



The Heating Helper

Burnham®
by U.S. Boiler Company

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Simple Steps to the Best Boiler Installation...Ever!

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Keeping up with the Technology

The technology of the heating equipment we are using today is changing daily and so are the requirements of how these boilers need to be installed. All boilers have always needed certain standards in order to operate with maximum efficiency and longevity. These standards involve correct sizing, correct flow and correct temperature differentials. In order to reap the benefits of higher efficiency, correct sizing of boilers is of utmost importance today. Proper circulator selection on hot water boilers is also more critical than ever in order to maintain proper temperature differentials through the boiler. Failure to adhere to these standards in the past probably would have resulted in excessive short cycling or at the very worst, possible premature failure of the boiler heat exchanger due to temperature differential extremes. Today's high efficiency boilers have advanced technologies involving burner modulation and electronic methods of monitoring the boiler supply and return temperatures as well as exiting flue gas temperatures. If the supply to return temperature differences become too great or too small or if the flue gas temperatures become excessively high, the burner may shut down to protect the boiler heat exchanger. This technology is necessary to provide for maximum efficiency and increased longevity of the boiler.

This report will focus on several of the most important points necessary to adhere to in order to achieve the most successful installation. What is a successful boiler installation you may ask? By successful I mean that you will not have to deal with common system problems that many installers encounter such as short cycling, captive air problems, flue gas condensation issues, improper byproducts of combustion and possible short term failure of the boiler due to any or all of these issues. The principles you will learn today will serve to provide you with the ability to make each and every one of your boiler installations the very best one possible. Installations that operate flawlessly, efficiently, comfortably and safely for decades to come are what we should all be striving for in our trade.

Proper Boiler Sizing - The Most Important Step

It is a well-known fact that there are an over abundance of boilers out there that are somewhat grossly oversized for their respective application. This is due in general to the methods used by the previous installers in sizing these boilers. When it comes to proper sizing of hot water and steam boilers there are numerous wrong ways but only two correct methods of sizing.

Hot Water Boilers...Size them by the building heat loss!

The majority of older homes that have hot water boilers have been upgraded over the years with wall and ceiling insulation, more energy efficient windows and doors and an overall “buttoning up” of the loose construction of yesteryear. If the original boiler was sized based on a heat loss of the structure, which I doubt it was, then that would have been based on the older construction guidelines. As previously stated those guidelines, for the most part, have changed and therefore the present day heat loss will be much different than the original. We have included a simple Short Form Heat Loss Method in Chapter 7 of the Heating Helper along with an example of how to use it.

Indirect Hot Water Needs...Do I add more capacity to prioritize?

When upgrading from a conventional type water heater to an Indirect Water Heater, it would nearly always make sense to take into effect the larger of the two heating needs, space heating or indirect heater capacity and then size the boiler based on the larger of the two. Most indirect heaters, depending on their usage and how they were sized, will only require approximately 15 to 20 minutes of boiler run time to fulfill their recovery needs and this generally only happens a couple of times a day. With this in mind, prioritizing the indirect needs for those brief periods of time will not really have any adverse effects on the ability to maintain proper comfort levels of space heating. The end result will significantly lower operating costs. Many of today’s boilers are or can be equipped with priority controls to accomplish this and most are also equipped with a priority override function if the recovery time of the indirect should become prolonged for some reason.

Sizing for Tankless Heaters...Consider adding some storage

When sizing boilers for heating and domestic hot water production by means of an immersion type tankless heater, one must bear in mind that you cannot cheat the laws of physics. In order to raise the temperature of a gallon of water flowing through a tankless coil from 40°F to 140°F, you will require 50,000 btuh of boiler capacity. Therefore to be able to produce 3 gpm or 5 gpm of hot water through this coil the boiler capacity will need to be 150,000 btuh or 250,000 btuh respectively. Unfortunately there are an abundance of oversized boilers out there wasting valuable energy dollars just sitting there waiting to produce "on demand" domestic hot water with no provision for storage. A much better alternative would be to add an aqua booster or storage tank and controls to maintain a volume of hot water to fulfill those larger needs without the need for a larger tankless coil and boiler. The end result, once again, will be substantial fuel savings due to less short burner cycles in the long run.

Steam Boilers...Size it by connected load

The function of a steam boiler is to create steam vapor which in essence is water that has turned to a super heated gaseous state. When enough latent energy, in the form of heat, has been applied to water it changes it’s state from liquid to a vapor state. The steam vapor in turn gives up its latent energy to the radiators and other heat emitting devices connected to the boiler piping by means of conduction. These in turn transfer their heat to the surrounding air and objects by means of convection and radiant principles. You only need to size the boiler based on the capacity of steam vapor needed to fill all of the connected radiation and related piping. Therefore it is absolutely imperative that you check each and every radiator or heat-emitting device to establish its capacity of steam in Square Feet of Radiation or Equivalent Direct Radiation (EDR). There are a number of tables in Chapter 5 of this publication to help you in accomplishing this. You do, of course, have to take into effect that there will be some steam required to fill the connecting pipes and that there will be standby losses related to that piping, but these factors have already been built into the Net IBR boiler steam ratings to the capacity of 33%. This means that unless there is a larger than normal amount of piping, pipes that run through colder than normal spaces or pipes with no insulation, you will not need to add any additional capacity for pipe losses. Again the end result will be substantial fuel savings without constant short cycling of the boiler.

Boiler Application...The right boiler for the right application

Unlike the old days, there are now numerous types of boilers available for various types of job applications today. These range from natural vent types using an existing chimney to power vent and direct vent type boilers utilizing stainless steel or other types of proprietary venting material and terminating through the sidewall or roof of the building. In addition to fuel and vent type differences, there are also high efficiency boilers available today that have capabilities of modulating input based on system demand and condensing the flue gasses. With all of these choices available today, it can be a difficult task to decide which may be the best type for any given installation.

Normally the factors that govern hot water boiler selection are space concerns, chimney issues and combustion air issues and available fuel type. If a building has an exterior chimney or unlined chimney then more consideration should be placed on either upgrading the chimney with a properly configured liner or replacing the boiler with a boiler with built-in power vent or direct vent capabilities. If the building has both chimney and insufficient combustion air issues, then more and more consideration is now being given to direct vent or sealed combustion type boilers.

With direct vent boilers there are additional choices that have to be made as to proper boiler application. These involve where the vent and intake terminals can terminate, vent pipe lengths and whether to utilize the two-pipe vent/intake method or to install concentric venting. Above and beyond this yet lies the choice of conventional Energy Star rated boilers or very high efficiency modulating/condensing type boilers. Although the preference for high efficiency equipment usually lies with consumer choice and available budgets, there should also be some consideration given to the actual application for these boilers.

Modulation/Condensing Boilers...Are they for every job?

The high efficiency modulating/condensing boilers available today can provide for up to three benefits. The first is the ability to modulate the boiler input based on the load or actual demand at any given time. Second comes the benefit of being able to cool the flue gasses down enough to extract all or most of their latent energy to form condensate and third lies with the ability to provide for greater building system efficiency by taking advantage of integrated outdoor reset functions. The problem lies with the fact that not all systems may be able to operate with system water temperatures low enough to appreciate the benefits of condensing mode and outdoor reset. Systems such as hydro air and some hydronic baseboard applications will more than likely need system water temperatures in excess of 140°F most of the time, so they will seldom take advantage of the condensing or outdoor reset capabilities the boiler offers. Sure, the modulation aspect of the boiler will still be functional but that is just a part of the whole picture.

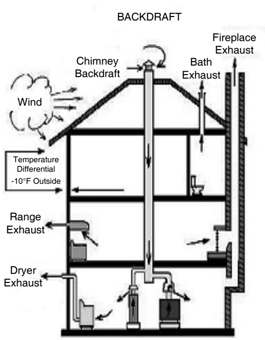
Hydronic baseboard applications with greater than normal amounts of radiation and cast iron radiator based systems do have the ability to operate at greatly reduced temperatures ranging from 120°F to 140°F and therefore will work well with these types of boilers and take advantage of some of the energy saving aspects of condensing and outdoor reset modes. Usually, only systems with very low operating temperatures such as radiant heating or large mass cast iron radiator systems will take full advantage of all these boilers have to offer in respect to fuel savings and efficiency. All in all, condensing/modulating boilers will perform efficiently in most of today's hot water baseboard applications provided there is enough installed radiation to be able to operate at greatly reduced system water temperatures. Adding additional element or radiation can help accomplish this but available wall space limitations can prohibit this. Many installers are utilizing high capacity baseboard and element in their installations to help allow for these boilers to operate at lower temperatures. This gives them the ability to maintain an acceptable lineal footage of element aspect while getting the proper output with lower water temperatures.

Another huge benefit of modulating/condensing boilers is that they will always try and operate with the longest burn cycle and lowest input. This accounts for the greatest fuel efficiency….always. The same applies for their functionality when operating to satisfy the needs of an indirect water heater. They will modulate their input to meet the demand of the indirect and always try to operate with a continuous burn cycle without shutting off on limit until the indirect demand is satisfied. A conventional type boiler will usually always cycle on and off on limit while running for an indirect heater demand. This means that once the burner shuts off on limit that it will have to cool back down through a differential range before firing again. This range usually results in a temperature fluctuation of approximately 15°F to 20°F. This differential or cool down period results in decreased recovery. Modulating boilers will maintain a continuous burn cycle with the smallest flame to maintain a constant set point and the result will be a much quicker recovery period for the indirect. This is a benefit of these boilers that most in this business don't even know exists.

Combustion Air...Just what is a Confined Space anyway?

All boiler manufacturers make reference to confined spaces when referencing where a boiler can be placed and available air for combustion. When considering the term "confined space", most installers would envision a closet or alcove installation or possibly a finished basement where a very small closet like space was left for the mechanical equipment. In reality a confined space doesn't have to be confined at all to be unable to contain sufficient air for proper heating equipment combustion.

When considering a boiler replacement, one has to realize that the house or building that they are working in may be quite old. Not so many years ago these buildings were not nearly as tight in construction as they are today since in most cases, insulation and energy efficient windows and doors have been added.



There is now only a fraction of infiltration air coming into this building as compared to years ago and that the new boiler and other appliances are much more efficient and much more dependant upon proper air to fuel mixtures for efficient combustion. Add to this the fact that the building now has additional devices that can depressurize it or take air out such as exhaust and ventilation fans, fireplaces and clothes dryers and you may begin to appreciate why the confined space consideration is so important. Here are the guidelines and an example of how to figure for a confined space based on average type construction such as 2"x4" insulated sidewalls, attic insulation and insulated windows.

Example

Confined Space = Ratio of Cubic Feet of Area to Total BTUH Input in 1000's of BTUH (MBH)
Less than (<) 50 Cubic Feet per 1000 btuh is considered Confined Space
Example:
35' x 24' x 7' High Basement = 5880 Cubic Feet
130,000 btuh Boiler and 40,000 btuh Water Heater = 130 MBH + 40 MBH or 170 MBH Total Input
5880 Cubic Feet / 170 MBH Input = 35 Cubic Feet per 1000 btuh

The previous example very easily demonstrates the fact that the area where heating equipment is installed does not necessarily have to be physically small when taking into consideration available air for combustion. Methods of obtaining adequate combustion air may involve ducts from an outdoor area, mechanical makeup air devices or boilers and other devices with direct vent capabilities or burner equipped combustion air boot connections. Whatever the method may be, it will need to be taken into consideration before the installation progresses in order to be able to cover the cost of related labor and materials.

Chimney and Venting Concerns

There are literally countless chimneys in older buildings and homes that are either very large, unlined or both. Today's higher efficiency boilers extract more heat from the flue gasses flowing through them than ever before. The byproducts of combustion that have to be carried by these chimneys contain water vapor and over a period of time this vapor will be detrimental to the longevity of the chimney.

Even newer chimneys with a properly configured and installed liner but situated on the outside of the building or house can be harmed by flue gas condensation. Extreme caution should be exercised when attempting to use chimneys such as these. It would advisable to install an insulated metal liner in these types of chimneys to protect them against condensation damage and to allow the boiler and other attached appliances to perform properly.

Chimneys...Bigger is not necessarily better!

Caution should also be exercised when using larger internal lined chimneys with new boilers and other appliances. Bigger is not necessarily better when considering a chimney's venting capabilities. You need to remember that a new boiler's flue gas temperatures are lower than ever before and may not be able to establish the draft you need in one of these larger chimneys. Even if they can establish proper draft the concern still exists of the effect that flue gas condensation will have on life of the chimney. Be sure to abide by the venting regulations adopted and enforced by your state or locality regarding proper venting practices.

Most, if not all, higher efficiency gas boilers these days are vented by built-in induced draft fans and utilize AL29-4C stainless steel, Polypropylene Concentric or even PVC/CPVC venting materials. Most of these boilers allow for venting distances of up to 50 equivalent feet of venting and have a multitude of venting options such as sidewall, vertical and concentric venting. Bear in mind that the venting options and materials listed in the Installation Manual for one manufacturer's boiler are proprietary to that particular boiler and may not apply to a different model or brand of boiler. Read the Installation Manual carefully and abide by the information provided in that manual to ensure that the boiler operates correctly and safely. If you don't see a particular venting option listed in that boiler's manual then more than likely it has not been tested or certified and you cannot use it.

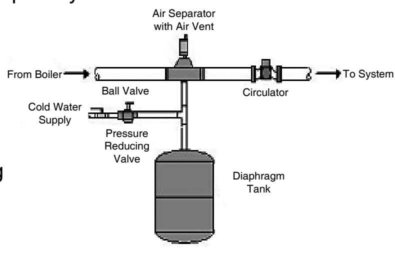
Aftermarket sidewall power venting equipment and related controls have been commonly used when a chimney is not an option. Be cautious of using them with the boiler and other equipment you are installing in that they will more than likely involve cutting into the boiler's factory wiring harness. If the person performing this wiring procedure is unfamiliar with the internal wiring of the boiler and controls, this can develop into a severe safety concern. Even if the power venter control wiring is done correctly there is also a concern as to whether the venter's internal damper is adjusted properly to maintain proper draft over fire and that the byproducts of combustion are correct for optimum efficiency. Burnham manufactures several gas-fired and oil-fired boilers with built in induced draft capabilities for jobs where power venting and direct venting is necessary. The boiler's venting applications have been tested and certified for proper operation and safety where aftermarket power venter applications have not.

Proper Circulator Placement..."Pumping Away"

The term "pumping away" in regards to circulator placement in a hot water heating system has been around for many years now, but there is still some confusion as to what it means. It is a known fact of physics that any liquid or gas in a piping system will always move from a point of higher pressure to a point of lesser pressure. Any heating system circulator, large or small, will create this mechanical pressure differential while it is operating. The bigger the circulator, the greater the pressure differential. When a circulator operates, the impeller will add a small amount of pressure at the discharge side of the veins but in turn will try and reduce the pressure by an almost identical amount at the inlet side or impeller eye, thus creating the mechanical pressure differential. If you have a system maintaining a static fill pressure of 12 psi when the circulator is not running, that pressure will remain somewhat constant throughout the system. Turn the circulator on and it may add 4 psi of discharge pressure to the outlet side for a total discharge pressure of 16 psi to begin moving the water through the system where it encounters friction losses on its way back to the boiler. Depending on the location of the expansion tank in the system, when water returns through the system back to the inlet side of the circulator, the pressure may be reduced below the static fill pressure of 12 psi by the system pressure drop and the fact that the circulator is trying to reduce the pressure at its suction side by an equal amount of 4 psi. This may result in the pressure being reduced to approximately 8 psi at the suction side of the circulator. Based on the gpm requirement of the system and the developed length of the longest circuit, you probably now have a pump capable of overcoming the system pipe and fitting friction losses and you may have proper flow through the system. But the question is…how well will it do its job based on its placement in the system?

"Pumping Away"...but from what?

The question still at hand is where to place the circulator in the system so it reaches its maximum effectiveness. This is where the term “pumping away” sometimes gets misconstrued. Many believe that the term “pumping away” means to pump away from the boiler and therefore they end up mounting the circulator directly off the top of the boiler on the supply pipe. While this may seem to be somewhat correct, in reality it is wrong. The real meaning of the term “pumping away” means pumping away from the system expansion or compression tank. The reason for this has to do with the functions that the circulator and expansion tank serve. The function of the circulator is to create a pressure differential and the function of the expansion tank is to regulate the system pressure as close to static fill as possible. If the tank encounters a drop in pressure it will try and fill that pressure void and if it encounters a pressure increase due to mechanical means or thermal expansion, it will try and absorb it. When a circulator is mounted on the boiler supply but is situated before the expansion tank, nearly all of the extra discharge pressure that the circulator is capable of developing will be absorbed by the expansion tank resulting in static fill pressure or less being exerted through the system piping. The water will still move through the system but there will be relatively low system return side pressures and more than likely, captive air and noise will be encountered in the farthest circuits of the system. When the circulator is mounted on the system supply directly after (as close as possible) the expansion tank you will now be exerting the extra pressure it is developing where it is needed most or to the system supply piping. Now it will more effectively move the water and keep high enough pressures in the remote portions of piping to prevent air from accumulating or coming out of solvency. The lesser pressure that pump is developing on its suction side will be in contact with the expansion tank. The action now will be that the expansion tank diaphragm will move into place to fill that pressure void causing an increase to static fill pressure at the suction side of the pump.



Air Removal System

The end result will be a well working, quiet and captive air free system with no consumer complaints or callbacks. In final review, the term “pumping away” means pumping away from the expansion or compression tank.

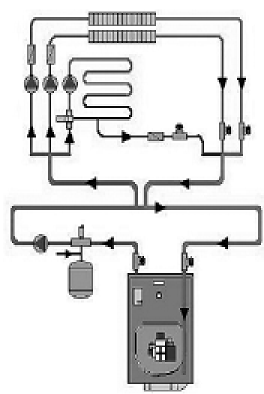
Pressure Reducing Valve Placement...Point of no pressure change

I would be lax at this point if I failed to mention the proper placement of the system pressure-reducing valve. As I described in the previous paragraphs, the function of the expansion tank is to try and keep the system pressure as close to static fill pressure as possible. The job of the pressure reducing valve is to reduce the incoming building water pressure to the desired static fill pressure of the boiler and heating system. Most are preset to a static fill pressure of 12-15 psi as are the precharge sides of the expansion tanks. Whatever static fill pressure happens to be is what the air charge in the expansion tank should be. Interestingly enough, if you could shrink yourself down and get into the system piping, you would find that there is only one place in that whole system where the pressure never changes when things are beginning to run or are already running. That one place happens to be at the point where the expansion tank is attached to the system piping which usually is some sort of an air removal device such as an air scoop. Bear in mind now that if you connect the pressure reducing valve at nearly any point in the system, except one, it will encounter either an increase or decrease in pressure. If it happens to be the latter it will introduce more water pressure to fill that void resulting in a somewhat higher static fill pressure than desired that you will never get rid of due to an internal check valve inside the valve. That one place you should mount the pressure reducing valve happens to be between the expansion tank and whatever it is connected to because that is the only place where the pressure really never changes. The end result will be properly regulated system pressure, little if no phantom pressure rise and increased fuel savings.

