january 2012 10

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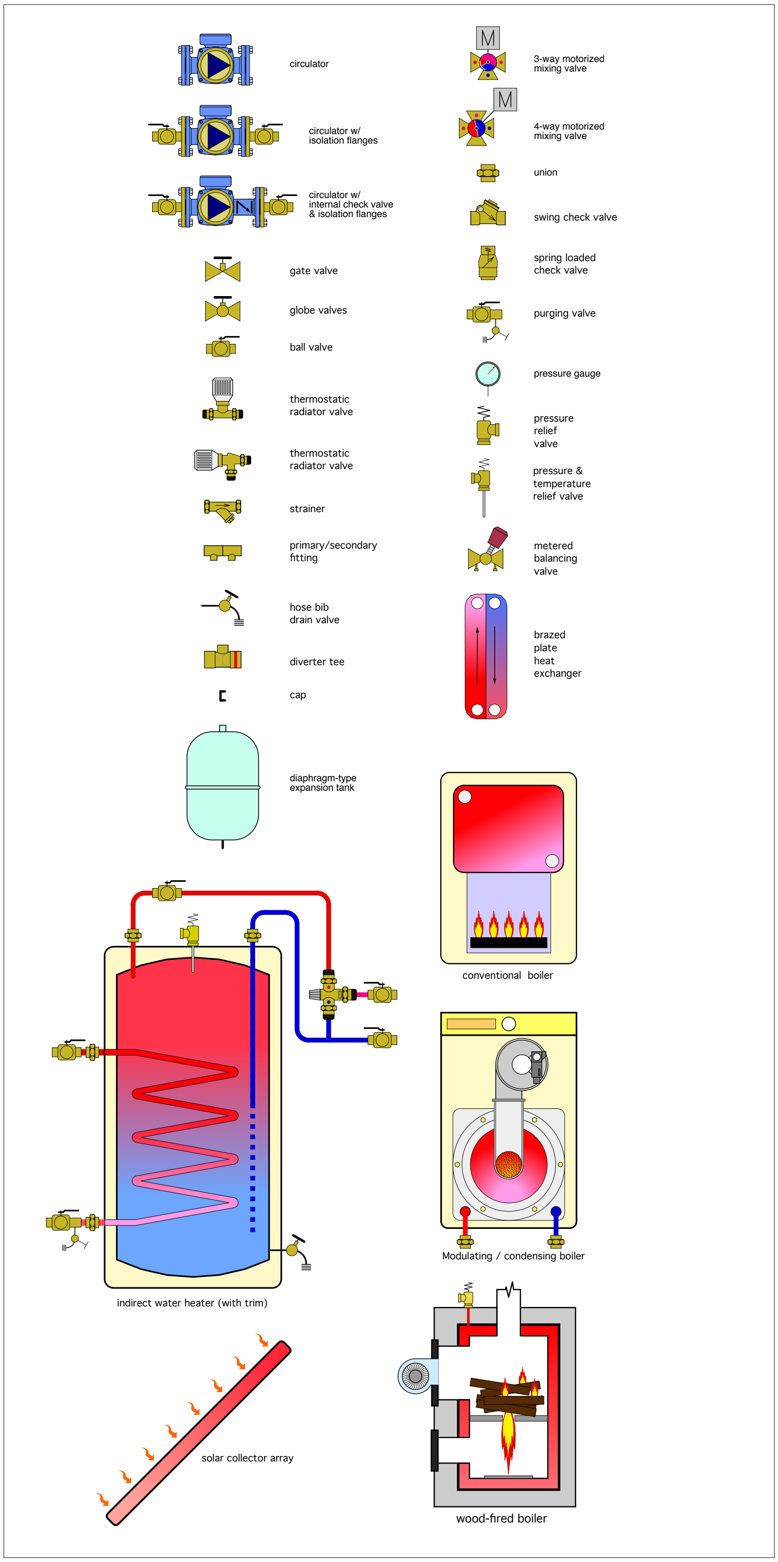
JOURNAL OF DESIGN INNOVATION FOR HYDRONIC PROFESSIONALS

Hydronics For Wood-Fired Heat Sources

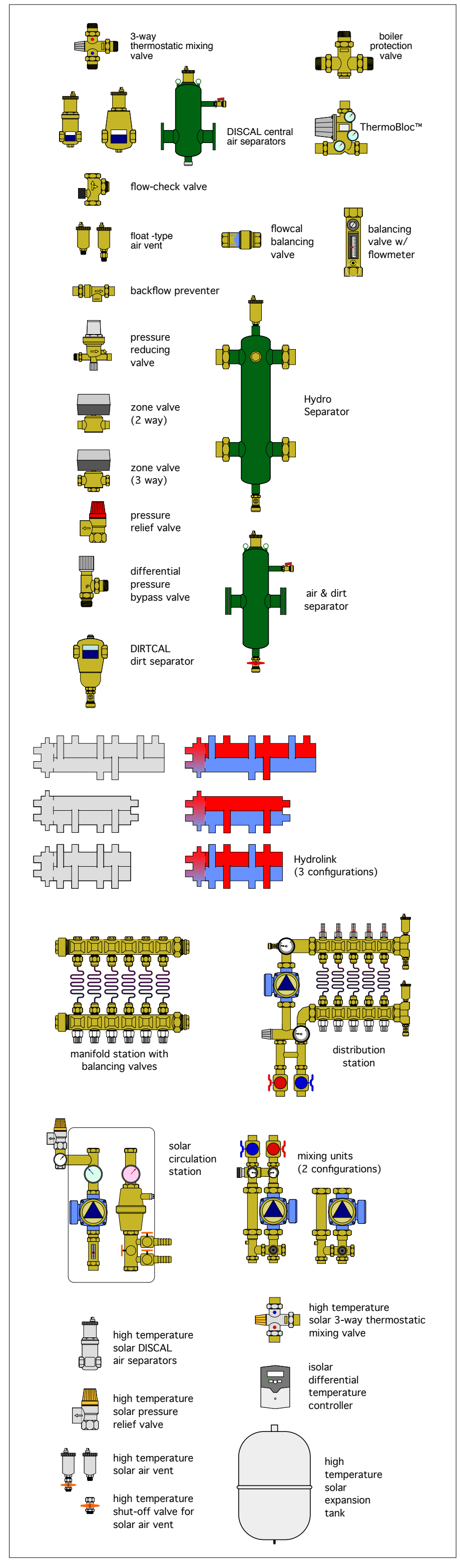
CALEFFI

APPENDIX A: PIPING SYMBOL LEGEND

GENERIC COMPONENTS



CALEFFI COMPONENTS



APPENDIX B: SIZING DIAPHRAGM-TYPE EXPANSION TANKS

All closed-loop hydronic systems require expansion tanks regardless of the heat source used. Closed-loop systems with wood-fired boilers and relatively large buffer tanks often require substantially larger expansion tanks due to the volume of water in the system. This appendix presents information for sizing the diaphragm-type expansion tanks commonly used in residential and light commercial systems.

