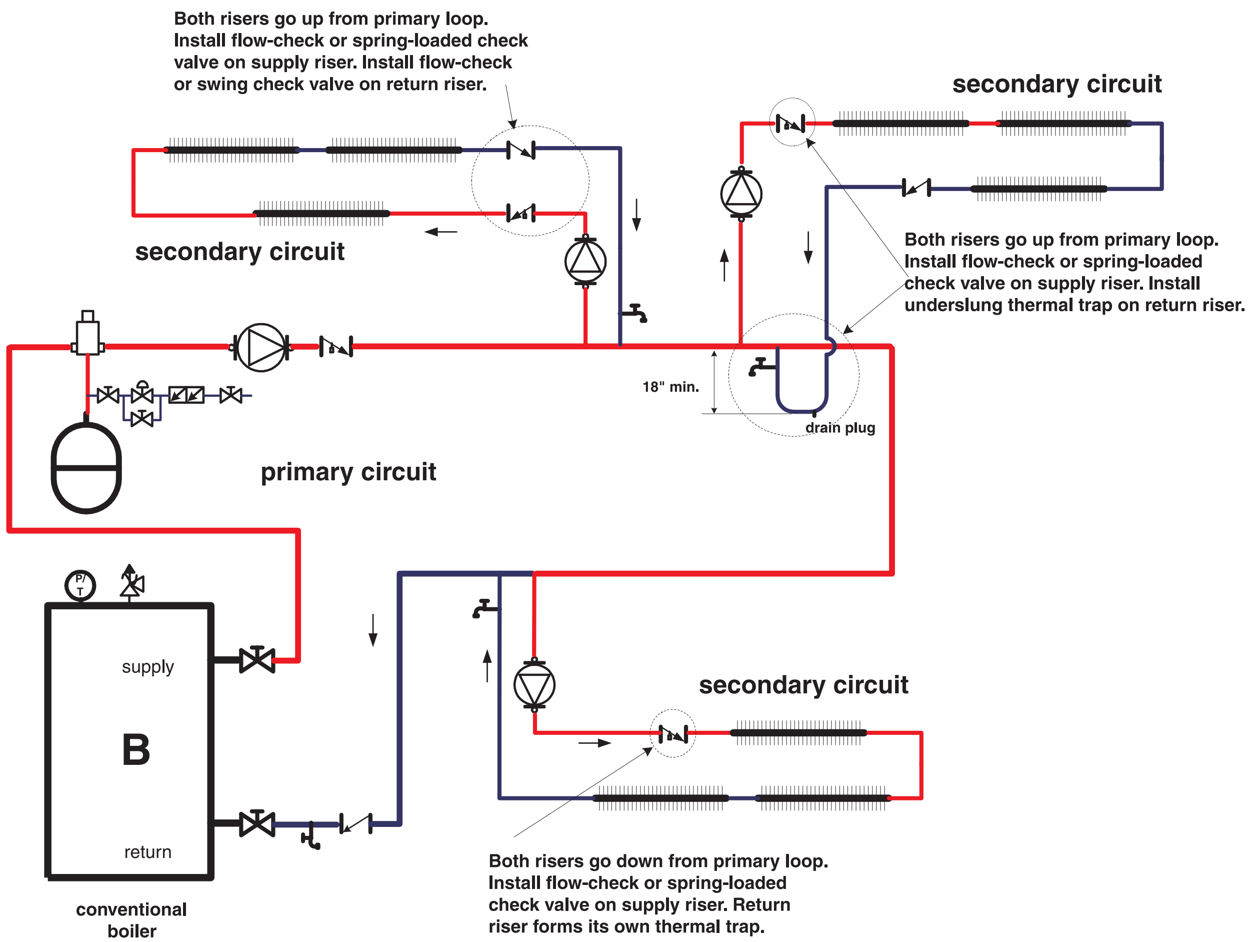


Figure 8-9

heat source using a selected temperature drop can be found using formula 8-2:

Formula 8-2

$$f_{primary} = \frac{Q}{500 \times \Delta T}$$

Where:

$f_{primary}$ = Flow rate in the primary circuit (gpm)

Q = Heat output rate of the heat source (Btu /hr)

ΔT = Intended temperature drop of the primary circuit (deg. F.)