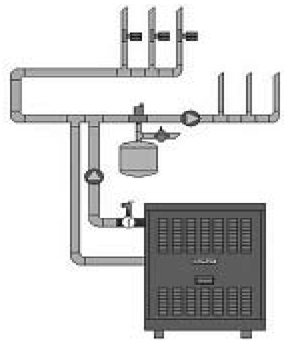
Near Boiler Piping...Remember what boilers need!

There are endless types of various system piping methods employing circulators, zone valves, mixing valves and other system devices. In addition to this there are several controls, both aftermarket and proprietary, to establish better system efficiency levels via outdoor reset technology. When installing a conventional cast iron hot water boiler, however, one must keep in mind two basic things that are important to boilers like this…return water temperatures above 140°F and consistent flow through the boiler. Conventional parallel piping of a multizone hot water heating system may not maintain either of these two parameters. Fractional amounts of system flow through the boiler when only one or more small zones are operating can result in extreme short cycling based on how the boiler was sized. Return water cooler than 140°F for prolonged periods of time can cause flue gas condensation within the flue passageways of the boiler.

There are certainly methods of system piping such as venturi or Mono-flo tee or reverse return systems that will help ensure that consistent flow rates and warmer return water prevail, but they are seldom used due to increased material and labor costs. There are various methods of near boiler piping that can be employed to help safeguard against these issues. The simplest of these is bypass piping. While it helps in dealing with possible cool return water, it does little in controlling consistent flow through the boiler unless it happens to be a system bypass. Another method that can be much more effective in dealing with this is boiler loop piping. This method incorporates a full size main that connects the boiler supply directly to the boiler return via a loop. A pair of tees with spacing less than 5 pipe diameters connects the system piping and related circulator(s) to the boiler loop. This method of piping will blend hot boiler supply water with the cooler return water keeping the boiler return water warm nearly all of the time while always maintaining a consistent flow rate through the boiler.



There are many other methods such as primary secondary piping, variable speed injection and motorized mixing and blending valves that can accomplish this as well. Whatever method you elect to use, keep in mind what you are trying to accomplish by doing so. It is not needed in all hot water boiler applications, but is becoming more and more commonplace these days.



High Efficiency Boiler Piping... Do it by the book!

When installing a new high efficiency modulating/condensing boiler, it is extremely important that you pay close attention to the recommended near boiler piping methods spelled out in the Installation Manual provided with the boiler. In most cases this method will involve primary secondary piping of the boiler into a system loop main. As discussed earlier, these boilers have “state of the art” electronic control systems that monitor Supply, Return, Flue Gas and Outdoor temperatures every second of operating time. It is imperative that you comply with the recommended near boiler piping methods when installing these boilers. Failure to do so could hinder the proper operation of the boiler and most surely will result in what every installer fears most…. nuisance callbacks! Be sure to read the boiler’s Installation Manual thoroughly before proceeding with the installation.

Conclusion

Installation callbacks to correct system issues that could have been avoided in some way are both unexpected and costly at times and they are something that we would all prefer to avoid dealing with. The focus of this report has been to bring to light many of these unexpected issues and to provide you with the knowledge necessary to both identify and avoid them. We have no control over whether you will choose to employ the methods you learned today since that choice is entire up to you.
We feel very confident that if you utilize the things you learned from this publication, that each of your installations will be better than the last and will operate flawlessly, efficiently, comfortably and safely for decades to come. Thank you for taking the time to learn something new today and we hope you strive to keep on learning because technology keeps on changing…every single day!

ONE AND TWO PIPE SYSTEMS - MAINS AND RISERS

The steam system piping recommendations that follow are designed to help guide an individual working on existing systems; systems that may require alterations or additions for a variety of reasons. These recommendations are conservative but in light of many unknown variables, they will serve one well.

TWO PIPE STEAM

1. STEAM MAIN Capacity in Sq. Ft. E.D.R.

Size of Pipe (inches)	Distance of Main		
	100'	200'	300'
2	650	461	375
2-1/2	1,030	731	595
3	1,860	1,320	1,075
4	3,800	2,698	2,196
6	11,250	7,987	6,502
8	22,250	15,797	12,860
10	40,800	28,968	23,582
12	66,000	46,860	38,148

Note: Mains must be pitched for steam & condensate to flow in same direction.

2. STEAM RISERS
Maximum Capacity (Sq. Ft. E.D.R.) at Various Riser Pitch With Steam and Condensate Flowing in Opposite Direction.

Size of Pipe (inches)	Pitch of Pipe per 10' Length				
	1"	2"	3"	4"	5"
3/4	22.8	28.4	33.2	38.6	42.0
1	46.8	59.2	69.2	76.8	82.0
1-1/4	79.6	108.0	125.2	133.6	152.4
1-1/2	132.0	168.0	187.2	203.2	236.8
2	275.2	371.6	398.4	409.6	460.0

Note: above E.D.R. is maximum.
Greater load will cause problems with increased steam velocities.

3. CONDENSATE RETURN MAINS (Horizontal, Pitched)

Capacity based on Sq. Ft. E.D.R. (2 oz. PD per 100")		
Pipe Size (inches)	Dry Return	Wet Return
1	370	900
1-1/4	780	1.530
1-1/2	1,220	2,430
2	2,660	5,040
2-1/2	4,420	8,460
3	8,100	13,500
4	17,380	27,900

4. CONDENSATE RETURN RISERS (Vertical, Horizontal Pitch)

Capacity based on Sq. Ft. E.D.R. (2 oz. PD per 100")	
Pipe Size (inches)	**Dry Return**
3/4	170
1	410
1-1/4	890
1-1/2	1,350

ONE PIPE STEAM

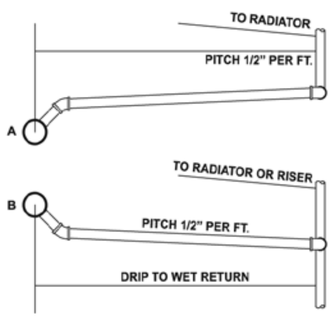
1. STEAM MAIN

Capacity based on Sq. Ft. E.D.R. (2 oz. PD per 100")		
Pipe Size (inches)	**T.E.L. 100"**	**T.E.L. 200"**
2	350	235
2-1/2	580	385
3	1,050	700
4	2,210	1,480
6	6,880	4,480

NOTES: Mains must be pitched for steam & condensate to flow in same direction. If steam and condensate counterflows, increase piping one size.

2. STEAM RISER

Capacity in Sq. Ft. (E.D.R.) (Up-feed Riser - Horizontal Travel 8' Max. - Riser not Dripped)	
Pipe Size (inches)	**Sq. Ft. E.D.R.**



NOTES:
(A) Horizontal travel beyond 10' increase one size
(B) Horizontal travel sloped down and dripped decrease one size

3. DRY RETURN - Capacity in Sq. Ft. (E.D.R.)

Pipe Size (inches)	Sq. Ft. E.D.R.
1-1/4	640
1-1/2	1,000
2	2,180

4. WET RETURN - Capacity in Sq. Ft. (E.D.R.)

Pipe Size (inches)	Sq. Ft. E.D.R.
1-1/4	1,100
1-1/2	1,700
2	3,600

NUMBER OF SMALLER PIPES EQUIVALENT TO ONE LARGER PIPE

PIPE SIZE	PIPE SIZE (in inches)											
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
1/2	1	2.27	4.88	10	15.8	31.7	52.9	96.9	140	205	377	620
3/4		1	2.05	4.3	6.97	14	23.2	42.5	65	90	166	273
1			1	2.25	3.45	6.82	11.4	20.9	30	44	81	133
1-1/4				1	1.5	3.1	5.25	9.1	12	19	37	68
1-1/2					1	2	3.34	6.13	9	13	23	39
2						1	1.67	3.06	4.5	6.5	11.9	19.6
2-1/2							1	1.82	2.7	3.87	7.12	11.7
3								1	1.5	2.12	3.89	6.39
3-1/2									1	1.25	2.5	4.25
4										1	1.84	3.02
5											1	1.65
6												1

STEAM VELOCITIES IN STEAM PIPING

To obtain steam velocity in feet per second, multiply load by proper factor shown below.

Inital Pressure of Dry Steam		PIPE SIZE (inches)											
		1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8	10	12
Sq. Ft. EDR Factor	5 PSI Gauge			.1000	.0610	.0425	.0276	.0160	.0101	.0071	.0041	.0026	.00182
	2 PSI Gauge	.2750	.1580	.1170	.0700	.0490	.0320	.0186	.0118	.0082	.0047	.0030	.0021
	0 PSI Gauge	.3094	.1778	.1316	.0788	.0551	.0360	.0209	.0133	.0093	.0054	.0034	.0024

FRICTION LOSSES-FLOW OF STEAM THROUGH PIPES

Based on: dry steam at 2PSI guage inital
Pressure: schedule 40 steel pipe
Loads: are in sq. ft. EDR

Friction losses: are in ounces per 100 linear feet of pipe, or the equivalent
For capacities in lbs. per hour: divide sq. ft. EDR by 4

LOAD Sq. Ft. EDR	PRESSURE LOSS OUNCES - per 100 FEET of STEEL PIPE							
	PIPE SIZE (inches)							
	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
30	0.80							
35	1.05							
40	1.31							
45	1.62							
50	1.95	.60						
75	4.01	1.21						
100	6.7	2.05	.54					
125	10.2	3.07	.80					
150	14.3	4.27	1.12	.54				
175	18.9	5.7	1.48	.70				
200	24.3	7.2	1.88	.89				
225		9.0	2.33	1.11				
250		10.9	2.83	1.33				
275		13.2	3.35	1.59				
300		15.4	3.92	1.86				
350		20.6	5.2	2.47				
400		26.5	6.7	3.15	.92			
450			8.3	3.90	1.14			
500			10.0	4.75	1.38			
550			12.0	5.6	1.64			
600			14.1	6.6	1.91			
650			16.4	7.7	2.22			
700			19.0	8.8	2.55	1.06		
800			24.4	11.4	3.27	1.35		
900				14.1	4.05	1.68		
1000				17.2	4.93	2.04		
1100				20.6	5.9	2.43		
1200				24.3	6.9	2.85		
1300				28.3	8.1	3.32	1.14	
1400					9.3	3.81	1.30	
1500					10.6	4.31	1.48	
1600					11.9	4.89	1.66	
1700					13.4	5.5	1.86	
1800					14.9	6.1	2.07	
1900					16.6	6.8	2.28	
2000					18.2	7.5	2.51	
2200					21.8	8.9	3.00	
2400					25.8	10.6	3.53	
2600						12.3	4.08	1.08
2800						14.1	4.73	1.24
3000						16.1	5.4	1.40
3200						18.2	6.1	1.58
3500						21.6	7.2	1.86
4000						27.9	9.2	2.41
4500							11.5	2.98
5000							14.1	3.62
5500							16.9	4.34
6000							20.0	5.1
6500							23.3	6.0
7000							26.8	6.9
7500								7.8
8000								8.8
8500								9.9
9000								11.0
10,000								13.6

PROPERTIES OF SATURATED STEAM

PRESSURE psig	TEMP. °F	HEAT in BTU / lb. SENSIBLE	LATENT	TOTAL	SPECIFIC VOLUME Cu. Ft. per lb.
Inches Vac. 25	134	102	1017	1119	142
20	162	129	1001	1130	73.9
15	179	147	990	1137	51.3
10	192	160	982	1142	39.4
5	203	171	976	1147	31.8
0	212	180	970	1150	26.8
1	215	183	968	1151	25.2
2	219	187	966	1153	23.5
3	222	190	964	1154	22.3
4	224	192	962	1154	21.4
5	227	195	960	1155	20.1
6	230	198	959	1157	19.4
7	232	200	957	1157	18.7
8	233	201	956	1157	18.4
9	237	205	954	1159	17.1
10	239	207	953	1160	16.5
12	244	212	949	1161	15.3
14	248	216	947	1163	14.3
16	252	220	944	1164	13.4
18	256	224	941	1165	12.6
20	259	227	939	1166	11.9
22	262	230	937	1167	11.3
24	265	233	934	1167	10.8
26	268	236	933	1169	10.3
28	271	239	930	1169	9.85
30	274	243	929	1172	9.46
32	277	246	927	1173	9.10
34	279	248	925	1173	8.75
36	282	251	923	1174	8.42
38	284	253	922	1175	8.08
40	286	256	920	1176	7.82
42	289	258	918	1176	7.57
44	291	260	917	1177	7.31
46	293	262	915	1177	7.14
48	295	264	914	1178	6.94
50	298	267	912	1179	6.68
55	300	271	909	1180	6.27
60	307	277	906	1183	5.84
65	312	282	901	1183	5.49
70	316	286	898	1184	5.18
75	320	290	895	1185	4.91
80	324	294	891	1185	4.67
85	328	298	889	1187	4.44
90	331	302	886	1188	4.24
95	335	305	883	1188	4.05
100	338	309	880	1189	3.89
105	341	312	878	1190	3.74
110	344	316	875	1191	3.59
115	347	319	873	1192	3.46
120	350	322	871	1193	3.34
125	353	325	868	1193	3.23

RELATIONS OF ALTITUDE, PRESSURE & BOILING POINT

Altitude (feet)	Atmospheric Pressure Absolute		BOILING POINT of WATER °F (Gauge Pressure PSI)				
	Inches of Mercury (Barometer)	Lbs. per Sq. In.	0	1	5	10	15
-500	30.46	14.96	212.8	216.1	227.7	239.9	250.2
-100	30.01	14.74	212.3	215.5	227.2	239.4	249.9
Sea Level	29.90	14.69	212.0	215.3	227.0	239.3	249.7
500	29.35	14.42	211.0	214.4	226.3	238.7	249.2
1000	28.82	14.16	210.1	213.5	225.5	238.1	248.6
1500	28.30	13.90	209.4	212.7	225.0	237.6	248.2
2000	27.78	13.65	208.2	211.7	224.1	236.8	247.7
2500	27.27	13.40	207.3	210.9	223.4	236.3	247.2
3000	26.77	13.15	206.4	210.1	222.7	235.7	246.7
3500	26.29	12.91	205.5	209.2	222.1	235.1	246.2
4000	25.81	12.68	204.7	208.4	221.4	234.6	245.7
4500	25.34	12.45	203.7	207.5	220.7	234.0	245.2
5000	24.88	12.22	202.7	206.8	220.1	233.4	244.7
6000	23.98	11.78	200.9	205.0	218.7	232.4	243.8
7000	23.11	11.35	199.1	203.3	217.3	231.3	242.9
8000	22.28	10.94	197.4	201.6	216.1	230.3	242.0
9000	21.47	10.55	195.7	200.0	214.8	229.3	241.3
10,000	20.70	10.17	194.0	198.4	213.5	228.3	240.4
11,000	19.95	9.80	192.2	196.8	212.3	227.3	239.6
12,000	19.23	9.45	190.6	195.2	211.1	226.3	238.7
13,000	18.53	9.10	188.7	193.6	209.9	225.4	237.9
14,000	17.86	8.77	187.2	192.3	208.8	224.5	237.2
15,000	17.22	8.46	185.4	190.6	207.6	223.6	236.4

EXPANSION OF PIPES IN INCHES PER 100 FT

TEMP. °F	CAST IRON	WROUGHT IRON	STEEL	BRASS or COPPER
0	0.00	0.00	0.00	0.00
50	0.36	0.40	0.38	0.57
100	0.72	0.79	0.76	1.14
125	0.88	0.97	0.92	1.40
150	1.10	1.21	1.15	1.75
175	1.28	1.41	1.34	2.04
200	1.50	1.65	1.57	2.38
225	1.70	1.87	1.78	2.70
250	1.90	2.09	1.99	3.02
275	2.15	2.36	2.26	3.42
300	2.35	2.58	2.47	3.74
325	2.60	2.86	2.73	4.13
350	2.80	3.08	2.94	4.45

CHAPTER 1 - STEAM

STEAM SUSPENDED UNIT HEATERS/UNIT VENTILATORS

Output is normally based on 2PSI steam/60° entering air.
Output will increase or decrease with changes in steam pressure and/or entering air.

Factors			For Conversion of Basic Steam Ratings at 2 lbs. gal./60° entering air to various conditions of steam pressure and air temperature											
lbs. per Sq. In.	Temp °F	1. Heat BTU/lb.	Entering Air Temperature °F											
			-10	0	10	20	30	40	50	60	70	80	90	100
0	212.0	970.2					1.19	1.11	1.03	.96	.88	.81	.74	.67
2	218.5	966.2				1.32	1.24	1.16	1.08	1.00	.93	.85	.78	.71
5	227.2	960.5	1.64	1.55	1.46	1.37	1.29	1.21	1.13	1.05	.97	.90	.83	.76
10	239.4	952.5	1.73	1.64	1.55	1.46	1.38	1.29	1.21	1.13	1.06	.98	.91	.84
15	249.7	945.5	1.80	1.71	1.61	1.53	1.44	1.34	1.28	1.19	1.12	1.04	.97	.90

NOTE:
If it is found that operating conditions create a final air temperature below 90°, the output air stream may be uncomfortable and steam pressure should be increased.

Problem:
Condensate will increase. How much?

Example:
A unit heater rated at 100,000 btuh (2 psi/60° e.a.) is installed with 50° entering air but final air temperature is below 90°.

Factory Rating:
100,000 btuh ÷ 966.2 (latent heat at 2 psi) = 103.5 lbs. per hr.

Operating Conditions:
100,000 x 1.08 (50° e.a.) ÷ 966.2 = 111.8 lbs. per hr.

Increasing pressure to 5 psi:
100,000 x 1.13 ÷ 960.5 = 117.7 lbs. per hr.