A properly sized diaphragm-type expansion tank allows the pressure relief valve to reach a pressure about 5 psi lower than its rated opening pressure when the system reaches its maximum operating temperature. The 5 psi margin prevents the relief valve from leaking just below its rated opening pressure.

The first step in sizing a diaphragm-type expansion tank is to determine the proper air-side prepressurization of the tank using Formula B-1.

Formula B-1

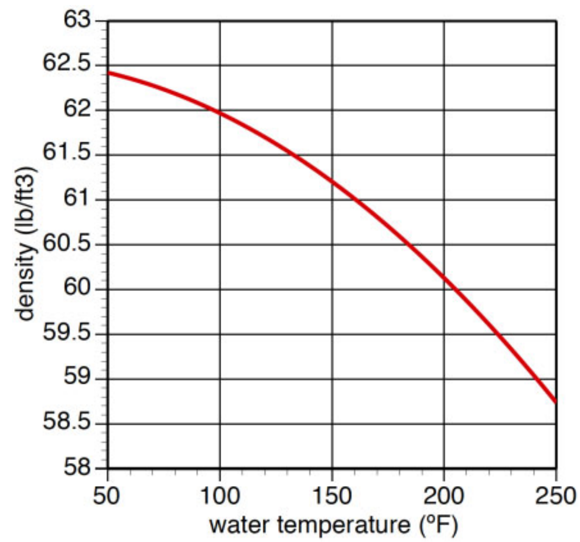
$$P_a = H\left(\frac{D_c}{144}\right) + 5$$

Where:

Pa = air-side pressurization of the tank (psi)
H = distance from inlet of expansion tank to top of system (ft)
Dc = density of the fluid at its initial (cold) temperature (lb/ft^3)

The proper air-side prepressurization is equal to the static fluid pressure at the inlet of the tank, plus an additional 5 psi allowance at the top of the system. The pressure on the air-side of the diaphragm should be adjusted to the calculated prepressurization value before fluid is added to the system. This is done by either adding or removing air through the Schrader valve on the shell of the tank. A small air compressor or bicycle tire pump can be used when air is needed. An accurate 0 to 30 psi pressure gauge should be used to check this pressure as it is being adjusted. Many smaller diaphragm-type expansion tanks are shipped with a nominal air-side prepressurization of 12 psi. However, the air-side pressure should always be checked before installing the tank.

Figure B-2



Proper air-side pressure adjustment ensures the diaphragm will be fully expanded against the shell of the tank when the system is filled with fluid, but before it is heated.

Failure to properly prepressurize the tank can result in the diaphragm being partially compressed by the fluid's static pressure before any heating occurs. If this occurs, the full expansion volume of the tank will not available as the fluid heats up.

Figure B-1

Copper (Type M)		PEX		PEX-AL-PEX	
	gal./ft.		gal./ft.		gal./ft.
3/8" copper	0.008272	3/8" PEX	0.005294	3/8" PEX-AL-PEX	0.004890
1/2" copper	0.01319	1/2" PEX	0.009609	1/2" PEX-AL-PEX	0.01038
		5/8" PEX	0.01393	5/8" PEX-AL-PEX	0.01658
3/4" copper	0.02685	3/4" PEX	0.01894	3/4" PEX-AL-PEX	0.02654
1" copper	0.0454	1" PEX	0.03128	1" PEX-AL-PEX	0.04351
1.25" copper	0.06804	1.25" PEX	0.04668		
1.5" copper	0.09505	1.5" PEX	0.06516		
2" copper	0.1647	2" PEX	0.1116		
2.5" copper	0.2543				
3" copper	0.3630				

Once the air-side prepressurization is determined, Formula B-2 can be used to find the minimum required volume of the expansion tank:

Formula B-2

$$V_t = V_s\left(\frac{D_c}{D_h} - 1\right)\left(\frac{P_{RV} + 9.7}{P_{RV} - P_a - 5}\right)$$

Where:

V_t = minimum required tank volume (gallons) Not “acceptance volume.”
Vs = fluid volume in the system (gallons)
Dc = density of the fluid at its initial (cold) temperature (lb/ft^3)
D_h = density of the fluid at the maximum operating temperature of the system (lb/ft^3)
P_a = air-side pressurization of the tank found using Equation B-1 (psi)
PRV = rated pressure of the system’s pressure-relief valve (psi)

System volume can be estimated based on the total volume of the boiler, piping and other components in the system. Figure B-1 gives volumes for several common pipe types and sizes used in residential and light commercial systems.

The density of water over the temperature range of 50° to 250°F can be read from Figure B-2.

Example: Determine the minimum-size diaphragm-type expansion tank for the system shown and described in Figure B-3.