500 = A constant for water at an average temperature of 140ºF., (use 479 for 30% glycol, 450 for 50% glycol)

For example: Assume a primary circuit is connected to a boiler having an output rating of 100,000 Btu/hr. The intended temperature drop of the primary loop with all secondary loads operating is 20 deg. F. What is the necessary primary loop flow rate?

Solution:

$$f_{primary} = \frac{Q}{500 \times \Delta T} = \frac{100{,}000}{500 \times 20} = 10gpm$$

The designer now chooses a piping size and estimates the head loss of the primary loop based on this flow rate. A circulator capable of providing the necessary head at the calculated flow rate is then selected. Notice there was no need to examine the specifics of the secondary circuits when selecting the primary loop circulator.

Selecting a high temperature drop (ΔT) for the primary circuit results in lower flow rates, and often reduces primary loop pipe size. It may also reduce the size of the primary loop circulator. However, selecting a large temperature drop also implies lower supply water temperature to secondary circuits located farther downstream along the primary loop. This is fine for systems using both high temperature and lower temperature heat emitters provided the higher temperature secondary circuits are located near the beginning of the primary loop, while those with lower water temperature requirements are located near the end.

Split Primary Circuits:

When the same water temperature needs to be supplied to each of several secondary circuits, the primary circuit can be split into several parallel crossover bridges as shown in figure 8-10.

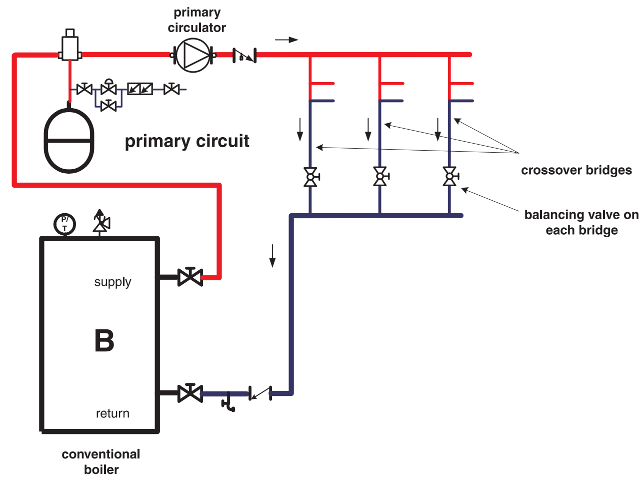


Figure 8-10

Each crossover bridge should have a flow-balancing valve so flow rates can be proportioned to the loads being supplied. See figure 8-11. For example, if one crossover bridge serves a load that has twice the heating requirement of a load on another crossover bridge, that bridge should have about twice the flow rate of the other. The pipe sizes of the crossover bridges can even be different if necessary depending on the flows needed. The split primary loop approach is especially helpful when several of the secondary circuits need to operate within a narrow water temperature range.

Secondary Circuit Design:

The design of secondary circuits is not limited to a series loop of heat emitters. Any piping design that could be connected to a boiler can also be connected to the closely spaced tees at the P/S interface. Some examples are shown in figure 8-12.

The secondary circuit risers can even be treated as "headers" from which two or more independently controlled zone circuits can begin and end. Another option is to configure the secondary circuit as a two pipe direct- or reverse-return subcircuit. The secondary circuit can also be set up as a home run subsystem use several independent circuits of Kitec pipe to supply individual heat emitters.

Secondary circuits can also contain a mixing device allowing them to operate at lower water temperatures than the primary loop.

Examples are shown in figure 8-13.