CHAPTER 1 - STEAM

STEAM CONVERSION FACTORS

MULTIPLY	BY	TO GET
• Boiler Horsepower (BHP)	34.5	Lb. of Steam Water per hour (lb/hr)
• Boiler Horsepower (BHP)	0.069 Minute	Gallons of Water Per (GPM)
• Sq. Feet of Equivalent Direct Radiation (EDR)	0.000637	Gallons of Water per Minute(GPM)
• Boiler Horsepower (BHP)	33,479	B.T.U.
• Boiler Horsepower (BHP)	108	Sq. Feet of Equivalent Direct Radiation (EDR)
• Lbs. of Steam Water per Hour (lb/hr)	0.002	Gallons of Water per Minute(GPM)
• Lbs. per square inch	2.307	Feet of Water
• Lbs. per square inch	2.036	Inch of Mercury
• Feet of Water (head)	0.4335	Lbs. per square inch
• Inch of Mercury	13.6	Inch of Water Column
• Gallons of Water	8.34	Lbs. of Water
• Cubic Feet of Water	7.48	Gallons of Water
• Cubic Feet per Minute	62.43	Lbs. of Water per Minute
• Cubic Feet per Minute	448.8	Gallons per hour
• Cubic Centimeters per ltr. of Oxygen	1,400	Parts per billion of Oxygen
• Lbs. of Condensate	4	Sq. ft. E.D.R.

NOTE: Use above factors to match condensate return and boiler feed equipment with boiler size.

- Size Condensate Receivers for 1 min. net storage capacity based on return rate.

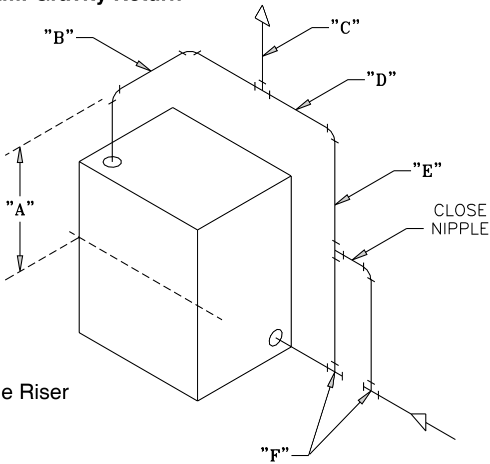
- Size Boiler Feed Receivers for system capacity (normally estimated at 10 min.)

- Size Condensate Pumps at 2 to 3 times condensate return rate.

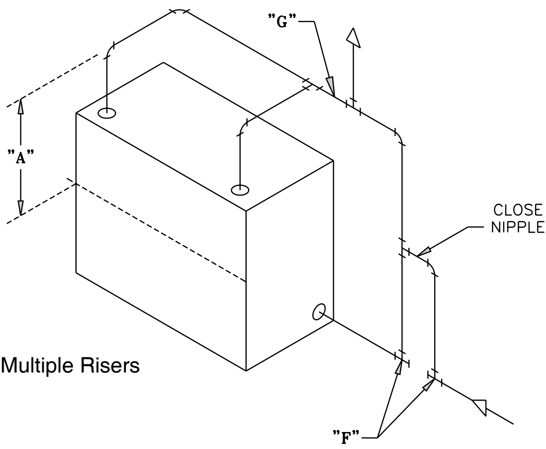
- Size Boiler Feed Pumps at 2 times boiler evaporation rate or .14 GPM/boiler HP (continuous running boiler pumps may be sized at 1-1/2 times boiler evaporation rate or .104 GPM/boiler HP)

STEAM PIPING BOILER DETAIL

A. Steam: Gravity Return



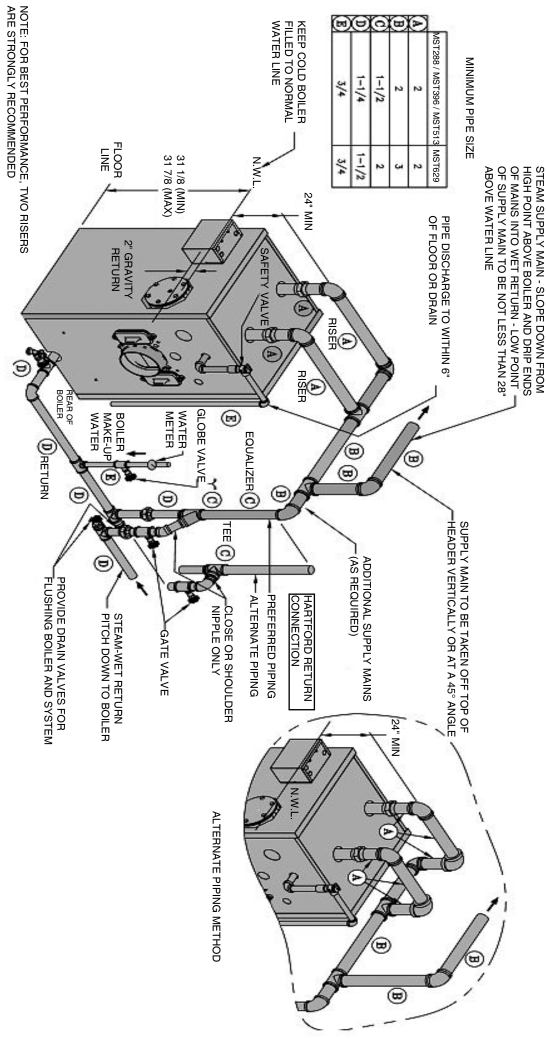
Boiler: One Riser



Boiler: Multiple Risers

A. 24" vertical rise.
B. Horizontal traverse to line up header with rear return tapping.
C. Vertical rise to existing main. Same size as header.
D. Nipple: 6" residential; 12" commercial.
E. Hartford Loop. Height/size, consult manufacturer.
F. Preferable use plugged tees in lieu of 90° elbow in wet returns.
G. Header all steam risers before moving steam to system.

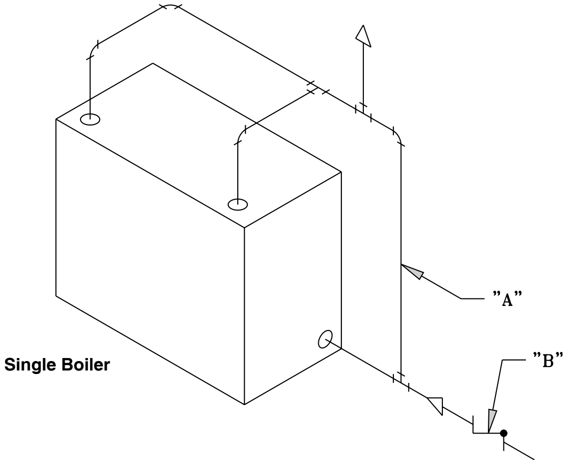
B. Dropped Header Piping



MINIMUM PIPE SIZE

	MST288 / MST396 / MST513	MST629
A	2	2
B	2	3
C	1-1/2	2
D	1-1/4	1-1/2
E	3/4	3/4

C. Steam: Pump Return



Notes refer to Single & Multiple Boilers

A. Header drip. Use in lieu of Hartford Loop when pump returns condensate. Size same as equalizer. May reduce below W.L.

B. Install check valve. Preferably lift check in lieu of swing.

C. Install F & T trap in header drip at N.W.L. Will maintain proper water level in unfired boilers. Return overflow to condensate receiver.

D. Multiple boilers with common boiler feed system must have each boiler return isolated with motorized valves.

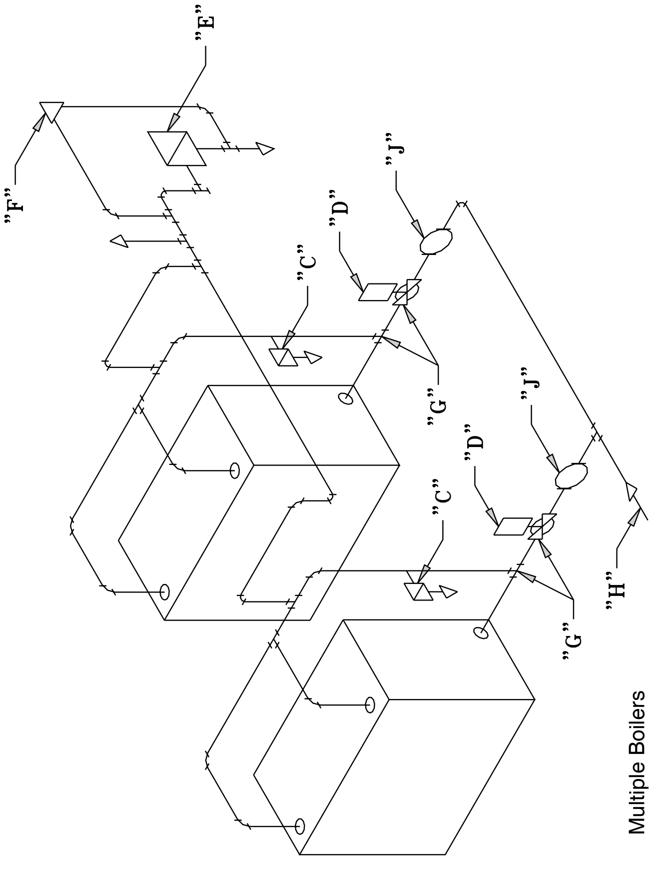
E. Initial call for steam may create excess condensate in common drop header. F & T trap will safely guide condensate to condensate receiver.

F. Thermostatic trap piped from header to F & T will help remove air from header.

G. Size motorized valve by GPM flow. Increase pipe size between solenoid and boiler to reduce water velocity into boiler. See recommendations for water flow on condensate pump piping detail.

H. See pump piping detail for condensate return to boiler.

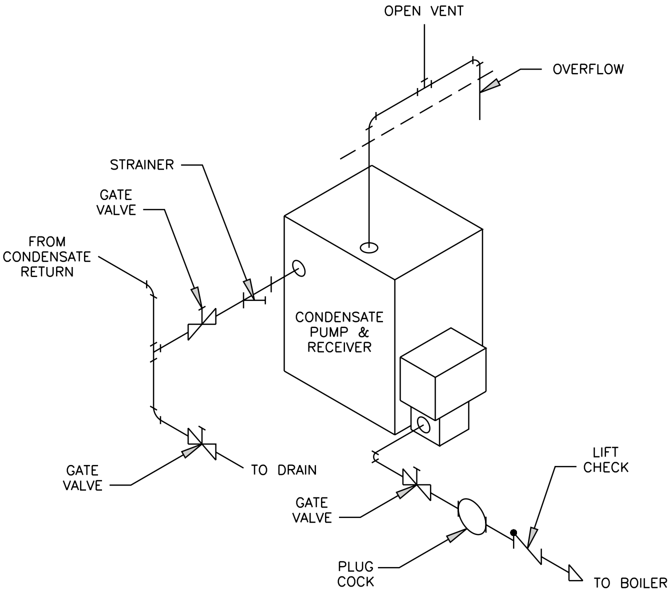
J. Plug valves must be installed next to each motorized valve to regulate GPM flow to each boiler from common pumping.



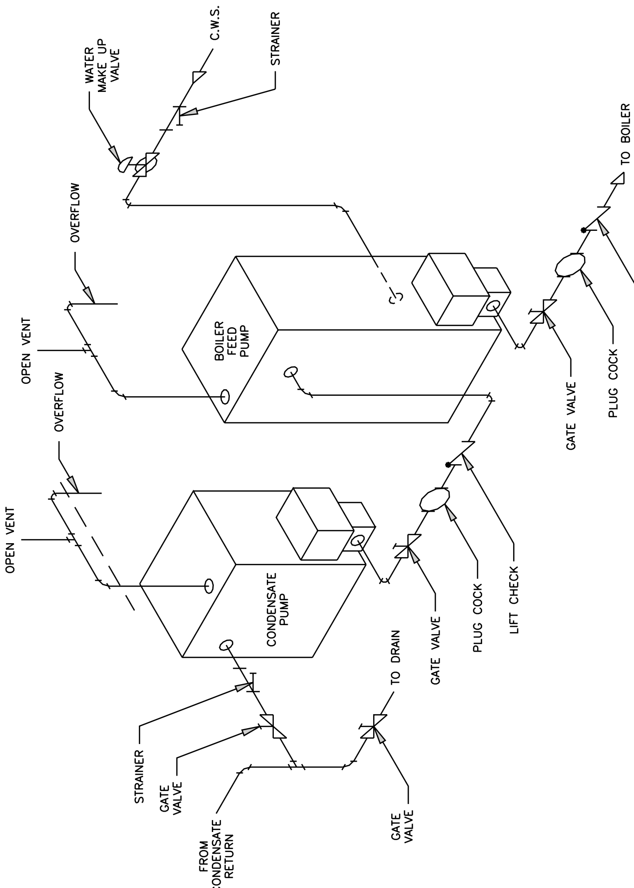
Multiple Boilers

STEAM PIPING - PUMP DETAIL

A. Condensate Pump



B. Boiler Feed Pump and Condensate Pump



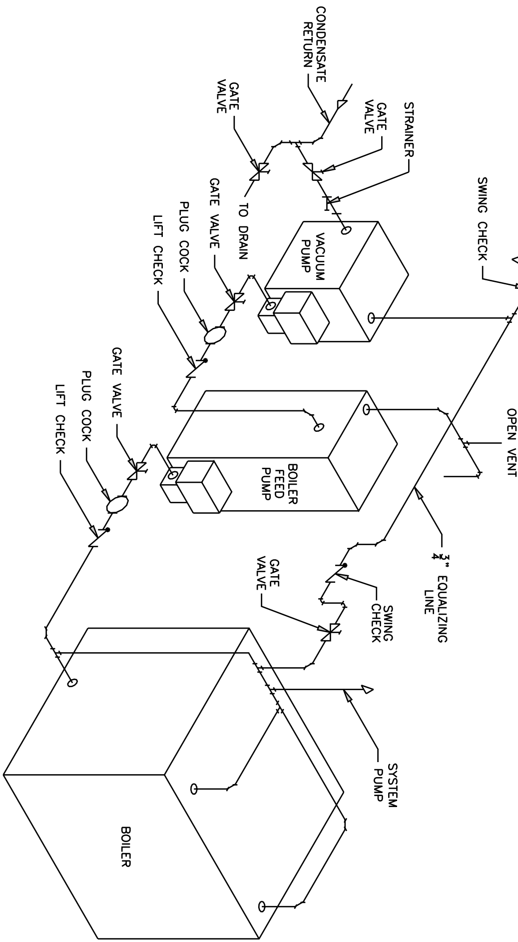
Control of Combination Units

- **Condensate Unit**. Float mechanism in receiver operates pump. It will move water to the boiler feed receiver.
- **Boiler Feed Unit**. Pump Controller (#150/42A McDonnell-Miller are typical) will control the movement of water directly to the boiler. Should the water in the boiler feed receiver drop too low, an installed water make-up valve will raise the receiver to a safe level.

C. Boiler Feed and Vacuum Pumps

Control & Pipe (same as Boiler Feed & Condensate Pump)

Additional Piping: Equalizing line between boiler steam header and vacuum pump. Equalizing line will prevent a possible vacuum developing in steam supply that could be greater than vacuum in the return.



SIZING OF VACUUM PUMP

Vacuum condensate pumps are normally sized at 2 or 3 times the system condensing rate. This is the same procedure for sizing standard condensing rate. The vacuum pump must also remove air from the return system. The system size, the inches of vacuum desired, and tightness of the system piping must be considered. The following chart will help.1 210

Air Removal Requirement

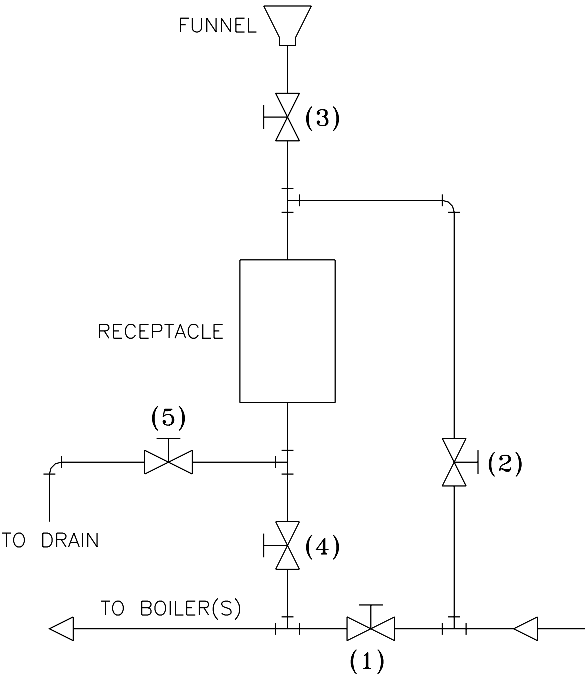
System	Vac / In. Hg.	CFM / 1,000 EDR
• up to 10,000 EDR (tight)	0 - 10	.5
• over 10,000 EDR (tight)	0 - 10	.3
• all systems, some air in-leakage	0 - 10	1.0

Highest Temperature °F of Condensate
Permissible with Vacuum Pumps

Vacuum Inches of Mercury in Pump Receiver	Highest Permissable Temperature of Condensate °F
15	179
12	187
10	192
8	196
6	201
4	205
2	209
1	210

STEAM PIPING CHEMICAL FEED TO BOILER

Placement of Chemical Feed to Boiler



- Between boiler and boiler feed pump.
- Chemical treatment added ahead of the pump suction will increase the friction and shorten the life of the mechanical pump seals.

Procedure:
- Open valve (3).
- Pour chemicals into funnel to rest in receptacle.
- Close valves (1) - (3) - (5); open valves (2) - (4). Condensate will move from the pump through the receptacle and take the chemicals to the boiler.
- When feeding is complete, close valves (2) and (4), then open valve (1).

CONVERTING A STEAM SYSTEM TO HOT WATER

GUIDELINES

1. If the heat emitters are cast iron radiators make certain that the sections are nippled (connected) at both the top and bottom.

2. Size boiler based on a calculated heat loss not installed radiation.

3. Measure the installed radiation. Divide total E.D.R. (sq. ft.) into the calculated heat loss. The answer will indicate the number of BTU's each sq. ft. of radiation must develop at outdoor design temperature.

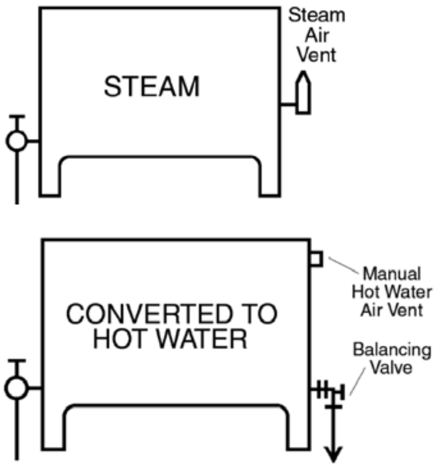
Refer to the chart on page 22. In the BTU column move horizontally to the number nearest your calculation. Above that number will be the maximum system temperature you need. Vertically below will be the amount of radiation (sq. ft.) that the various pipe sizes will handle.