Boiler volume = 20 gallons
Piping estimates:
50 feet of 1.5” copper
100 feet of 1” copper
2000 feet of 1/2” PEX
Miscellaneous component volume = 3 gallons
Maximum buffer tank temperature = 200°F
Minimum system water temperature = 50°F
Vertical distance from top of system to inlet of expansion tank = 12 feet
Pressure relief valve setting = 30 psi

Solution: Start by getting the density of water at both extremes:

D50°F = 62.4 lb/ft3
D200°F = 60.15 lb/ft3

The total estimated system volume is found by totaling up the volume in piping and other components:

Vs = (50)(0.09505) + (100)(0.0454) + (2000)(0.009609) + 23 + 2(119) = 290 gallons

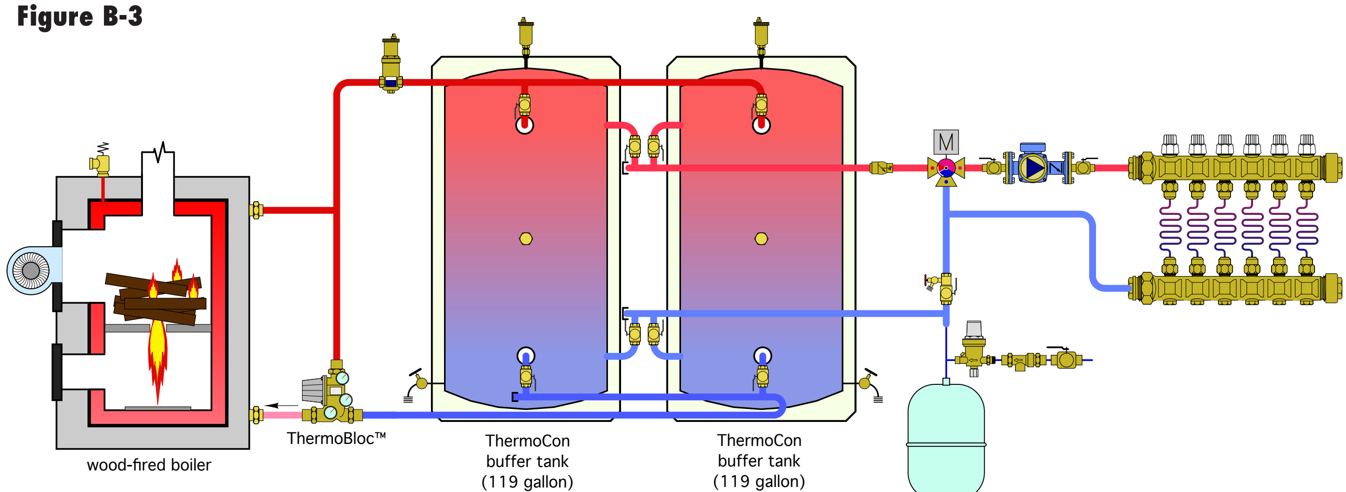
Formula B-1 can now be used to calculate the cold fill pressurization of the expansion tank:

$$P_a = H\left(\frac{D_c}{144}\right) + 5 = 12\left(\frac{62.4}{144}\right) + 5 = 10.2\,psi$$

Formula B-2 can now be used to calculate the expansion tank volume:

$$V_t = 290\left(\frac{62.4}{60.15} - 1\right)\left(\frac{30 + 9.7}{30 - 10.2 - 5}\right) = 29.1\,gallons$$

Figure B-3



Discussion: This expansion tank volume is “conservatively” large because it assumes that all water in the system reaches the upper temperature of 200ºF simultaneously. This is not the case for piping downstream of the mixing valve (e.g., the radiant panel circuits). Thus, it is not necessary to add any additional safety factor to this volume.

The expansion tank volume is also considerably larger than required in most residential hydronic systems. This is a direct result of the large buffer tank volume (238 gallons) out of the total system volume (290 gallons). In this case, the expansion tank volume was approximately 10% of the total system volume. Given similar system operating conditions, it is reasonable to make a rough estimate of expansion tank volume using the 10% rule of thumb. However, variations in temperature, height or pressure-relief valve settings should always be evaluated using the above procedure.

ThermoMix™ boiler protection high-flow thermostatic mixing valve

series 280

Function

The ThermoMix™ boiler protection high-flow thermostatic mixing valve is used in hydronic heating systems with non-condensing boilers, including solid fuel, biomass, gas, LP or oil-fired. It can be installed with steel, cast iron and copper tube style boilers, automatically controlling the return water temperature, preventing condensation of the water vapor contained in the flue gas.

The 280 series ThermoMix valve mixes bypass flow from the boiler with return flow from the system, sending a fixed temperature flow to the boiler which protects against corrosion from condensation occurring when a minimum flue gas temperature is not otherwise maintained.

Changable thermostatic sensor cartridges modifies valve temperature setting. The thermostatic sensor cartridge can easily be removed for maintenance or to change the valve set temperature, with out removing the valve body from the piping.

Product range

Code 280xxxA Boiler protection high-flow thermostatic mixing valve with 140ºF cartridge, threaded and sweat connections .... sizes 1", 1-1/4"
Code F29633 Themostatic sensor cartridge .... 115º F
Code F29634 Themostatic sensor cartridge .... 130º F
Code F29635 Themostatic sensor cartridge .... 140º F
Code F29636 Themostatic sensor cartridge .... 160º F

Technical specifications

Materials

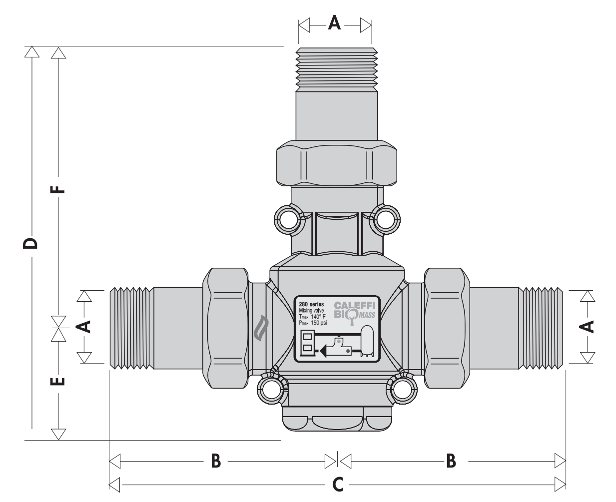
Body and lower body plug:	brass
Shutter:	polysulfone
Spring:	stainless steel
Seal:	EPDM
Union seals:	non-asbestos fiber
Thermostatic sensor:	wax