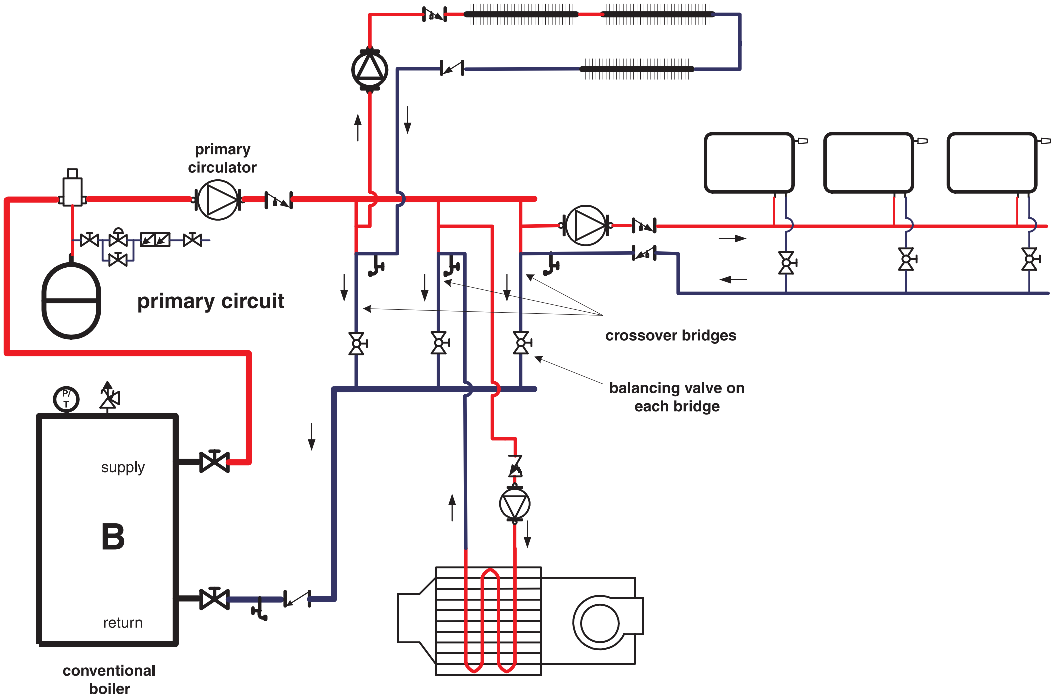


Figure 8-11

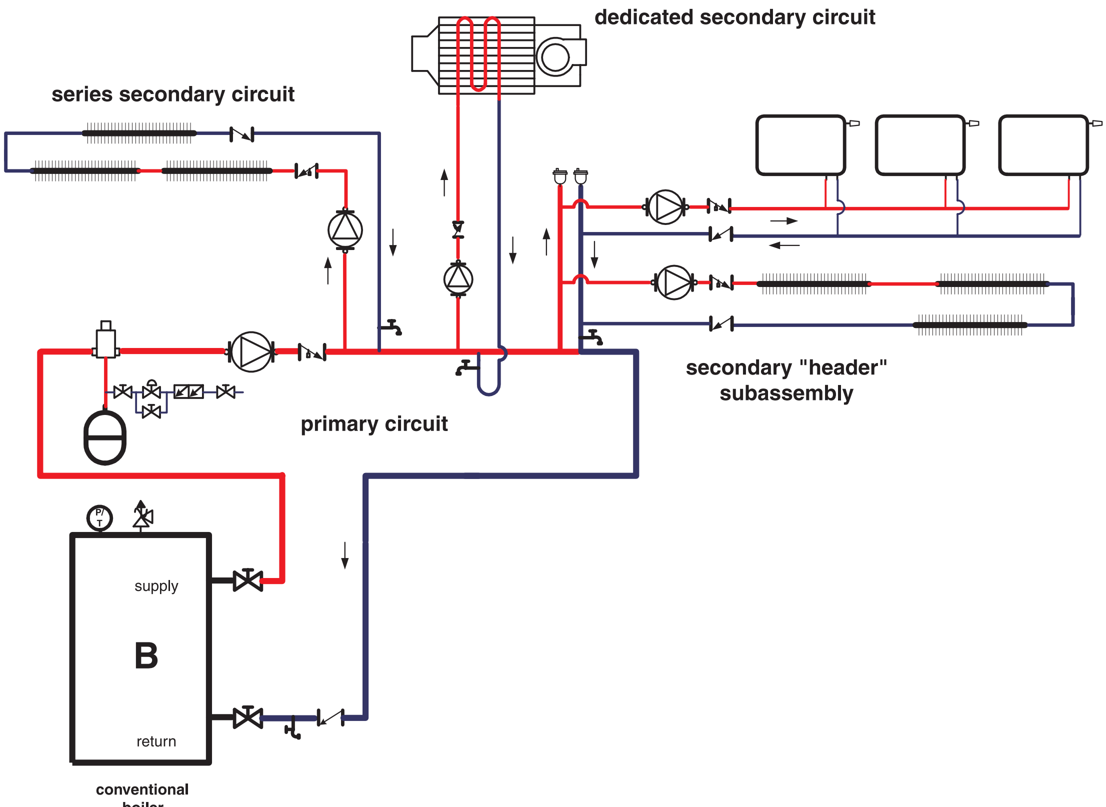


Figure 8-12

When a mixing device is used to reduce the supply temperature in the secondary circuit the primary loop creates a second mix point that boosts water temperature returning to the heat source. With the proper controls, this configuration can reliably protect a conventional boiler against sustained flue gas condensation.