4. One-Pipe Steam System: Existing steam mains and risers may be reused. However, new return risers and return main must be installed. Use the chart on page 23 to determine their size.

5. Two-Pipe Steam System: With the exception of the near boiler piping, all the system piping (steam mains, risers, and condensate returns) may be reused. Typically, a residential steam system that has 2" steam mains will have a minimum 1 1/4" dry return. If the heat loss is less than the 160 MBH that 1 1/4" dry return would be of sufficient size. The chart on page 23 gives the MBH capacity of pipe sizes from 1/2" to 2".

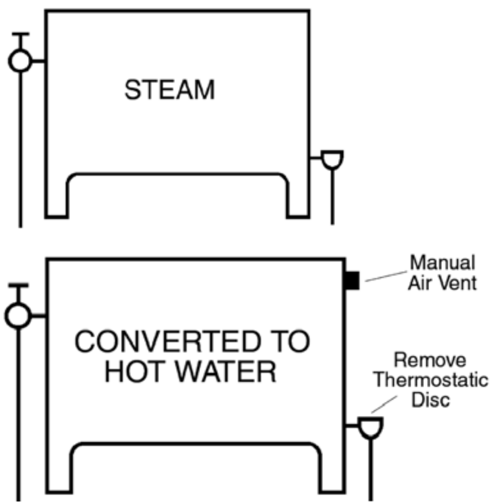
6. Regardless of the system, never reuse existing wet return piping.

ONE PIPE STEAM (Figure 1)



NOTE: Radiator must be nippled top & bottom.

TWO PIPE STEAM (Figure 2)



Capacity Basis: 70°F Room Temperature 20°F Temperature Drop												
Sq. Ft. Radiation												
Temp.		215°	200°	190°	180°	170°	160°	150°	140°	130°	120°	110°
BTU		240	210	190	170	150	130	110	90	70	50	30
Pipe Size	**MBH**											
1/2"	17	71	81	90	100	113	131	155	189	243	340	567
3/4"	39	163	186	205	229	260	300	355	433	557	780	1300
1"	71	296	338	374	418	473	546	646	789	1014	1420	2367
1-1/4"	160	667	762	842	914	1067	1231	1455	1778	2286	3200	5333
1-1/2"	240	1000	1143	1263	1412	1600	1846	2182	2667	3429	4800	8000
2"	450	1875	2143	2368	2647	3000	3462	4091	5000	6429	9000	15,000

Use chart to determine BTU load on radiation converted from steam to H.W.

NOTE: Heat loss of building will determine BTU load on system piping.
Divide sq. ft. of installed radiation into heat loss = BTU load per sq. ft.

Pipe Capacity in MBH at 500 Milinches Restriction Per Foot of Pipe

Pipe Size (inches)	MBH	+ Friction Head Feet per 100'	GPM at 20° T.D.	Velocity Flow of Water	
				Inches per Section	Feet per Min.
1/2	17	4.2’	1.7	23	115
3/4	39	4.2’	3.9	27	135
1	71	4.2’	7.1	34	170
1-1/4	160	4.2’	16.0	40	200
1-1/2	240	4.2’	24.0	*45	225
2	450	4.2’	45.0	*54	270
2-1/2	750	4.2’	75.0	*62	310
3	1400	4.2’	140.0	*72	360
4	2900	4.2’	290.0	*80	400

* - Maximum velocity flow

+ - In order for a pump to move the G.P.M. listed, the pump must overcome a friction head of 4.2 feet per 100' of pipe travers.
(Total Equivalent Length)

Example:
If one wants to carry 16 gpm in a 1-¼" pipe through a pipe circuit of 300' (T.E.L.), the pump must overcome a friction head of 4.2' x 3 or 12.6 ft. In other words, the pump specification would be to pump 16 gpm against a 12.6 friction head.

SYSTEM PURGE IN LIEU OF AIR VENTS

APPLICATION
Any series loop piping, especially where system high points may be concealed or venting is impractical. “System purge” is designed to remove air initially from the piping system, especially the high points.

GUIDELINES
After the initial removal of air it is important for the system to be able to handle air that will develop when the system water is heated. Installation of an air scoop or an in-line airtrol at the boiler supply will be necessary to either vent the air from the system or direct the air to a standard expansion tank.

A system purge is recommended only on Series Loop Installations. If other than non-ferrous baseboard is used, such as Base-Ray, the interconnecting pipe will purge but vents must be placed on each free standing assembly of Base-Ray.

PROCEDURE
1. Fill system with water. Isolate boiler by closing valves (B) and (C).

2. Begin purge by opening first zone or loop. Next, open valve (A) (cold water supply). Finally and immediately, open hose bib (D) Once water flows freely, close the first zone or loop and then do the same for the remaining zones or loops.

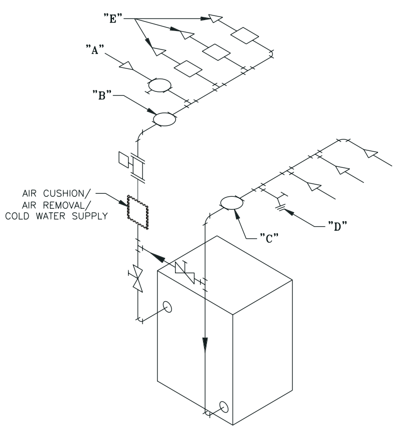
A. Separate ½” C.W.S. with Globe valve or by-pass P.R.V.

B. Ball valve: optional but preferred

C. Ball valve

D. Hose bib (for purging)

E. Zone valves or ball valves



INDIRECT DOMESTIC HOT WATER PIPING

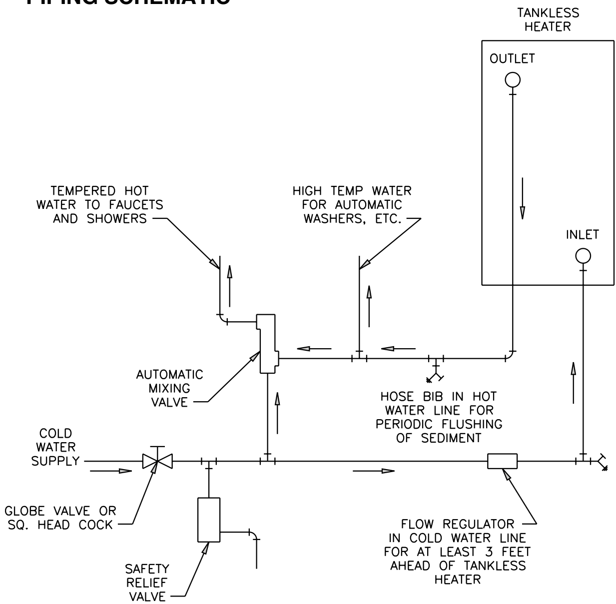
1. APPLICATION

A. Tankless Heater: Piping below is essential for safe and reliable operation.

B. Storage Heater: If the storage water temperature is maintained at or below 120°F, piping below is unnecessary.

If there is need to increase the storage, this can be accomplished by storing hotter water then tempering it. This will necessitate the piping below.

2. PIPING SCHEMATIC



(1) Preferably the mixing valve should be set no higher than 120°F. Install mixing valve 15" below H.W. outlet. This will create a beneficial cooling leg.

(2) Automatic Flow Regulator (tankless only) must match GPM rating of the tankless. If piped downstream of mixing valve, GPM flow will increase if heater water is hotter than 120°F.

(3) Placement of hose bibs will permit periodic back flushing of heater (coil).

3. INDIRECT DOMESTIC HOT WATER CONCERN

Scalding: Temperature - Minimum Time - Degree of Burn

Temp (°F)	1st Degree	2nd & 3rd Degree
111.2°	5 hrs.	7 hrs.
116.6°	35 min.	45 min.
118.4°	10 min.	14 min.
122.0°	1 min.	5 min.
131.0°	5 sec.	22 sec.
140.0°	2 sec.	5 sec.
149.0°	1 sec.	2 sec.
158.0°	1 sec.	1 sec.

INDIRECT SWIMMING POOL HEATING

APPLICATION
The use of a house heating boiler to indirectly heat a swimming pool is possible and even desirable. A factor of major significance would be comparable heat loads.

SIZING CONSIDERATIONS
Gallons of water to heat, temperature rise, and time allotted for temperature rise.

1. **SIZING FORMULA** (INITIAL RAISING OF WATER TEMPERATURE)
   Gallons of Water = Pool (width x length x avg. depth) x 7.48 (gal. per cu. ft.)
   Gallons of water x 8.34 x temp. rise ÷ hours to heat pool = BTUH

   Example:
   Pool (40' x 20' x 5' avg.) with initial pool water of 55°F to be raised to 75°F allowing 48 hours to raise temperature
   40' x 20' x 5' x 7.48 = 29,920 gallons of water
   29,920 x 8.34 x 20 ÷ 48 = 103,972 BTUH (I=B=R Net Ratings)

2. **HEAT LOSS FROM POOL SURFACE***
   (MAINTAINING WATER TEMPERATURE)

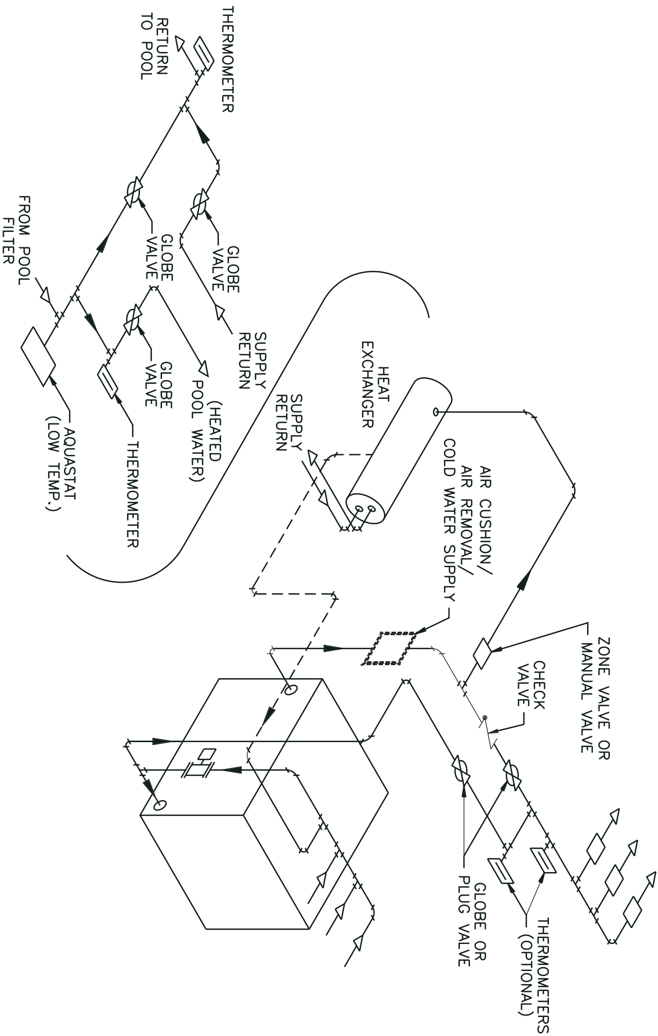
Temperature Difference °F	10°	15°	20°	25°	30°
BTUH/per Sq. Ft.	105	158	210	263	368

NOTES:
- Assumed wind velocity: 3.5 mph
  Wind velocity of 5 mph multiply BTUH by 1.25
  Wind velocity of 10 mph multiply BTUH by 2.00
- Temperature Difference: Ambient air and desired water temp.

*Maintaining pool temperature when outside air is 20° to 30°F lower than pool water may require a larger boiler.

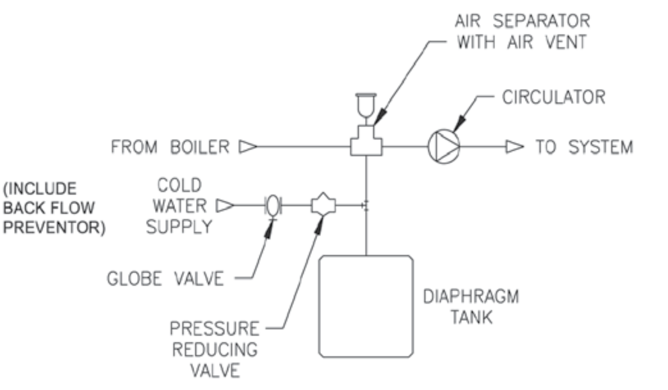
PIPING: INDIRECT SWIMMING POOL HEATING

NOTE: By-pass enables one to regulate flow through heat exchanger and also provide a manual disconnect from heating system.

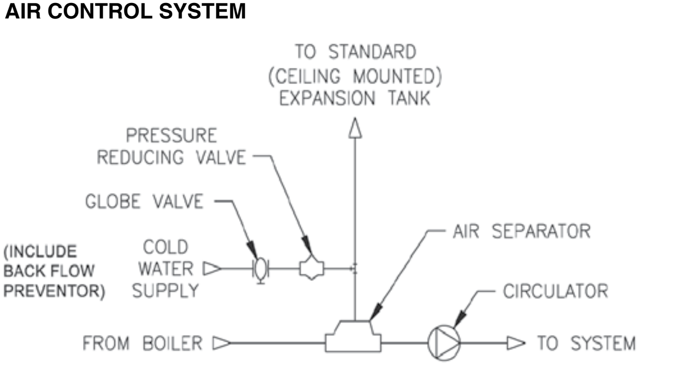


PIPING: HOT WATER SYSTEM AIR CUSHION AND AIR REMOVAL OPTIONS

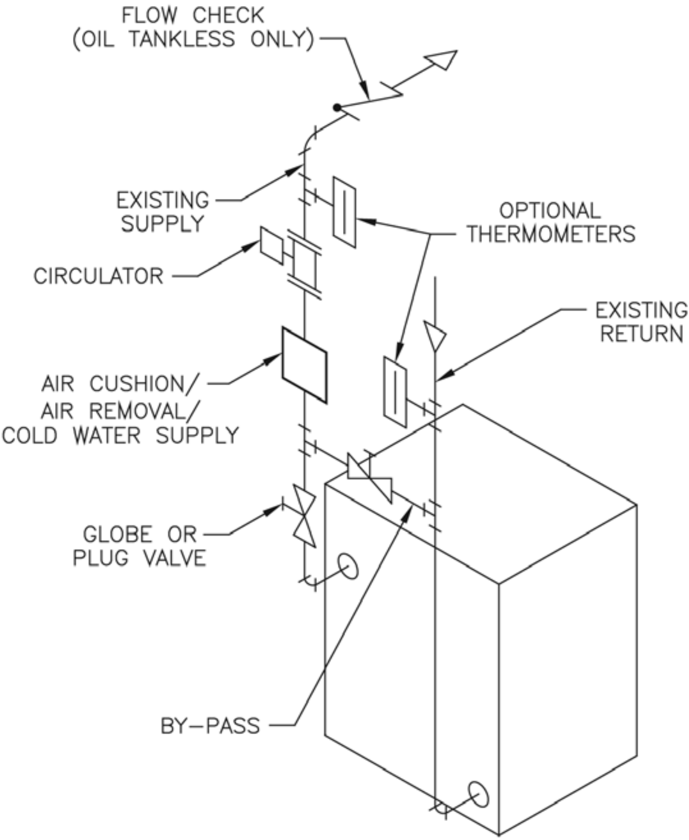
AIR REMOVAL SYSTEM



AIR CONTROL SYSTEM



1. BOILER BY-PASS - ONE ZONE



1. BOILER BY-PASS - ONE ZONE (CONT.)

PURPOSE FOR BY-PASS

GAS BOILER CONNECTED TO
<u>LARGE WATER CONTENT RADIATION</u>

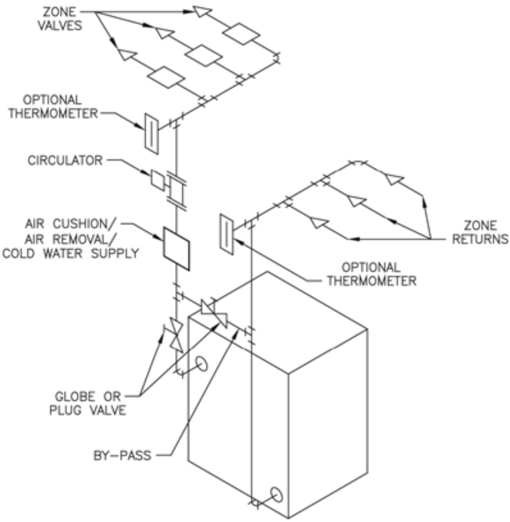
- Flue gas condensation will occur when the "burner" is on and the water in the boiler is less than 130°F. Over 50% of the heating season the radiators will satisfy the need for heat with less than 130°F. By-pass piping will permit the boiler to carry a higher temperature than the radiation. Regulation comes from the globe or plug valves. Thermometers, positioned above, will facilitate a proper by-pass. The supply water temperature need only overcome the temperature drop of the system. Even with water moving as slow as 2' to 1' per second in the oversized gravity piping, within a few minutes the thermometer mounted in the by-pass (return water) will begin to register temperature rise then serious balancing can start.

OIL BOILER WITH TANKLESS CONNECTED
<u>TO LARGE WATER CONTENT RADIATION</u>

- Flue gas condensation can occur in oil boilers too. However, there is greater concern regarding system operation. Without a boiler by-pass, water returning from one radiator will drastically drop the boiler temperature and cause the circulator to stop. Heat leaves the boiler in "spurts" and all the "hot spurts" end up in the same radiator and the heating system is quickly out of balance. By-pass piping properly set will dramatically minimize this problem.