Performance

Suitable fluids: water, up to 50% glycol solutions
Max working pressure: 150 psi (10 bar)
Working temperature range: 40-212°F (5-100°C)
Thermostatic sensor cartridge: 140°F (60°C) standard
115°F (45°C), 130°F (55°C), 160°F (70°C) optional cartridges
Sensor cartridge accuracy: ±3.6°F (±2°C)
By-pass from boiler complete closing temperature: Tset +18°F (10°C)
Cv: size 1"... 10Cv
size 1-1/4" ... 14Cv

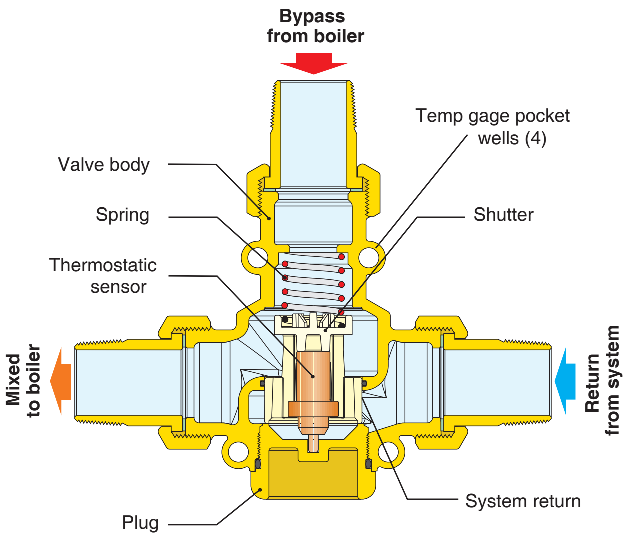
Connections: - NPT male union 1" and 1¼"
- sweat union 1" and 1¼"

Dimensions



Code	A	B	C	D	E	F
280166A	1" NPT	3 1/2"	7"	6"	1 5/8"	4 3/8"
280966A	1" SWT	3 1/2"	7"	6"	1 5/8"	4 3/8"
280176A	1 1/4" NPT	3 13/16"	7 5/8"	6 3/16"	1 9/16"	4 3/8"
280976A	1 1/4" SWT	3 13/16"	7 5/8"	6 3/16"	1 9/16"	4 3/8"

Characteristic components



Operating principle

The thermostatic sensor, completely immersed in the medium, controls the movement of a shutter that regulates the bypass flow from the boiler and toward the system. At boiler startup, the boiler protection thermostatic mixing valve recirculates the bypass flow from the boiler to bring the boiler up to temperature as quickly as possible (fig. 1). When the bypass flow from the boiler Tf exceeds the setting of the boiler protection mixing valve Tset, the valve's return from the system port starts opening to produce the water mixing Tmix: in this phase the system loading begins (fig. 2).

When the mixed flow to the boiler temperature Tmix is greater than the set point of the boiler protection mixing valve by approximately 18°F (10°C), the bypass flow from the boiler port closes and water returns to the boiler at the same temperature as the return flow from the system.

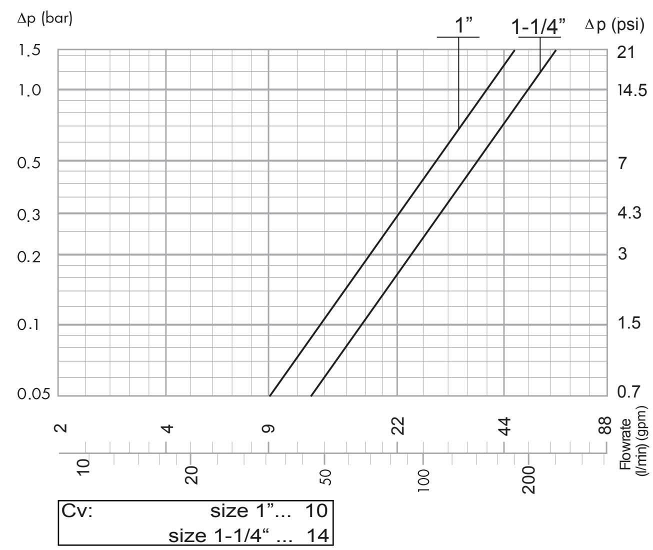
Construction details

The brass body prevents the formation of ferrous residues in the system, prolonging boiler operating life.

The thermostatic sensor can be easily replaced for maintenance or set point change.

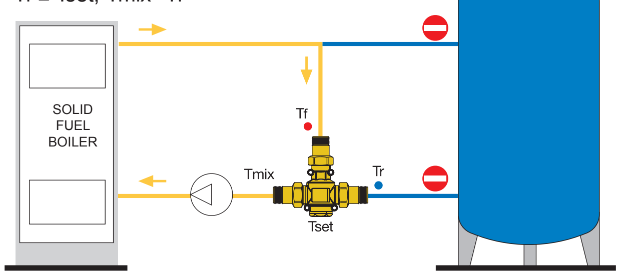
The boiler protection mixing valve body features temperature gage pocket wells on front and rear sides, allowing installation of a temperature gage (code F29571) for monitoring the working temperatures: bypass from boiler, return from system, and mixed to boiler.

Flow curve



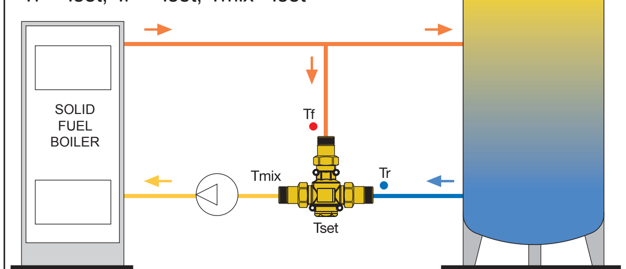
Tf ≤ Tset SYSTEM START UP 1
- by-pass open
- system return closed

Tf ≤ Tset, Tmix= Tf



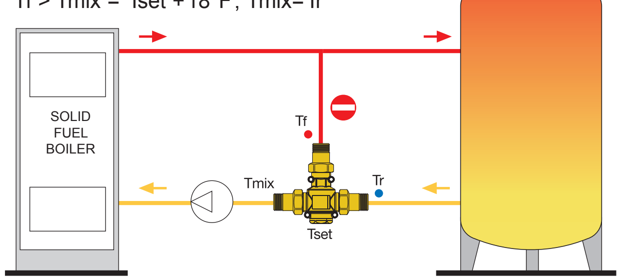
Tf > Tset START OF SYSTEM LOADING 2
- by-pass open
- system return open