The possibilities of what can be constructed using the piping techniques discussed in this section are nearly endless. The next section will show you how to apply these piping techniques when necessary to create sophisticated multi-load / multi-temperature systems.

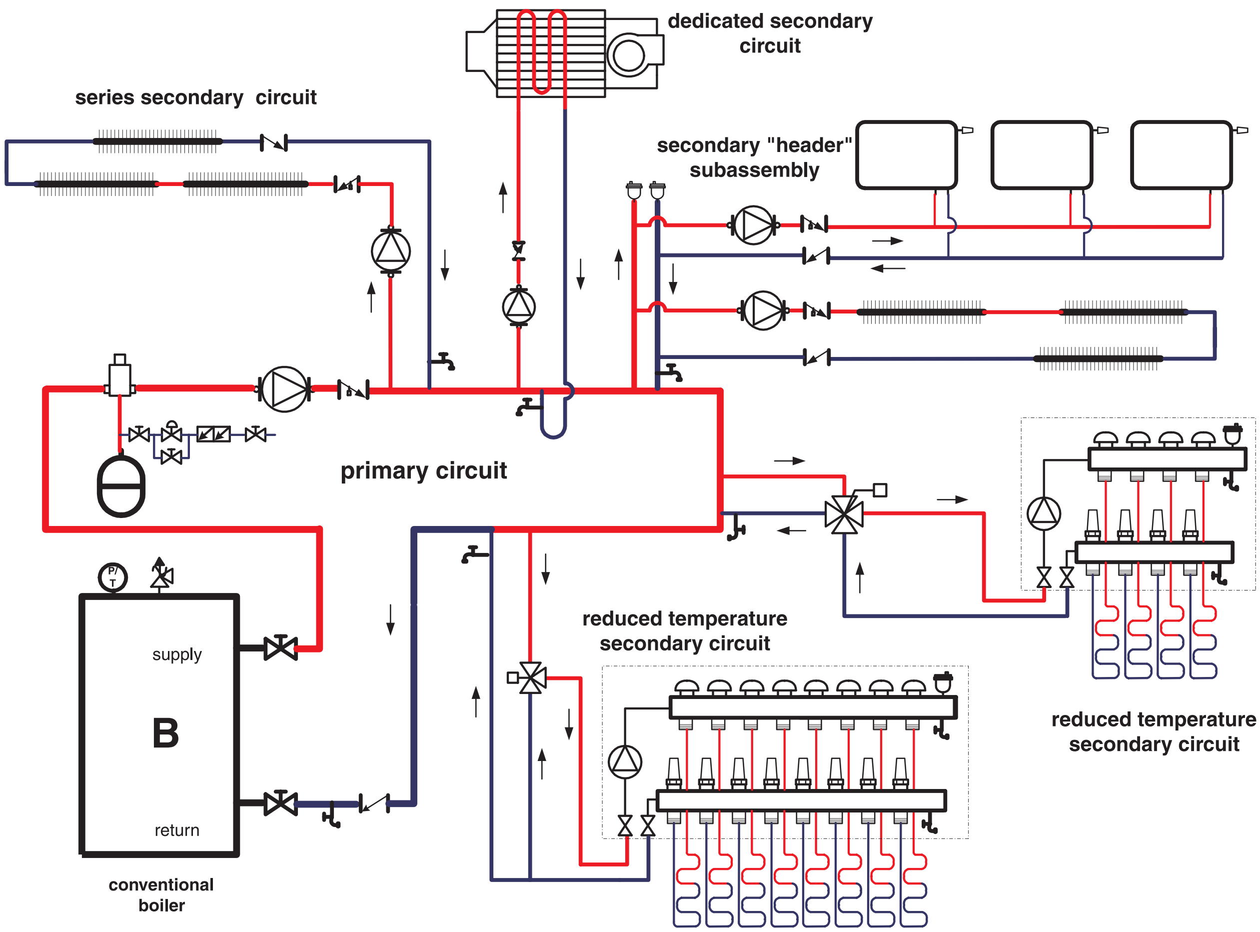


Figure 8-13