2. BOILER BY-PASS - MULTI-ZONE HEATING

PURPOSE OF BY-PASS (GAS AND OIL)



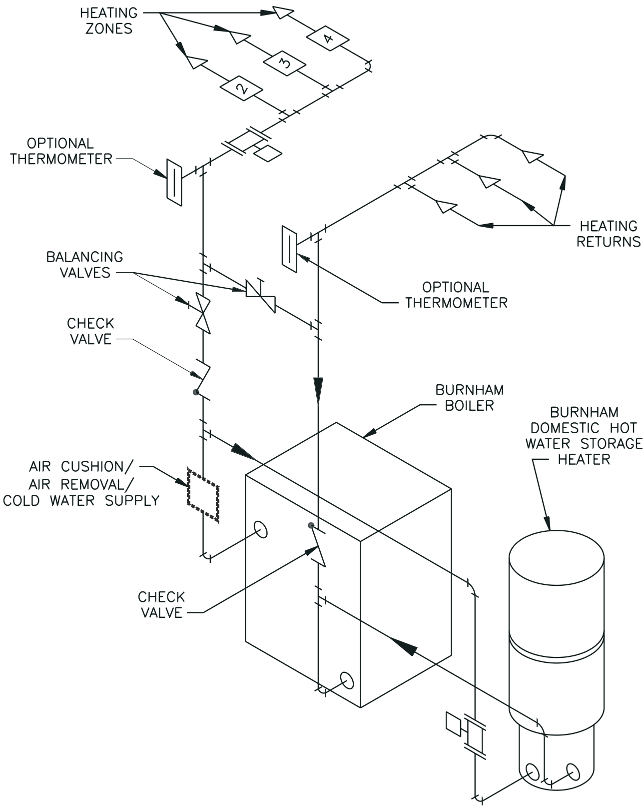
- In a multi-zone (cold start) system excess temperature develops. When one zone calls for heat it cannot dissipate the heat the boiler (sized for all zones) creates. When the zone is satisfied the hot water trapped in the boiler stays hot while the hot water trapped in the non-ferrous baseboard cools quickly. Before the next call for heat the temperature difference may be as high as 100°F. The system will be plagued with expansion noises unless boiler by-pass piping is installed. If, for example, the temperature drop in each of the zones is approximately 10°F then the balancing valves need only show on the thermometers a 15°F variance between supply and return piping, and expansion noises will be eliminated.

  Beyond Boiler By-Pass

- Two-stage thermostats or an indoor-outdoor reset controller will minimize the temperature rise in the boiler but even with these controls, boiler by-pass piping will help.

NOTE: If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 43 for further details.

3. BOILER BY-PASS - MULTI-ZONE HEATING AND INDIRECT D.H.W. ZONE



NOTE: If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 43 for further details.

3. BOILER BY-PASS - MULTI-ZONE HEATING AND INDIRECT D.H.W. ZONE (CONT.)

PURPOSE OF BY-PASS (GAS AND OIL)

- Serves only the heating zones. Though, indirectly, the hotter boiler water it creates will help the indirect domestic hot water zone. Boiler by-pass piping, per se, is helpful to the heating zones yet detrimental to the DHW zone. However, with properly positioned check valves by-pass piping can serve both operations.

EXAMPLES

1. Heating zone (2, 3 or 4) calls for heat: Full flow of the circulator will move from the radiation to point (A). If the balancing valves (globe or plug) are adjusted to slightly overcome the temperature drop of the zone(s), typically 30% of the flow will move into the boiler at point (B) and 70% will by-pass the boiler at (C). At point (D) the full, but blended flow will move to the radiation.

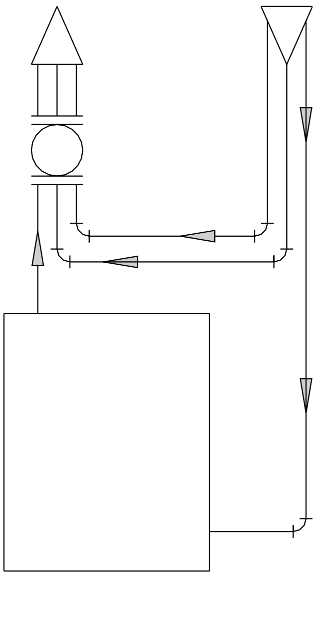
2. Indirect DHW zone (1) calls for heat: Full flow of the circulator will move through the boiler at (B). No water will move through the by-pass at (C) because of the check valve at point (E). In other words, all the heat in the boiler will be dedicated to satisfying the DHW needs.

3. Heating zone and indirect DHW zone call for heat simultaneously. Through the use of a special relay the DHW zone could be given priority. This means the heating zone is put on hold until the DHW zone is satisfied. One option would be to let the piping handle the situation. Remember, water flow takes the course of least restriction and there is considerably less restriction in the DHW zone piping.

4. BOILER BY-PASS VS SYSTEM BY-PASS

Several variations of by-pass piping exist for different reasons. Because the piping is near the boiler it is commonly categorized as "boiler by-pass" even though some may be a "system by-pass". The difference is illustrated below.

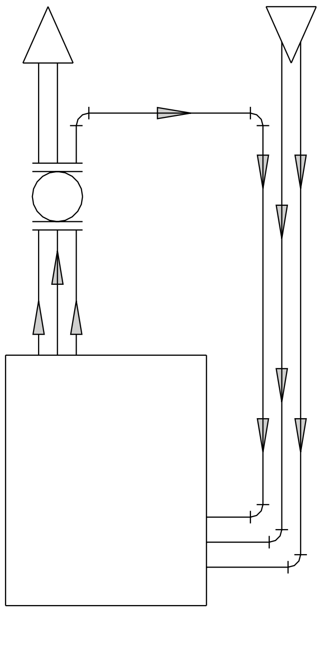
BOILER BY-PASS



1. Drawing illustrates how water by-passes the boiler.

2. Total circulator's capacity is dedicated to the system.

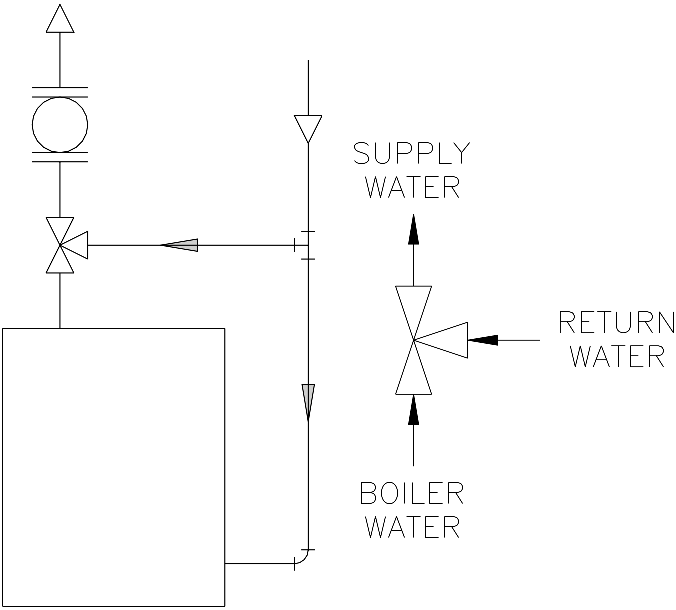
SYSTEM BY-PASS



1. Drawing illustrates how water by-passes the system.

2. Some of the circulator's capacity is used to recirculate boiler water.

5. BOILER BY-PASS - THREE-WAY MIXING VALVES



NOTES:

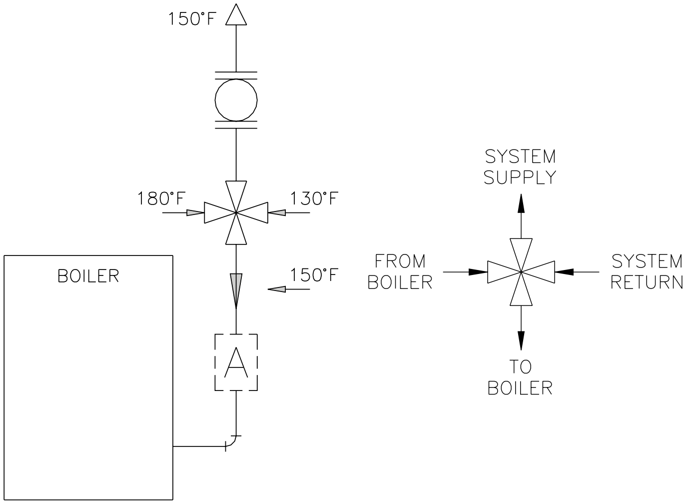
- Restricting boiler water flow will increase return water flow and vice versa. Supply water flow will always be boiler water plus return water.

- Mixing may be accomplished manually or with an actuating motor.

- Three-way valve application in this drawing creates a boiler by-

NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

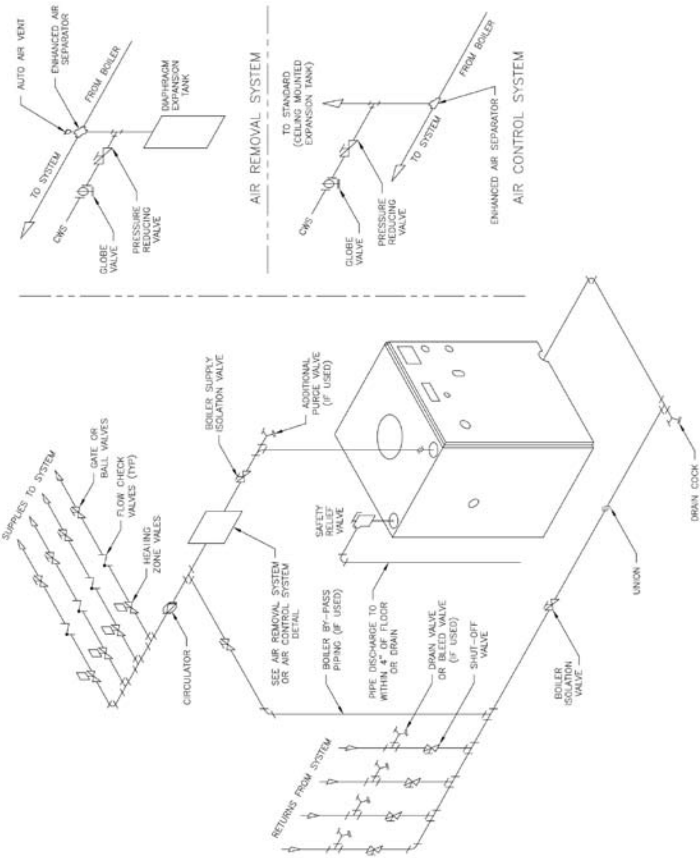
6. SYSTEM BY-PASS - FOUR-WAY MIXING VALVE



1. With application of four-way valve the preferred location of the circulator is on the "system supply" side.
2. Mixing may be accomplished manually or with an actuating motor.
3. Four-way valve application is a system by-pass.
4. Four-way valve application may require a second circulator, one dedicated to system flow and the other to boiler flow. The second circulator should be installed at point (A) pumping into the boiler
5. **Concern:** Should four-way valve be fully opened to the system, both circulators will be pumping in series.

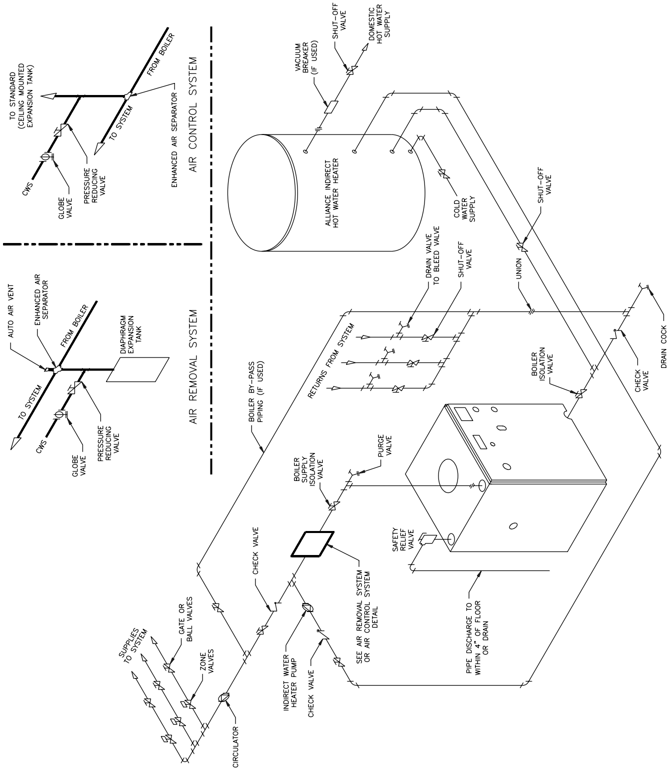
NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

PIPING & MULTI-ZONE W/ ZONE VALVES



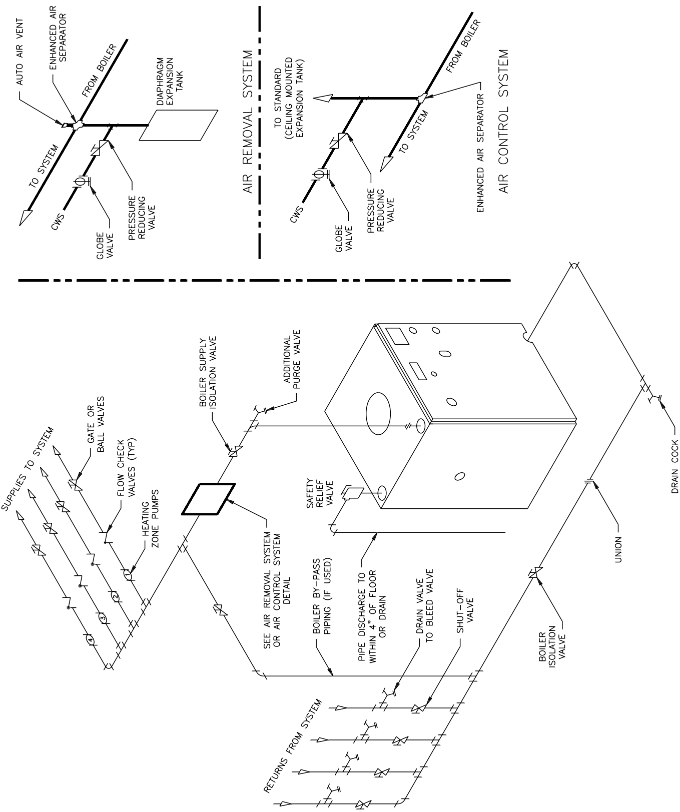
NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

PIPING: MULTI-ZONE W/ZONE VALVES & INDIRECT HEATER



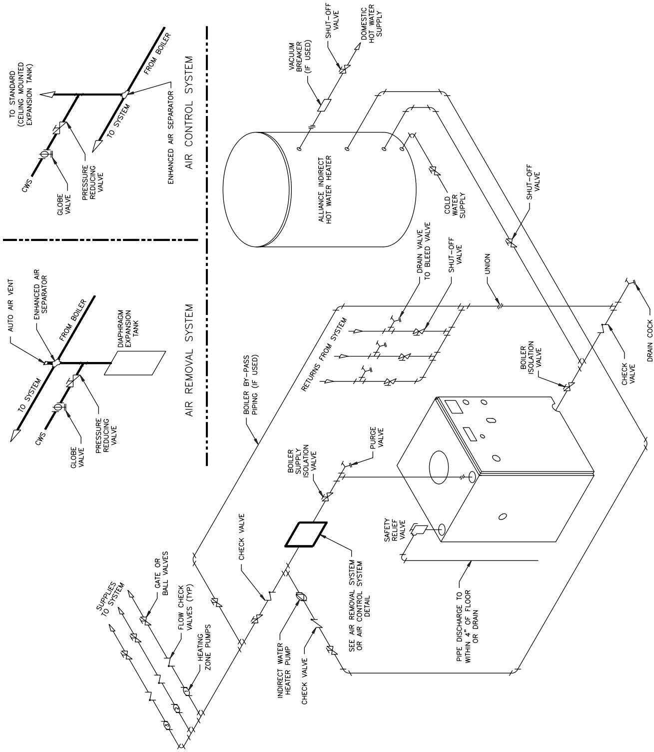
NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

PIPING: MULTI-ZONE W/ CIRCULATORS



NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

PIPING: MULTI-ZONE W/ CIRCULATORS AND INDIRECT HEATER

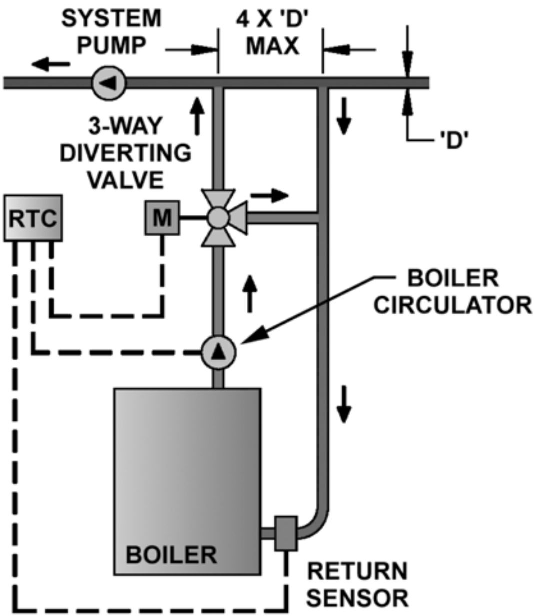


NOTE:

If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual and page 42 for further details.