Tf > Tset, Tr < Tset, Tmix= Tset



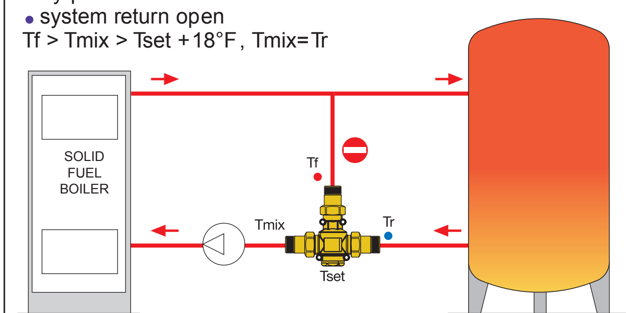
Tmix = Tset + 18°F BY-PASS CLOSING 3
- by-pass closed
- system return open

Tf > Tmix = Tset +18°F, Tmix=Tr



Tmix > Tset + 18°F SYSTEM LOADED 4
- by-pass closed
- system return open

Tf > Tmix > Tset +18°F, Tmix=Tr



Tf=Bypass flow from boiler
Tset=Boiler protection valve set point temperature
Tmix=Mixed flow to boiler temperature
Tr=Return from system temperature

ThermoBloc™ Boiler protection recirculation and distribution unit

series 281

Function

The ThermoBloc™ boiler protection recirculation and distribution unit is used in hydronic heating systems with non-condensing boilers, including solid fuel, biomass, gas, LP or oil-fired. It can be installed with steel, cast iron and copper tube style boilers, automatically controlling the return water temperature, protecting against corrosion from condensation occurring when a minimum flue gas temperature is not otherwise maintained.

The ThermoBloc unit is compact for easy installation, reducing required space and fittings. It combines the functionality of a boiler protection valve with a circulation pump and a unique flapper check valve allowing for thermosyphon flow between the boiler and distribution system during a power outage. The ThermoBloc includes three temperature gages and is encased in an insulation shell.

Product range

Code 281xxxA Boiler protection unit, with 140º F cartridge, threaded and sweat connections .... sizes 1", 1-1/4"

Technical specifications

Materials

Body:	brass
Shutter:	PSU
Spring:	stainless steel
Flapper check valve	PPS
Seal:	EPDM
Thermostatic sensor:	wax

Performance

Suitable fluids:	water, up to 50% glycol solutions
Max working pressure:	150 psi (10 bar)
Working temperature range:	40-210°F (5-100°C)
Termperature gage scale:	30-250°F (0-120°C)
Thermostatic sensor cartridge:	140°F (60°C) standard
	115°F (45°C), 130°F (55°C), 160°F (70°C) optional cartridges
Sensor cartridge accuracy:	±3.6°F (±2°C)
Bypass from boiler complete closing temperature:	Tset +18°F (10°C)

Connections:	- NPT male union	1" and 1-1/4"
	- sweat union	1" and 1-1/4"

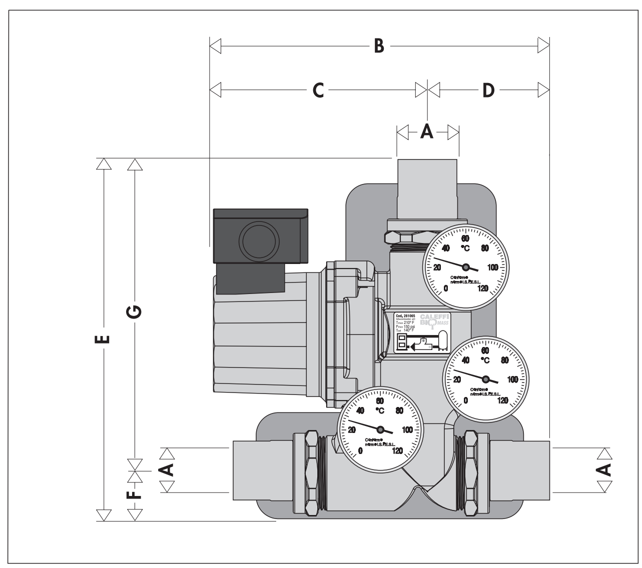
Pump

Three speed pump:	Wilo Star S-16 U15
Body:	cast iron
Power supply: 115 V - 60 Hz	
Max. pressure:	150 psi (10 bar)
Max. temperature:	230°F (110°C)
Agency approval:	cULus

Insulation

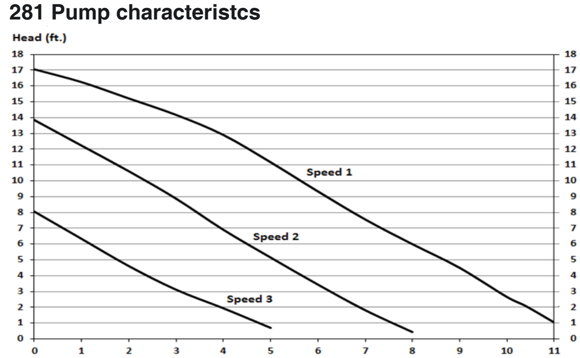
Material:	EPP
Mean thickness:	30 mm
Density:	45 kg/m^3
Working temperature range:	40-210°F (5-100°C)
Thermal conductivity:	0.037 W/(m·K) at 10°C
Reaction to fire (UL94):	class HBF