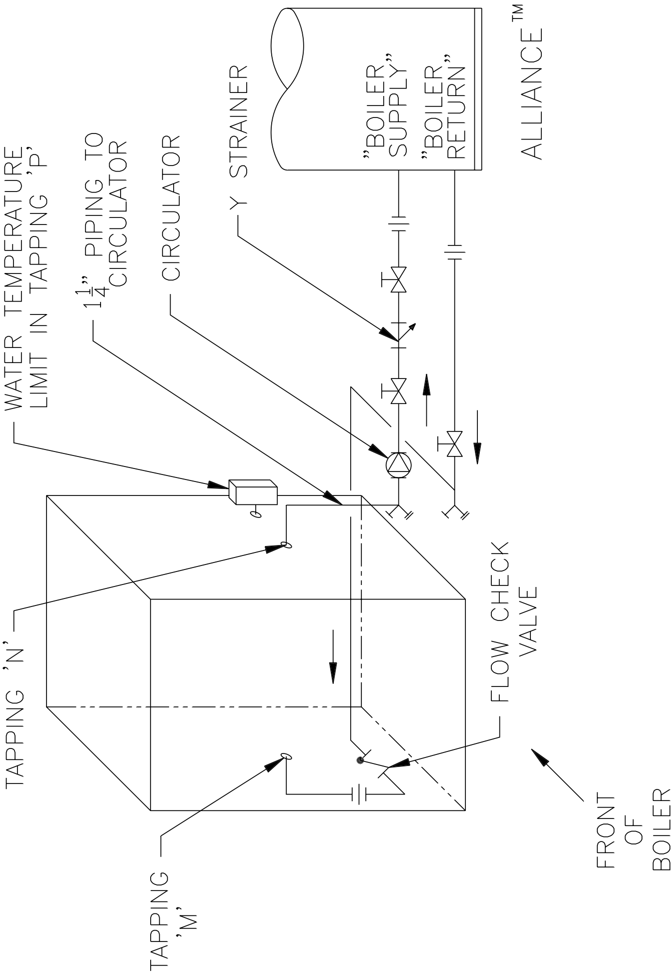
PIPING: BOILER RETURN TEMPERATURE PROTECTION USING BURNHAM COMMERCIAL RTC RETURN TEMPERATURE CONTROL FOR SYSTEMS THAT MAY GO BELOW 135°F RETURN WATER TEMPERATURE

- includes outdoor reset
- monitors boiler return water temperature
- operates boiler circulator and 3-way valve
- maintains minimum 135°F return water temperature
- provides LCD display of retun water temperature

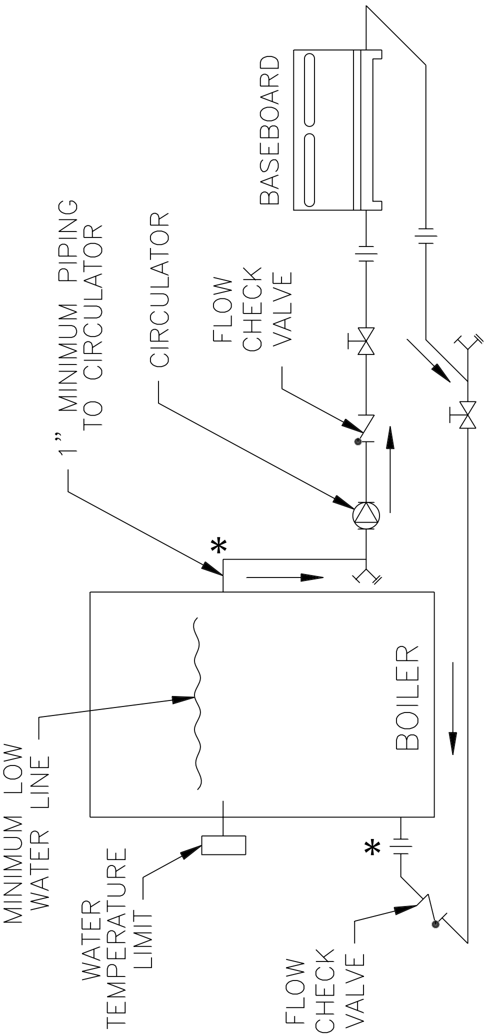


NOTE:
If the system return water temperature periodically or continuously operates below 135° F, the use of a three-way valve and Burnham RTC Return Temperature Control is recommended. See separate RTC manual for further details.

PIPING: INDEPENDENCE STEAM BOILER W/ INDIRECT HEATER

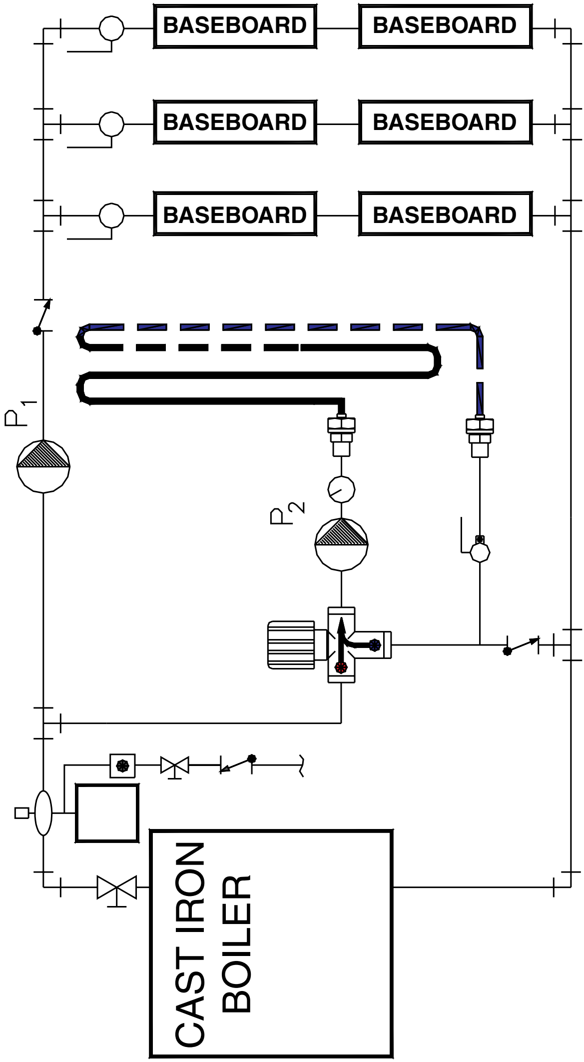


PIPING: TYPICAL STEAM BOILER W/ BASEBOARD LOOP

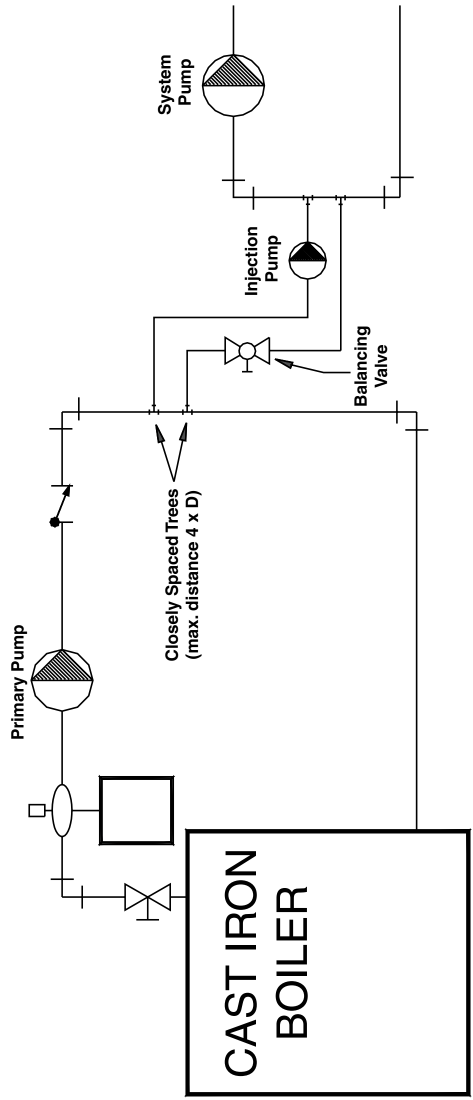


*** NOTE: Do not pipe both supply and returns into bottom tappings. Supply must be in higher tapping.**

PIPING: RADIANT FIRST ZONE W/ MIXING VALVE

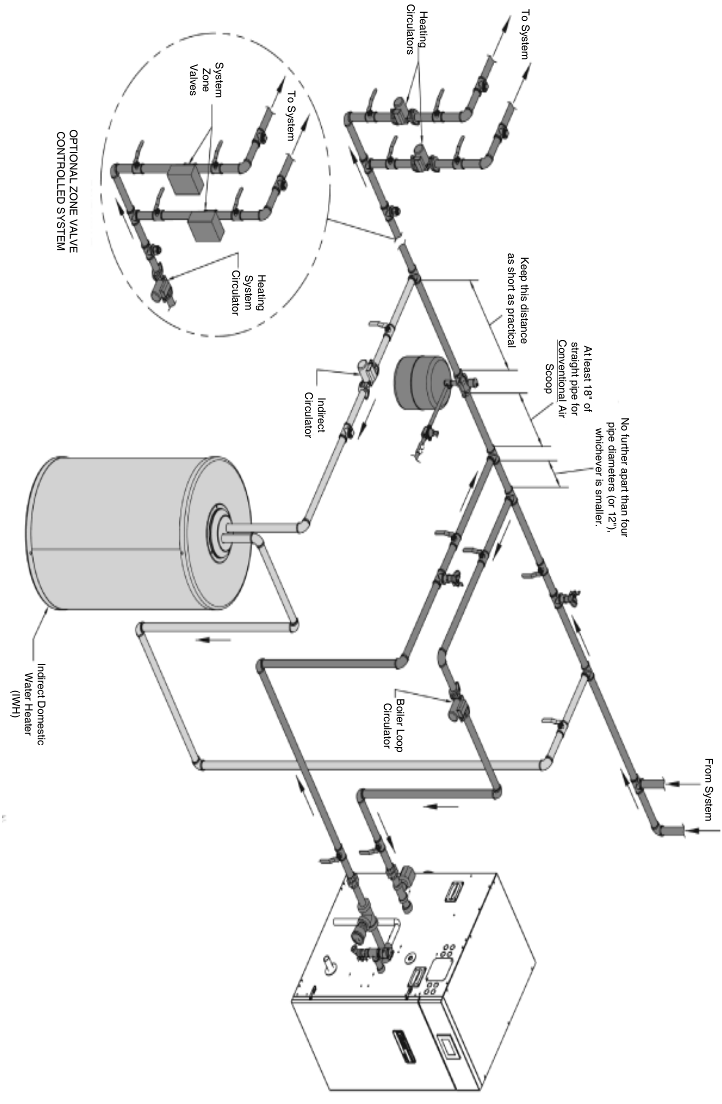


PIPING: RADIANT FIRST ZONE W/ INJECTION PUMPING



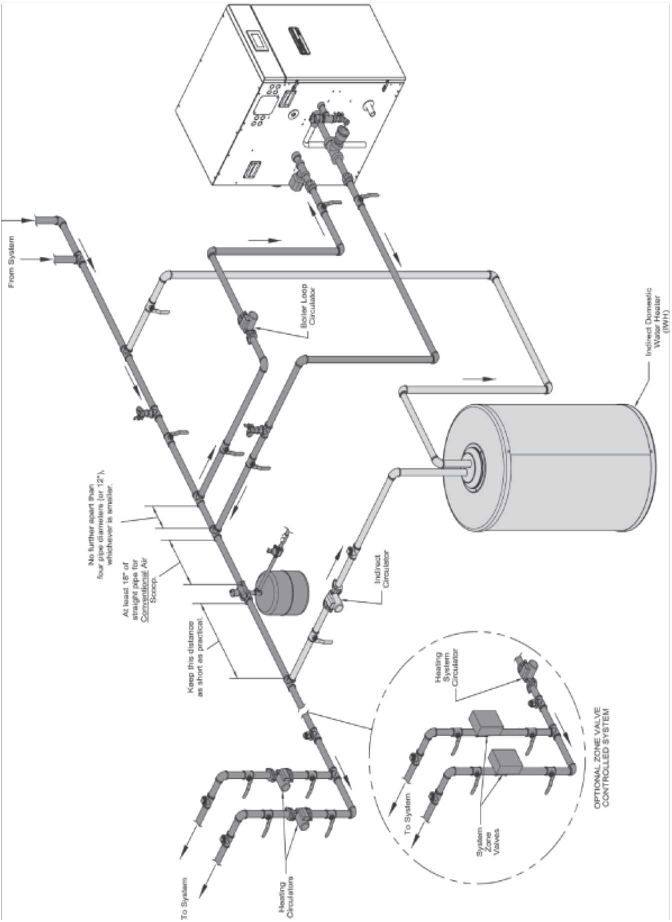
CHAPTER 3 - PIPING DIAGRAMS

NEAR BOILER PIPING FOR ALPINE BOILERS



CHAPTER 3 - PIPING DIAGRAMS

RECOMMENDED CIRCULATOR MODELS FOR ALPINE (ALP) BOILERS BASED ON 25°F TEMPERATURE DIFFERENTIAL AND UP TO 75 FT. EQUIVALENT LENGTH NEAR -BOILER PIPING-SPACE HEATING CIRCULATOR



CHAPTER 4 - DOMESTIC HOT WATER

DOMESTIC HOT WATER SIZING REQUIREMENTS

A. RESIDENTIAL: Sizing residential water heaters varies with manufacturers. HUD and FHA have stablished minimum permissible water heater sizes as shown in the floowing table.

HUD, FHA Minimum Water Heater Capacities for One and Two-Family Living Units

Number of Baths	**1 to 1.5**			**2 to 2.5**				**3 to 3.5**			
Number of Bedrooms	**1**	**2**	**3**	**2**	**3**	**4**	**5**	**3**	**4**	**5**	**6**
GAS (a)											
Storage, gal.	20	30	30	30	40	40	50	40	50	50	50
1000 Btu/h input	27	36	36	36	36	38	47	38	38	47	50
1-h draw, gal.	43	60	60	60	70	72	90	72	82	90	92
Recovery, gph	23	30	30	30	30	32	40	32	32	40	42
TANK TYPE INDIRECT (b,c)											
I-W-H rated draw, gal. in 3-h, 100°F rise		40	40		66	66	66	66	66	66	66
Manufacturer-rated draw, gal. in 3-h, 100°F (55.6°C) rise		49	49		75	75d	75	75	75	75	75
Tank capacity, gal.		66	66		66	66d	82	66	82	82	82
TANKLESS TYPE INDIRECT (c,e)											
I-W-H rated, gpm 100°F rise		2.75	2.75		3.25	3.25d	3.75d	3.25	3.75	3.75	3.75

A. Storage capacity, input, and recovery requirements indicated in the table are typical and may vary with each individual manufacturer. Any combination of these requirements to produce the stated 1-h draw will be satisfactory.

B. Boiler-connected water heater capacities [180°F boiler water, internal or external connection].

C. Heater capacities and inputs are minimum allowable. A.G.A. recovery ratings for gas heaters, and IBR ratings for steam and hot water heaters.

D. Also for 1 to 1.5 baths and 4 B.R. for indirect water heaters.

E. Boiler-connected heater capacities [200°F boiler water, internal or external connection].

Reference: ASHRAE/Systems Handbook (Service Water Heating)

B. COMMERCIAL: Commercial buildings have different domestic hot water needs. Building type will be the major variable. The two charts that follow analyze the demand based either on Fixture or Occupancy.

Note: Both charts presume the use of storage type heaters.

Chart #1

(Gallons of water per hour per fixture, calculated at a final temperature of 140°F)

	Apt. House	Club	Gym	Hospital	Hotel	Ind. Plant	Office Bldg.	Priv. Res.	School	YMCA
1. Basins, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basins, public lavatory	4	6	8	6	8	12	6	—	15	8
3. Bathtubs	20	20	30	20	20	—	—	20	—	30
4. Dishwashers	15	50-150	—	50-150	50-210	20-100	—	15	20-100	20-100
5. Food basins	3	3	12	3	3	12		3	3	12
6. Kitchen sink	10	20	—	20	30	20	20	20	20	20
7. Laundry, stationary tubs	20	28	—	28	28	—	—	20	—	28
8. Pantry sink	5	10	—	10	10	—	10	5	10	10
9. Showers	30	150	225	75	75	225	30	30	225	225
10. Slop sink	20	20	—	20	30	20	20	15	20	20
11. Hydrotherapeutic showers	—	—	—	400	—	—	—	—	—	—
12. Circular wash sinks	—	—	—	20	20	30	20	—	30	—
13. Semi-curcular wash sinks	—	—	—	10	10	15	10	15	—	—
14. Demand factor	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	.040

Notes:

A. #1 through #13 - Possible Maximum Demand

B. #14 (Demand Factor) - Probable Maximum Demand

C. #15 Ratio of Storage Tank Capacity to Probable Max. Demand Per Hr.

Example:

50 Unit Apartment Building

50 lavatories x 2	=	100 GPH
50 showers x 30	=	1500 GPH
50 kitchen sinks x 10	=	500 GPH
10 laundry tubs x 20	=	200 GPH
A) Possible Maximum Demand	=	2300 GPH
Demand Factor (#14)		x .30
B) Probable Maximum Demand	=	690 GPH
Storage Capacity Factor (#15)		1.25
C) Storage Tank Size	=	863 GAL.

Chart #2

This chart may be used as a cross check to Chart #1. The Hot Water Demand listed represents the actual metering of 129 buildings. The number of each building type sampled is listed at the extreme left side of chart.

Number	Type of Building	Maximum Hour	Maximum Day	Average Day
8	**Men's dormitories**	3.8 gal/student	22.0 gal/student	13.1 gal/student
8	**Women's dormitories**	5.0 gal/student	26.5 gal/student	12.3 gal/student
15	**Motels:** **no. of units (a)** 20 or less, 60 100 or more	 6.0 gal/unit 5.0 gal/unit 4.0 gal/unit	 35.0 gal/unit 25.0 gal/unit 15.0 gal/unit	 20.0 gal/unit 14.0 gal/unit 10.0 gal/unit
13	**Nursing homes**	4.5 gal/bed	30.0 gal/bed	18.4 gal/bed
6	**Office buildings**	0.4 gal/person	2.0 gal/person	1.0 gal/person
25	**Food establishments:** **Type A** full meal restaurants and cafeterias **Type B** drive-ins, grills, luncheonettes, sandwich and snack shops	 1.5 gal/max meals/h 0.7 gal/max meals/h	 11.0 gal/max meals/h 6.0 gal/max meals/h	 2.4 gal/avg meals/day* 0.7 gal/avg meals/day*
26	**Apartment houses:** **no. of apartments** 20 or less 50 75 100 200 or more	 12.0 gal/apt. 10.0 gal/apt. 8.5 gal/apt. 7.0 gal/apt. 5.0 gal/apt.	 80.0 gal/apt. 73.0 gal/apt. 66.0 gal/apt. 60.0 gal/apt. 50.0 gal/apt	 42.0 gal/apt. 40.0 gal/apt. 38.0 gal/apt. 37.0 gal/apt. 35.0 gal/apt.
14	**Elementary schools**	0.6 gal/student	1.5 gal/student	0.6 gal/student*
14	**Junior and senior high schools**	1.0 gal/student	3.6 gal/student	1.8 gal/student*

*Per day of operation.
(a) Interpolate for intermediate values.