Dimensions

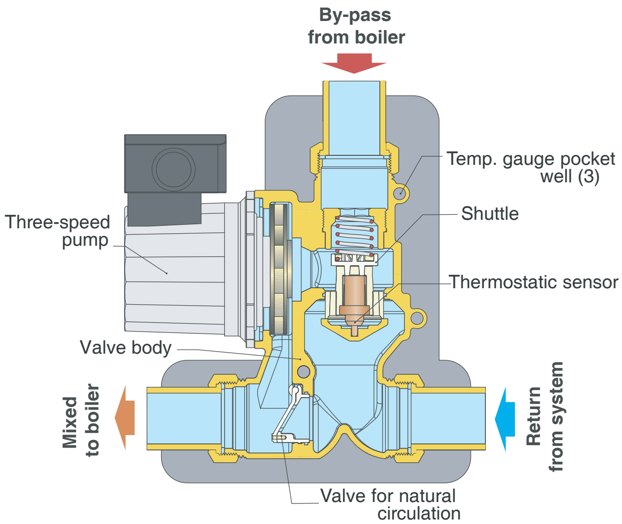


Code	A	B	C	D	E	F	G
281166A	1" NPT	8 3/4"	5 5/8"	3"	9 7/8"	1 7/8"	8"
281966A	1" SWT	8 3/4"	5 5/8"	3"	9 7/8"	1 7/8"	8"
281176A	1 1/4" NPT	8 3/4"	5 5/8"	3"	9 7/8"	1 7/8"	8"
281976A	1 1/4" SWT	8 3/4"	5 5/8"	3"	9 7/8"	1 7/8"	8"

281 Pump characteristcs



Characteristic components



Operating principle

The thermostatic sensor, completely immersed in the medium, controls the movement of a shutter that regulates the bypass flow from the boiler and toward the system. At boiler startup, the boiler protection recirculation and distribution unit recirculates the bypass flow from the boiler to bring the boiler up to temperature as quickly as possible (fig. 1). When the bypass flow from the boiler Tf exceeds the setting of the fixed thermostatic sensor Tset, the unit's return from the system port starts opening to produce the water mixing Tmix: in this phase the system loading begins (fig. 2).

When the mixed flow to the boiler temperature Tmix is greater than the set point of the boiler protection recirculation and distribution unit by approximately 18°F (10°C), the bypass flow from the boiler port closes and water returns to the boiler at the same temperature as the return flow from the system (fig. 3).

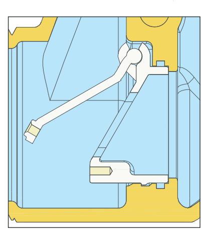
When power is out and the circulation pump stops running, the flapper check valve, which is closed during normal operation, opens with a slight pressure differential resulting from the effects of heated water in the boiler and cooler water in the distribution syste, a natural thermosyphon flow. This prevents a excessive heat buildup which eventually would cause the pressure relief valve to open(fig. 4).

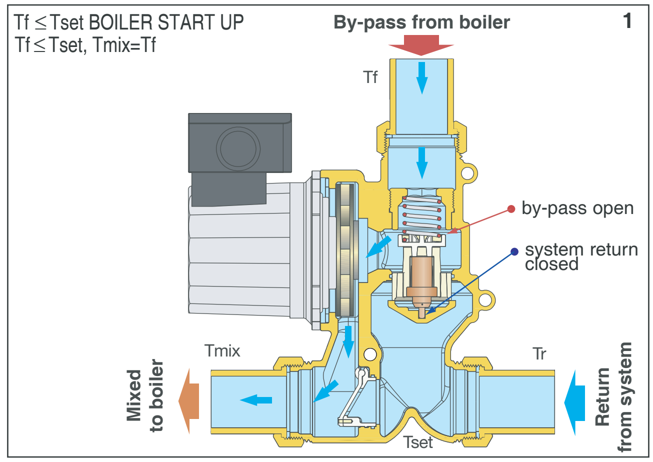
The compact brass body casting houses the pump and all functioning components, offering easy installation, either on the right or left side of the boiler. The temperature gages can be easily removed and re-inserted on the back side of the unit.

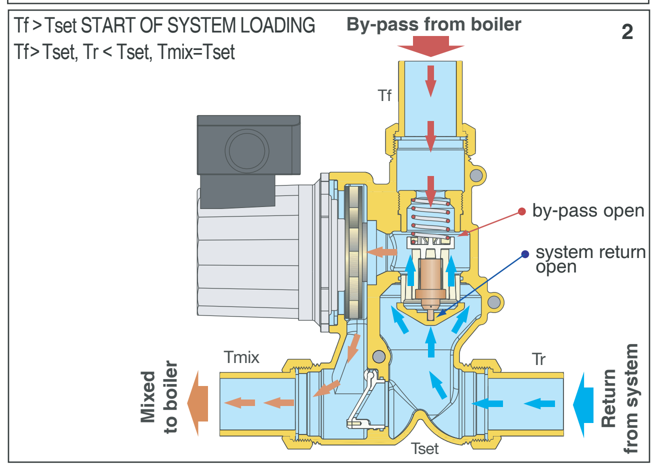
The brass body prevents the formation of ferrous residues in the system, prolonging boiler operating life.

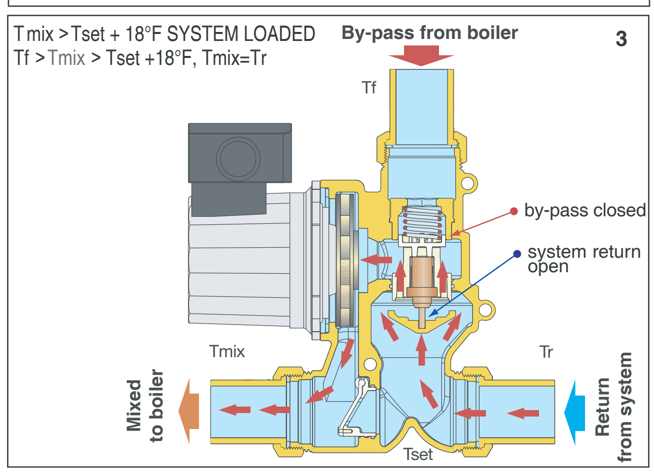
The unit features a thermostatic sensor to control the temperature of water returning to the boiler to prevent condensation. The sensor can be easily replaced for maintenance or set point change.

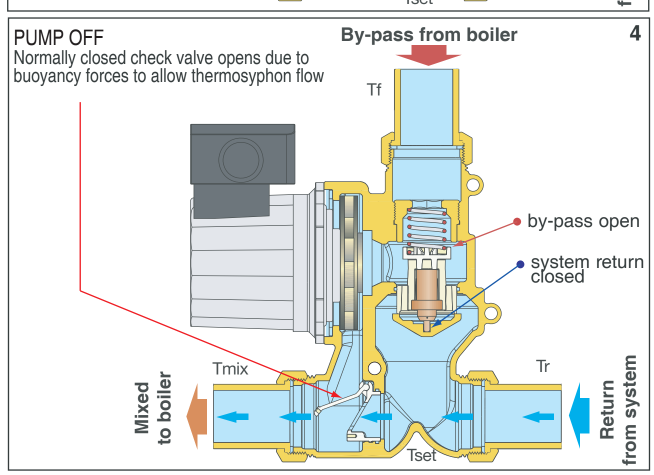
The flapper check valve allows the natural thermosyphon circulation of the system heat transfer fluid when the pump stops running due to power failer. When the pump is running under normal conditions the thust of the flowing medium keeps the flapper closed, forcing flow past the thermostatic sensor. When the pump stops running and the fluid in the boiler is at high temperature, natural circulation begins, bypassing the thermostatic sensor, preventing overheating in the boiler.











ThermoCon™ buffer storage tanks

series NAS200

Function

ThermoCon™ tanks are designed to be used for wood boilers, solar and geothermal storage, plus in heating systems with low-mass boilers, chilled water systems and low-mass radiation. ThermoCon tanks are used in systems operating below the design load condition, which is most of the time, or in systems having several low cooling or heating loads demands at different times. Boilers operating at low loads will short cycle, resulting in reduced operating efficiency and shorter equipment life. When piped correctly, the ThermoCon will serve as both a thermal buffer and a hydraulic separator. The solar, boiler or chiller system will be hydraulically separated from the distribution system.

Meets and exceeds CSA C309 requirements

Product range

Code NAS20050 Storage tank .... 50 gallon
Code NAS20080 Storage tank .... 80 gallon
Code NAS20120 Storage tank .... 120 gallon

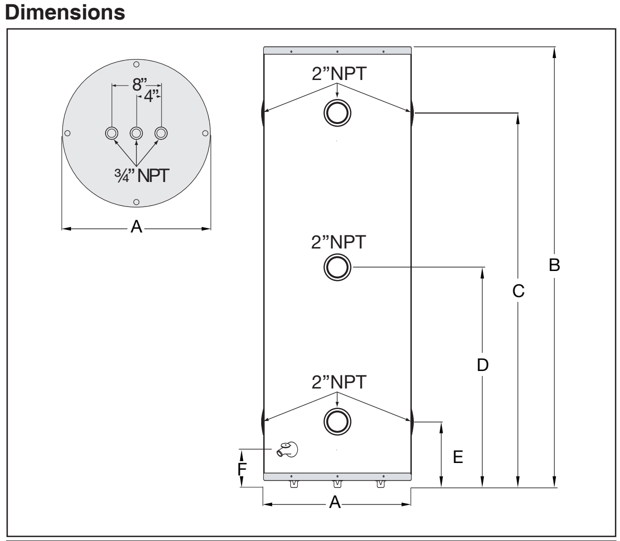
Technical specifications

Tank materials:	porcelain coated steel
Tank insulation:	2" non-CFC foam
Tank external cover:	powder-coated steel (20-24 ga.)
Insulation thermal conductivity:	R16
Connections:	top (3) 3/4" NPT female side (7) 2" NPT female
Maximum working pressure:	150 psi
Testing pressure:	300 psi
Maximum tank temperature:	180°F
Recommended maximum delivery hot water temperature:	120°F