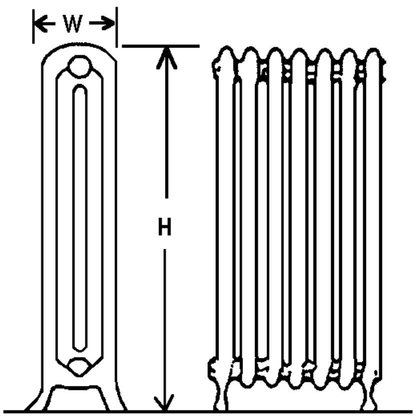
Reference: ASHRAE/Systems Handbook (Service Water Heating)

SIZING OBSOLETE RADIATION - CAST IRON RADIATORS

The output of a radiator is measured in square feet of radiation. To determine the number of square feet of radiation in a radiator:

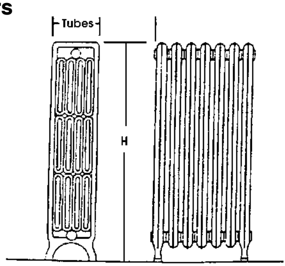
1. Measure the height of the radiator.
2. Count the number of columns in a section.
3. Count the number of sections.
4. Multiply the total number of sections by the number of square feet per section as shown in the following tables:

Column Type Radiators



Sq. Ft. Radiation per Section					
Height (inches)	4-1/2" W One Column	7-1/2" W Two Column	9" W Three Column	11-1/2" W Four Column	13" W Five Column
13	—	—	—	—	3
16	—	—	—	—	3-3/4
18	—	—	2-1/4	3	4-1/4
20	1-1/2	2	—	—	5
22	—	—	3	4	—
23	1-2/3	2-1/3	—	—	—
26	2	2-2/3	3-3/4	5	—
32	2-1/2	3-1/3	4-1/2	6-1/2	—
38	3	4	5	8	—
45	—	5	6	10	—

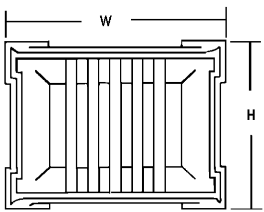
Tube Type Radiators



Sq. Ft. Radiation per Section					
Height Inches	5" Three Tube	7" Four Tube	8-3/4" Five Tube	9-3/4" Window Six Tube	12-1/2" Seven Tube
14	—	—	—	—	2-1/2
17	—	—	—	—	3
20	1-3/4	2-1/4	2-2/3	3	3-2/3
23	2	2-1/2	3	3-1/2	—
26	2-1/3	2-3/4	3-1/2	4	4-3/4
32	3	3-1/2	4-1/3	5	—
38	3-1/2	4-1/4	5	6	—

Wall Type Radiators

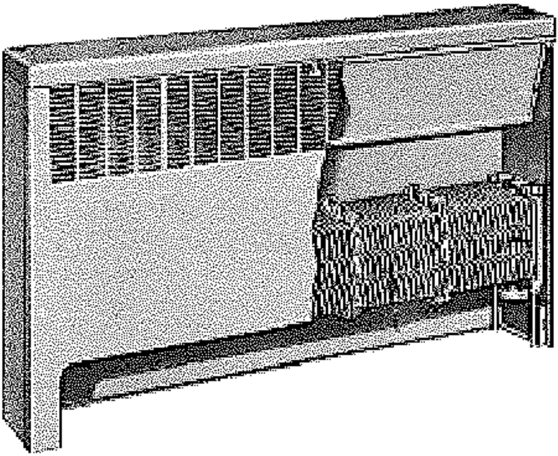
Wall radiators are measured by their height, length and thickness. The following table shows the number of square feet of heating surface per section.



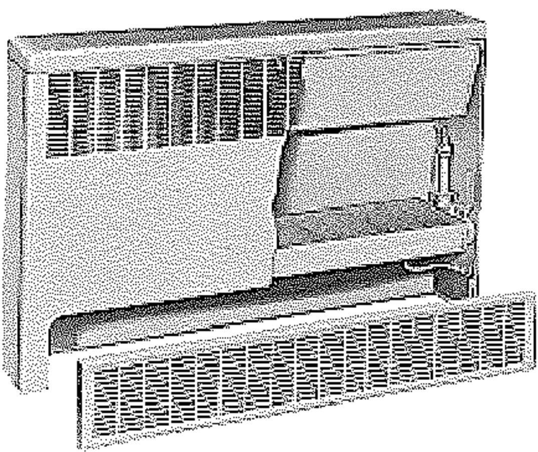
Sq. Ft. Radiation per Wall Radiator Section Heating				
Type of Section	Height (inches)	Length or Width (inches)	Thickness (inches)	Sq. Ft. Radiation
5-A	13-5/16	16-5/8	2-7/8	5
7-A	13-5/16	21-7/8	2-7/8	7
7-B	21-7/8	13-3/16	3-1/16	7
9-A	18-5/16	29-1/16	2-7/8	9
9-B	29-1/16	18-5/16	3-11/16	9

Convectors

Cast Iron - Ratings: Page 53



Copper - Ratings: Page 54



CHAPTER 5
INSTALLED RADIATION: DETERMINING HEAT LOAD

SIZING: CONVECTORS - CAST IRON
RATINGS - SQUARE FEET OF RADIATION

Front Outlet and Sloping Outlet Type Units Cabinet Height - Floor Type							
Cabinet Depth (inches)	Cabinet Length (inches)	18	20	24	26	32	38
4-1/2"	18-1/2	8.4	9.1	10.5	11.0	11.8	12.3
	23-1/2	10.9	11.8	13.5	14.2	15.2	15.9
	28-1/2	13.3	14.4	16.5	17.4	18.6	19.4
	33-1/2	15.8	17.1	19.7	20.6	22.1	23.0
	38-1/2	18.2	19.7	22.7	23.8	25.5	26.5
	43-1/2	20.6	22.3	25.7	26.9	28.9	30.1
	48-1/2	23.1	25.0	28.7	30.1	32.3	33.6
	53-1/2	25.5	27.6	31.8	33.3	35.7	37.2
	58-1/2	28.0	30.3	34.8	36.5	39.1	40.7
	63-1/2	30.5	33.0	37.9	39.7	42.5	44.3
6-1/2"	18-1/2	12.3	13.5	15.4	16.2	17.5	18.2
	23-1/2	15.9	17.4	19.9	20.9	22.6	23.5
	28-1/2	19.5	21.3	24.4	25.6	27.7	28.8
	33-1/2	23.1	25.2	28.9	30.4	32.9	34.1
	38-1/2	26.7	29.2	33.4	35.1	38.0	39.4
	43-1/2	30.3	33.1	37.9	39.8	43.1	44.7
	48-1/2	33.9	37.0	42.4	44.5	48.1	50.0
	53-1/2	37.5	40.9	46.8	49.2	53.3	55.3
	58-1/2	41.1	44.8	51.3	53.9	58.4	60.6
	63-1/2	44.7	48.7	55.8	58.7	63.5	65.9
8-1/2"	18-1/2		17.1	19.4	20.4	22.5	23.7
	23-1/2		22.2	25.0	26.4	29.1	30.6
	28-1/2		27.2	30.7	32.4	35.7	37.5
	33-1/2		32.2	36.4	38.4	42.3	44.5
	38-1/2		37.2	42.1	44.3	48.9	51.4
	43-1/2		42.3	47.8	50.3	55.5	58.4
	48-1/2		47.3	53.5	56.3	62.0	65.3
	53-1/2		52.3	59.2	62.3	68.6	72.3
	58-1/2		57.3	64.9	68.3	75.2	79.2
	63-1/2		62.3	70.6	74.3	81.8	86.1
10-1/2"	18-1/2		20.6	23.4	24.6	27.3	28.8
	23-1/2		26.7	30.3	31.8	35.3	37.2
	28-1/2		32.8	37.2	39.1	43.3	45.7
	33-1/2		38.9	44.2	46.3	51.4	54.2
	38-1/2		45.0	51.1	53.6	59.5	62.7
	43-1/2		51.1	58.0	60.8	67.5	71.2
	48-1/2		57.2	64.9	68.1	75.6	79.6
	53-1/2		63.3	71.8	75.4	83.6	88.1
	58-1/2		69.4	78.7	82.6	91.6	96.6
	63-1/2		75.5	85.6	89.8	99.7	105.1

CHAPTER 5
INSTALLED RADIATION: DETERMINING HEAT LOAD

SIZING: CONVECTORS - COPPER
FRONT OUTLET TYPE UNITS
RATINGS - SQUARE FEET OF RADIATION

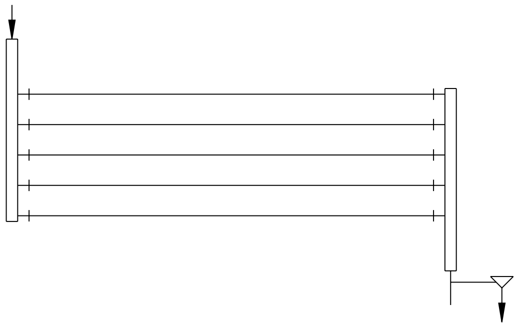
Front Outlet and Sloping Outlet Type Units Cabinet Height - Floor Type							
Cabinet Depth (inches)	**Cabinet Length (inches)**	**18**	**20**	**24**	**26**	**32**	**38**
4-1/2"	20-1/2	10.4	11.3	13.1	13.4	14.0	14.6
	24-1/2	12.8	13.9	16.1	16.4	17.2	18.0
	28-1/2	15.2	16.5	19.2	19.5	20.4	21.3
	32-1/2	17.6	19.1	22.2	22.5	23.6	24.6
	36-1/2	19.7	21.7	25.2	25.6	26.8	28.0
	40-1/2	22.3	24.3	28.2	28.6	30.0	31.3
	44-1/2	24.7	26.9	31.2	31.7	33.2	34.7
	48-1/2	27.1	29.5	34.2	34.7	36.4	38.0
	56-1/2	31.9	34.7	40.2	40.8	42.8	44.7
	64-1/2	36.6	39.9	46.2	46.9	49.2	51.7
6-1/2"	20-1/2	15.3	16.3	18.4	18.8	19.6	20.6
	24-1/2	18.8	20.1	22.6	23.1	24.1	25.3
	28-1/2	22.3	23.8	26.9	27.4	28.6	30.1
	32-1/2	25.8	27.6	31.1	31.7	33.2	34.8
	36-1/2	29.3	31.3	35.4	36.0	37.7	39.6
	40-1/2	32.8	35.1	39.6	40.3	42.2	44.3
	44-1/2	36.3	38.9	43.8	44.6	46.7	49.0
	48-1/2	39.8	42.6	48.1	48.9	51.2	53.8
	56-1/2	46.8	50.1	56.6	57.5	60.3	63.3
	64-1/2	53.9	57.7	65.0	66.2	69.3	72.7
8-1/2"	20-1/2	18.7	20.0	22.5	23.0	24.4	25.8
	24-1/2	22.9	24.5	27.7	28.2	30.0	31.7
	28-1/2	27.2	29.1	32.8	33.5	35.6	37.7
	32-1/2	31.5	33.7	38.0	38.8	41.2	43.6
	36-1/2	35.8	38.3	43.2	44.1	46.8	49.5
	40-1/2	40.1	42.9	48.3	49.4	52.4	55.5
	44-1/2	44.3	47.4	53.5	54.6	58.0	61.4
	48-1/2	48.6	52.0	58.7	59.9	63.6	67.3
	56-1/2	57.2	61.2	69.0	70.5	74.8	79.2
	64-1/2	65.7	70.3	79.4	81.0	86.0	91.0
10-1/2"	20-1/2	20.4	22.0	25.0	25.7	27.4	29.3
	24-1/2	25.2	27.1	30.9	31.7	33.8	36.2
	28-1/2	30.0	32.3	36.8	37.7	40.2	43.1
	32-1/2	34.8	37.4	42.6	43.7	46.6	50.0
	36-1/2	39.6	42.6	48.5	49.8	53.1	56.9
	40-1/2	44.4	47.7	54.4	55.8	59.5	63.7
	44-1/2	49.2	52.9	60.3	61.8	65.9	70.6
	48-1/2	53.9	58.0	66.1	67.8	72.3	77.5
	56-1/2	63.5	68.3	77.9	79.9	85.2	91.2
	64-1/2	73.1	78.6	89.6	91.9	98.0	105.0

CHAPTER 5
INSTALLED RADIATION: DETERMINING HEAT LOAD

STEEL PIPE COILS - Sq Ft of Radiating Surface Per Linear Ft of Coil

Nominal Pipe Size (inches)	Number of Rows of Pipe in Coil							
	1	**2**	**3**	**4**	**5**	**6**	**8**	**10**
1	.57	1.09	1.53	1.90	2.20	2.44	2.83	3.14
1-1/4	.71	1.36	1.91	2.37	2.74	3.04	3.52	3.90
1-1/2	.81	1.55	2.18	2.70	3.12	3.46	4.02	4.45
2	.95	1.81	2.55	3.17	3.66	4.05	4.71	5.22

Notes: 1. Based on 70°F room temperature.
2. Pipes are positioned level, on vertical wall.
3. For coils positioned along floor or ceiling.
Multiply chart value for 1 row of pipe x no. of rows of pipe.



CORRECTION FACTORS IF ROOM TEMPERATURE IS OTHER THAN 70°F DIVIDE SQ. FT. OF RADIATION BY

Room Temp.	80°	75°	70°	65°	60°	55°	50°

Heat Emissions for Cast Iron Radiators			
Design or Average Water Temperature	**Heat Emission Rates Btuh per Sq. Ft.**	**Design or Average Water Temperature**	**Heat Emission Rates Btuh per Sq. Ft.**
110°	30	180°	170
120°	50	185°	180
130°	70	190°	190
140°	90	195°	200
150°	110	200°	210
160°	130	205°	220
170°	150	210°	230
175°	160	215°	240

CHAPTER 5
INSTALLED RADIATION: DETERMINING HEAT LOAD

HEAT LOSSES FROM BARE STEEL PIPE

Based On 70° Surrounding Air

Diameter of Pipe (inches)	Temperature of Pipe °F					
	100	120	150	180	210	240
	Heat Loss per Lineal Foot of Pipe - BTU per Hour					
1/2	13	22	40	60	82	106
3/4	15	27	50	74	100	131
1	19	34	61	90	123	160
1-1/4	23	42	75	111	152	198
1-1/2	27	48	85	126	173	224
2	33	59	104	154	212	275
2-1/2	39	70	123	184	252	327
3	46	84	148	221	303	393
3-1/2	52	95	168	250	342	444
4	59	106	187	278	381	496
5	71	129	227	339	464	603
6	84	151	267	398	546	709
8	107	194	341	509	697	906
10	132	238	420	626	857	1114
12	154	279	491	732	1003	1305
14	181	326	575	856	1173	1527
16	203	366	644	960	1314	1711
18	214	385	678	1011	1385	1802
20	236	426	748	1115	1529	1990

HEAT LOSSES FROM BARE TARNISHED COPPER TUBE

Based On 70° Surrounding Air

Diameter of Pipe (inches)	Temperature of Pipe °F					
	100	120	150	180	210	240
	Heat Loss per Lineal Foot of Pipe - BTU per Hour					
1/4	4	8	14	21	29	37
3/8	6	10	18	28	37	48
1/2	7	13	22	33	45	59
5/8	8	15	26	39	53	68
3/4	9	17	30	45	61	79
1	11	21	37	55	75	97
1-1/4	14	25	45	66	90	117
1-1/2	16	29	52	77	105	135
2	20	37	66	97	132	171
2-1/2	24	44	78	117	160	206
3	28	51	92	136	186	240
3-1/2	32	59	104	156	212	274
4	36	66	118	174	238	307
5	43	80	142	212	288	373
6	51	93	166	246	336	432
8	66	120	215	317	435	562
10	80	146	260	387	527	681
12	94	172	304	447	621	802

Heat Losses from Covered Pipe
85% Magnesia Type
BTU per Linear Foot per Hour per °F Temperature Difference (surrounding air assumed 75°F)

Pipe Size	Insulation, Thickness (inches)	Maximum Temperature of Pipe Surface °F			
		125	175	225	275
1/2	1	.145	.150	.157	.160
3/4	1	.165	.172	.177	.180
1	1	.190	.195	.200	.203
	1-1/2	.160	.165	.167	.170
1-1/4	1	.220	.225	.232	.237
	1-1/2	.182	.187	.193	.197
1-1/2	1	.240	.247	.255	.260
	1-1/2	.200	.205	.210	.215
2	1	.282	.290	.297	.303
	1-1/2	.230	.235	.240	.243
	2	.197	.200	.205	.210
2-1/2	1	.322	.330	.340	.345
	1-1/2	.260	.265	.270	.275
	2	.220	.225	.230	.237
3	1	.375	.385	.395	.405
	1-1/2	.300	.305	.312	.320
	2	.253	.257	.263	.270
3-1/2	1	.419	.430	.440	.450
	1-1/2	.332	.339	.345	.352
	2	.280	.285	.290	.295
4	1	.460	.470	.480	.492
	1-1/2	.362	.370	.379	.385
	2	.303	.308	.315	.320
5	1	.545	.560	.572	.585
	1-1/2	.423	.435	.442	.450
	2	.355	.360	.367	.375
6	1	.630	.645	.662	.680
	1-1/2	.487	.500	.510	.520
	2	.405	.415	.420	.430
8	1	.790	.812	.835	.850
	1-1/2	.603	.620	.635	.645
	2	.495	.507	.517	.527

CHAPTER 6 - WATER CONTENT

EXISTING RADIATION/PIPING

A. RADIATION

Based on Sq. Ft. Rating	Water Content / Gal.	Weight / Lbs.
Slenderized Radiators	0.066	4.5
Large Tube Radiators	0.103	5.25
Column Radiators	0.188	7.0
Convectors (Non-Ferrous)	0.004	1.5
Convectors (Cast Iron)	0.040	3.4
Radiant Radiators	0.066	5.0
Base-Ray (Cast Iron Baseboard)	0.066	4.4

B. STEEL AND WROUGHT IRON PIPE (std. weight)

Nominal Size (inches)	Based on Lineal Feet	
	Water Content / Gal.	Weight / Lbs.
1/2	.016	.132
3/4	.028	.231
1	.045	.375
1-1/4	.078	.648
1-1/2	.106	.883
2	.174	1.455
2-1/2	.249	2.076
3	.384	3.205
4	.661	5.519
5	1.039	8.662
6	1.501	12.510

C. COPPER TUBING (Type L)

Nominal Size (inches)	Based on Lineal Feet	
	Water Content / Gal.	Weight / Lbs.
3/8	.007	.063
1/2	.012	.101
5/8	.018	.151
3/4	.025	.210
1	.043	.357
1-1/4	.065	.544
1-1/2	.092	.770
2	.161	1.340

D. WATER CONVERSION FACTORS

Lbs. of Water x 0.12 = Gallons
Gallons of Water x 8.34 = Lbs.
Lbs. of Water x 27.68 = Cubic Inches
Gallons of Water x 231 = Cubin Inches
Cubic Inches ÷ 1728 = Cubic Feet

SHORT FORM HEAT LOSS SURVEY

Application: Excellent when determining heat loss of a building as a whole. Precise method of sizing replacement hot water boilers.