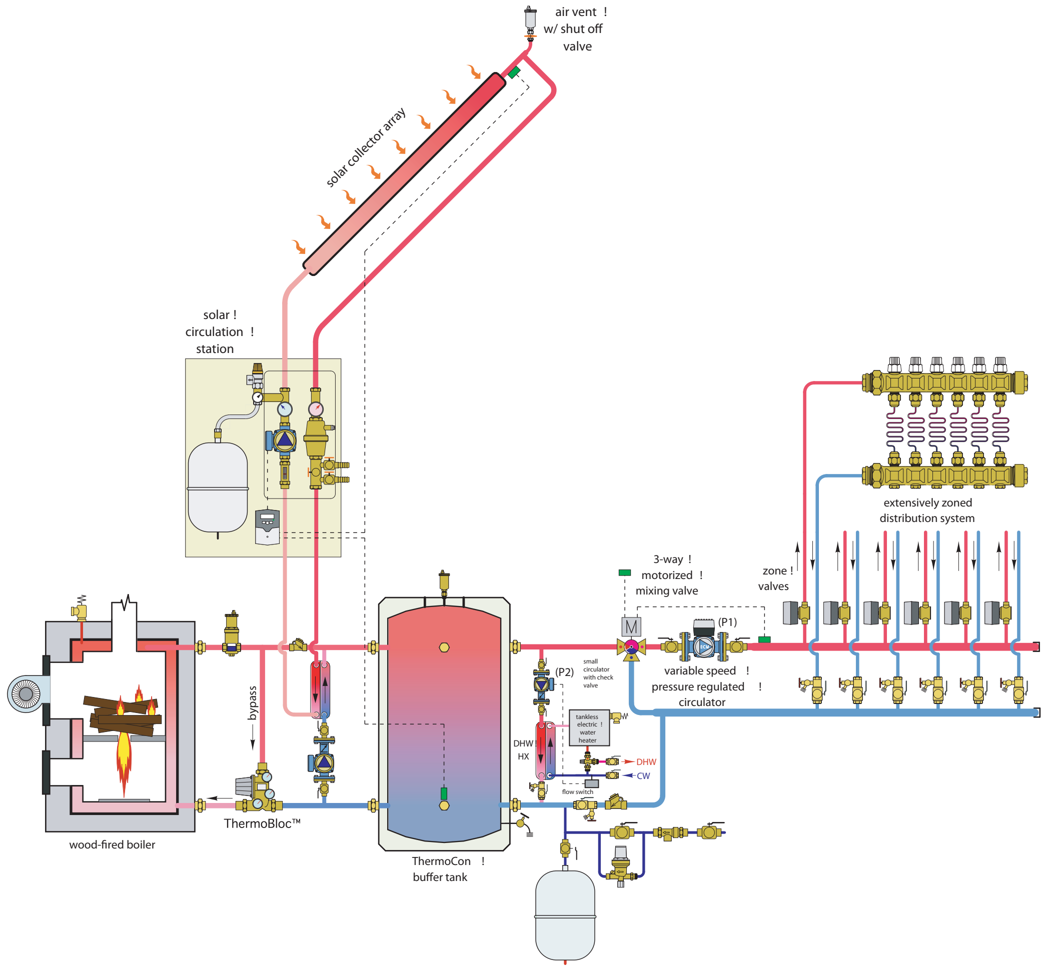
Construction details

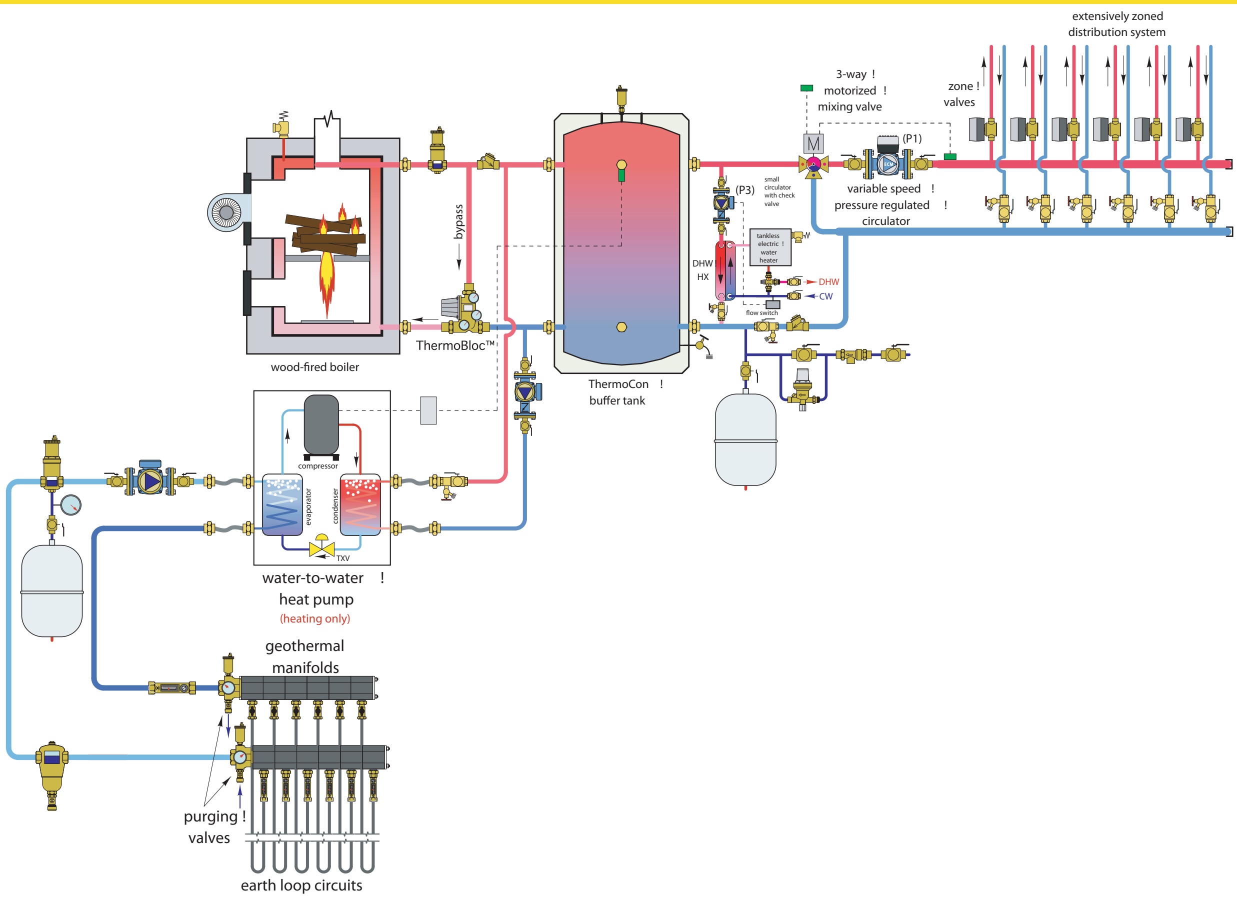
The ThermoCon tanks are engineered with seven (7) 2" NPT connections. Two connections can be piped to the solar, boiler or chiller side and two connections can be piped to the distribution system. Two additional connection are 90 degree from another which allows for positioning tank into a corner with the piping at a right angle. The tank has one 2" NPT connection for connecting an external heat exchange in the middle of the tank.

Dimensions



Model	A	B	C	D	E	F
NAS20050	22"	48¼"	39½"	23½"	7¾"	4½"
NAS20080	24"	64"	53"	32"	11"	5"
NAS20120	28"	65"	53"	32"	11"	7"


air vent
w/ shut off
valve
solar collector array
solar
circulation
station
extensively zoned
distribution system
3-way
motorized
mixing valve
zone
valves
(P1)
(P2)
small
circulator
with check
valve
variable speed
pressure regulated
circulator
tankless
electric
water
heater
DHW
HX
DHW
CW
flow switch
bypass
wood-fired boiler
ThermoBloc™
ThermoCon
buffer tank


extensively zoned
distribution system
3-way
motorized
mixing valve
zone
valves
(P1)
(P3)
small
circulator
with check
valve
variable speed
pressure regulated
circulator
tankless
electric
water
heater
DHW
HX
DHW
CW
flow switch
bypass
wood-fired boiler
ThermoBloc™
ThermoCon
buffer tank
compressor
evaporator
condenser
TXV
water-to-water
heat pump
(heating only)
geothermal
manifolds
purging
valves
earth loop circuits