* Heating Multipliers (H.M.) BTU/Hr. Based on 60°F Temperature Difference (T.D.)

Wall	H.M.	Ceiling	H.M.	Floor	H.M.	Glass	H.M.	Infiltration	H.M.
No Insulation	15	3"	5	No Insulation	4	Single	67	1-1/2 Air Change	1.61
2 Inches	6	6"	4	Overhang 3"	5	Single Insulated	41	1 Air Chnages	1.07
4 Inches	5	9"	3	Overhang 6"	3	Storm	34	3/4 Air Change	0.81
6 Inches	4	10"	2	Overhang 9"	2	Double Insulated	30		

PROCEDURE:

1. Measure the length (L) and width (W) of the outside walls of the house and record. Calculate gross wall area by multiplying height of the walls by total length of outside walls. (2L + 2W).
2. Measure the window and door area and record.
3. Record Net Wall Area = (gross wall area minus door and window area) select proper H.M.
4. Measure and record the ceiling area and select H.M.
5. Measure and record floor area and select H.M. (H.M. of 4 used unheated basement).
6. Multiply floor area by ceiling height to obtain volume of home and select proper air change factor: 1.61 for Loose House - 1.07 for Average House - .81 for Tight House.
   H.M. Floor over Basement T.D. 20°

WORKSHEET:

LENGTH ____________ WIDTH __________ HEIGHT ___________

	AREA (ft²)		H.M.(BTU/Hr.)		BTU/Hr. Loss
GROSS	____________				
WINDOWS & DOORS	____________	X	________	=	____________
NET WALL	____________	X	________	=	____________
CEILING	____________	X	________	=	____________
FLOOR	____________	X	________	=	____________
INFILTRATION (CU. FT.) (HEIGHT) X (FLOOR AREA)	____________	X	________	=	____________

TOTAL HEAT LOSS = ____________

TEMP. DIFFERENCE CORRECTION = ____________

*To Increase Temp. Difference to70°F, Multiply Total Heat Loss 1.18
80°F, Multiply Total Heat Loss 1.34
90°F, Multiply Total Heat Loss 1.50
100°F, Multiply Total Heat Loss 1.66

CHAPTER 7 - HEAT LOSS CALCULATION

SHORT FORM HEAT LOSS SURVEY

Application: Excellent when determining heat loss of a building as a whole. Precise method of sizing replacement hot water boilers.

* Heating Multipliers (H.M.) BTU/Hr. Based on 60°F Temperature Difference (T.D.)

Wall	H.M.	Ceiling	H.M.	Floor	H.M.	Glass	H.M.	Infiltration	H.M.
No Insulation	15	3"	5	No Insulation	4	Single	67	1-1/2 Air Change	1.61
2 Inches	6	6"	4	Overhang 3"	5	Single Insulated	41	1 Air Chnages	1.07
4 Inches	5	9"	3	Overhang 6"	3	Storm	34	3/4 Air Change	0.81
6 Inches	4	10"	2	Overhang 9"	2	Double Insulated	30		

PROCEDURE:

1. Measure the length (L) and width (W) of the outside walls of the house and record. Calculate gross wall area by multiplying height of the walls by total length of outside walls. (2L + 2W).
2. Measure the window and door area and record.
3. Record Net Wall Area = (gross wall area minus door and window area) select proper H.M.
4. Measure and record the ceiling area and select H.M.
5. Measure and record floor area and select H.M. (H.M. of 4 used unheated basement).
6. Multiply floor area by ceiling height to obtain volume of home and select proper air change factor: 1.61 for Loose House - 1.07 for Average House - .81 for Tight House.
   H.M. Floor over Basement T.D. 20°

WORKSHEET:

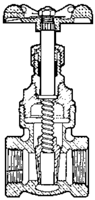
LENGTH 70 WIDTH 30 HEIGHT 8

	AREA (ft²)	H.M.(BTU/Hr.)		BTU/Hr. Loss
GROSS	1600			
WINDOWS & DOORS	265	X 41	=	10,865
NET WALL	1335	X 5	=	6,675
CEILING	2100	X 4	=	8,400
FLOOR	2100	X 4	=	8,400
INFILTRATION (CU. FT.) (HEIGHT) X (FLOOR AREA)	2100	X 8 X 1.07	=	17,976

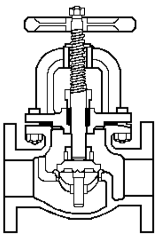
TOTAL HEAT LOSS = 52,316

TEMP. DIFFERENCE CORRECTION = 61,733

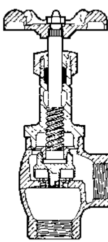
*To Increase Temp. Difference to70°F, Multiply Total Heat Loss 1.18
80°F, Multiply Total Heat Loss 1.34
90°F, Multiply Total Heat Loss 1.50
100°F, Multiply Total Heat Loss 1.66



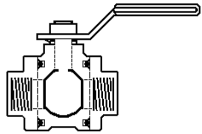
Gate Valve has a wedge-shaped disc that is raised to open and lowered to close the valve. It is used either fully open or totally closed and is not designed for throttling.



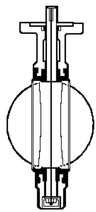
Globe Valve uses a round disc or tapered plug-type disc that seats against a port to close the valve. Globe valves are used where throttling and/or when frequent operation is required.



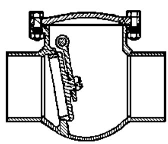
Angle Valve operates the same as globe valve. Has less resistance to flow than its globe counterpart and by design acts as a 90° elbow, eliminationg the need for a fitting.



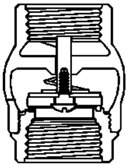
Ball Valve its operating device consists of a ball with a hole through its center. The valve operator rotates 90 degrees from fully open to the fully closed position. Its major application is isolation but can be used to regulate flow.



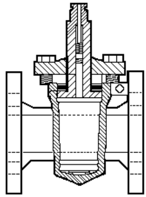
Butterfly Valve has a wafer-shaped body with a thin, rotating disc closing device. Like the ball valve, the butterfly operates with a one-quarter turn to go full open to closed. The disc is always in the flow but the disc is thin and offers little flow restriction.



Swing Check Valve has a hinged disc that swings on a hinge pin. When the flow reverses, the pressure pushes the disc against a seat preventing back flow.



Lift Check Valve has a guided disc that rises from its seat by upward flow pressure. Flow reversal pushes the disc down against its seat, stopping back flow. Though the lift check has greater flow resistance than the swing check, it is more suitable for rapid opera-



Plug Valve uses a tapered cylindrical plug that fits a body seat of corresponding shape. A one-quarter turn (90°) operates the valve from open to close. Valve plugs may be lubricated or non-lubricated.

APPLICATION

Valve Type	Principle Service Function	Full Open-flow Resistance	Throttling Application	Closure Speed	Allowable Frequency of Operation	Positive Shut-off
Gate	Isolation	Low	Unacceptable	Slow	Low	Poor
Globe	Flow Regulation	High	Good	Moderate	Moderate	Good
Angle	Flow Regulation	Medium - High	Good	Moderate	Moderate	Good
Ball	Isolation	Low	Fair	Fast	High	Good
Butterfly	Isolation	Low	Fair to Good	Fast	High	Good
Swing Check	Flow Reversal Control	Low	N/A	Fast	Low	Poor
Lift Check	Flow Reversal Control	High	N/A	Moderate	Moderate	Fair
Plug	Flow Regulation/ Isolation	Low	Good to Excellent	Fast	Moderate	Good

CHAPTER 9 - VENTING FLUE PRODUCTS

A. ACCEPTABLE VENTING MATERIAL

Type	Temperature	Application
AL29-4C® (Proprietary stainless gas equipment steel pipe)	00°F to 480°F	Pressure vented gas equipment
Single-wall Metal Pipe	Refer to codes and to manufacturer's recommendations	Aluminum, galvanized steel or stainless steel; depending on the application (1)
B and BW Vent	to 550°F	Gas equipment
L Vent	to 1000°F	Oil equipment (1)
Factory-built Chimney	500°F to 2,200°F	Oil or gas-fired equipment (1)
Masonry Chimney (title liner & air space)	360°F to 1,800°F	Gas or oil equipment (metal liner may be required) (2)

(1) Stainless-steel vents can resist the heat that is associated with oil-fired vent gases, but when the inner wall temperature is below 250°F, it loses its ability to resist acidic damage.

(2) Masonry chimneys also are susceptible to acidic damage.

B. METAL VENTS

Type	Description
"B"	Double-wall round gas vent pipe with a relatively low permissible temperature of vent gases.
"BW"	Double-wall oval gas vent pipe designed to fit within a conventional stud wall. Same application as Type "B".
"L"	Double-wall round stainless steel insulated. Type "L" is rated for higher temperature vent gas than the Type "B". Type "L" may be usedin lieu of "B" but not vice versa.
"C"	Single-wall galvanized

IMPORTANT:

VENTING GUIDE FOR ALL BURNHAM RESIDENTIAL GAS BOILERS -- SEE PAGE 124

C. VENTING CATEGORIES: GAS-FIRED EQUIPMENT

Operating Characteristics	**Category I**	**Category II**	**Category III**	**Category IV**
Pressure in the vent	Negative	Negative	Positive	Positive
Temperature of vent gas (4)	Above 275°F	Below 275°F	Above 275°F	Below 275°F
Annual efficiency	Below 84%	Above 84%	Below 84%	Above 84%
Condensation	Not Acceptable(1)	Possible (in vent)	Possible (3)	In Heat Exchanger
Design Requirements				
Gas (air) tight vent	No	No	Yes	Yes
Corrosion resistant vent (water tight)	No (1)	Yes	Possible (3)	Yes
Vent into masonry chimney	Permitted (1) and (2)	No	No	No
Combined venting	Permitted	No	No	No
Condensate drain	No	Ask Manufacturer	Possible (3)	Yes (at equipment)
Source of information	N.F.G.C. Fuel gas code, heating equipment and vent system manufacturers	Manufacturer Literature	Manufacturer Literature	Manufacturer Literature

NOTE 1 Usually, there is no problem when high vent gas temperature equipment is vented into double-wall vent or into a lined masonry chimney; but condensation could occur if mid-efficiency (80% to 84%) mechanical draft equipment is vented into a vent that has highly conductive walls, cold walls, or massive walls. In this case, design a vent system that minimizes the wall losses (use double-wall pipe for the whole run and avoid long runs through cold spaces).

NOTE 2 Install either a rigid or flexible metal liner inside of the masonry chimney and use a double-wall connector when venting mid-efficiency (80% to 84%), mechanical draft equipment.

NOTE 3 Condensation in the vent is possible with some types mid-efficiency (80% to 84%), direct-vent equipment, depending on the ambient temperature and the conductivity of the vent walls. In this case, design a vent system that minimizes the wall losses (use insulated pipe and avoid long runs through cold spaces). A corrosion-resistant flue and a drain may be required if condensation cannot be prevented — refer to the manufacturer's recommendations.

NOTE 4 The dewpoint of the vent gas depends on the fuel (natural or LP gas), the amount of excess air and the amount of dilution air. The limiting case occurs when the dewpoint of the vent gas is at a maximum, which is about 135°F. This maximum is produced when natural gas is burned with no excess air or dilution air. Therefore 275°F = 135°F dewpoint + 140°F rise.

CHAPTER 10 - MISCELLANEOUS

ENERGY TERMS - CONVERSIONS - HEAT VALUES

A. PREFIXES - Prefixes indicateorders of magnitude in steps. Prefixes provide a convenient way to express large and small numbers and to eliminate nonsignificant digits and leading zeros in decimal fractions. The following are the more commonly used prefixes:

Symbol	Represents
English System	
C	100
M	1,000
MM	1,000,000
Metric System	
K	1,000
M*	1,000,000

*Caution: make certain of the system.

B. NATURAL GAS ENERGY MEASUREMENTS IN BTU

1,000	=	1 Cubic Foot
100,000	=	1 therm or 1 CCF or 100 MBTU
1,000,000	=	1 MMBTU or 1,000 CF or 1 MCF
1,000,000,000	=	1 billion BTU or 1 MMCF
1,000,000,000,000	=	1 trillion BTU or 1 BCF
1,000,000,000,000,000	=	1 quadrillion BTU or 1 TCF

C. ENERGY MEASUREMENTS OF OTHER FUELS IN BTU

Propane	2,550 btu	=	1 CF
	21,650 btu	=	1 Lb.
	91,800 btu	=	1 Gal.
Butane	3,200 btu	=	1 CF
	21,500 btu	=	1 Lb.
	102,400 btu	=	1 Gal.
Oil	5,825,000 btus	=	1 barrel crude
	6,200,000 btus	=	1 barrel #5 (Residual)
	6,400,000 btus	=	1 barrel #6 (heating)
	134,000 btus	=	1 Gal. #1 oil (kerosene)
	139,000 btus	=	1 Gal. #2 oil
	146,800 btus	=	1 Gal. #4 oil
	150,000 btus	=	1 Gal. #6 oil
	(1 U.S. Barrel	=	42 U.S. Gallons)

Electric	3,412 btus	=	1 Kilowatt
Coal	21,700,000 btus	=	1 Ton Bituminous (soft)
	22,800,000 btus	=	1 Ton Anthracite (hard)
Wood	3,500 btus	=	1 Lb. (mixed average)
	14,000,000 btus	=	1 Cord (mixed average)

D. QUICK FUEL COMPARISONS BASED ON 1,000,000 BTUS

Natural Gas	=	10 Therms
Propane Gas	=	10.89 Gal.
Butane Gas	=	9.77 Gal.
#1 Oil	=	7.46 Gal.
#2 Oil	=	7.19 Gal.
#4 Oil	=	6.81 Gal.
#6 Oil	=	6.67 Gal.
Bituminous Coal	=	.046 Ton (92 Lbs.)
Anthracite Coal	=	.044 Ton (88 Lbs.)
Wood (mixed avg)	=	286 Lbs.

CHAPTER 10 - MISCELLANEOUS

MEASURING GAS & OIL INPUT

Gas on pages 80 and 81 - Oil on page 82

1. GAS RATE - CUBIC FEET PER HOUR

Second for One Revoltion	Size of Test Dial		Seconds for One Revolution	Size of Test Dial	
	2 Cu. Ft.	5 Cu. Ft.		2 Cu. Ft.	5 Cu. Ft.
10	720	1800	55	131	327
11	655	1636	56	129	321
12	600	1500	57	126	316
13	555	1385	58	124	310
14	514	1286	59	122	305
15	480	1200	60	120	300
16	450	1125	62	116	290
17	424	1059	64	112	281
18	400	1000	66	109	273
19	379	947	68	106	265
20	360	900	70	103	257
21	343	857	72	100	250
22	327	818	74	97	243
23	313	783	76	95	237
24	300	750	78	92	231
25	288	720	80	90	225
26	277	692	82	88	220
27	267	667	84	86	214
28	257	643	86	84	209
29	248	621	88	82	205
30	240	600	90	80	200
31	232	581	92	78	196
32	225	563	94		192
33	218	545	96	75	188
34	212	529	98		184
35	206	514	100	72	180
36	200	500	102		176
37	195	486	104	69	173
38	189	474	106		170
39	185	462	108	67	167
40	180	450	110		164
41	176	439	112	64	161
42	172	429	116	62	155
43	167	419	120	60	150
44	164	409	125		144
45	160	400	130		138
46	157	391	135		132
47	153	383	140		129
48	150	375	145		124
49	147	367	150		120
50	144	360	155		116
51	141	353	160		113
52	138	346	165		109
53	136	340	170		106
54	133	333	175		103
55	131	327	180		100

Second for One Revoltion	Size of Test Dial		Seconds for One Revolution	Size of Test Dial	
	1/2 Cu. Ft.	1 Cu. Ft.		1/2 Cu. Ft.	1 Cu. Ft.
10	180	360	35	103	
11	164	327	36	50	100
12	150	300	37	97	
13	138	277	38	47	95
14	129	257	39	92	
15	120	240	40	45	90
16	113	225	41		
17	106	212	42	43	86
18	100	200	43		
19	95	189	44	41	82
20	90	180	45	40	80
21	86	171	46		78
22	82	164	47	38	
23	78	157	48		75
24	75	150	49		
25	72	144	50	36	72
26	69	138	51		
27	67	133	52		69
28	64	129	53	34	
29	62	124	54		67
30	60	120	55		
31		116	56	32	64
32	56	113	57		
33		109	58	31	62
34	53	106	59		
35		103	60	30	60

2. OIL RATE -- GALLON PER HOUR

Nozzle Delivery Rates at Various Pressures for No. 2 Fuel Oil

Pump Pressure (PSI)

	100	125	140	150	175	200	225	250	275	300
1.0	1.0	1.1	1.18	1.2	1.3	1.4	1.5	1.6	1.7	1.75
1.5	1.5	1.7	1.77	1.8	2.0	2.1	2.3	2.4	2.5	2.6
2.0	2.0	2.2	2.37	2.5	2.6	2.9	3.0	3.2	3.3	3.5
2.5	2.5	2.8	2.96	3.1	3.3	3.5	3.8	4.0	4.1	4.3
3.0	3.0	3.3	3.55	3.7	3.9	4.2	4.5	4.7	5.0	5.2
3.5	3.5	3.9	4.14	4.3	4.6	5.0	5.3	5.5	5.8	6.0
4.0	4.0	4.5	4.73	4.9	5.3	5.6	6.0	6.3	6.6	6.9
4.5	4.5	5.0	5.32	5.5	5.9	6.3	6.8	7.1	7.4	7.8
5.0	5.0	5.6	5.95	6.1	6.6	7.1	7.5	7.9	8.3	8.7
5.5	5.5	6.2	6.51	6.7	7.3	7.8	8.3	8.7	9.1	9.5
6.0	6.0	6.7	7.10	7.3	7.9	8.5	9.0	9.5	9.9	10.4
7.0	7.0	7.8	8.28	8.5	9.2	9.9	10.5	11.0	11.6	12.0
8.0	8.0	8.9	9.47	9.8	10.5	11.3	12.0	12.6	13.2	13.8
9.0	9.0	10.0	10.65	11.0	11.8	12.6	13.5	14.2	14.8	15.6
10.0	10.0	11.2	11.83	12.2	13.2	14.1	15.0	15.8	16.6	17.3
11.0	11.0	12.3	13.02	13.4	14.5	15.6	16.5	17.4	18.2	19.0
12.0	12.0	13.4	14.20	14.6	15.8	16.9	18.0	18.9	19.8	20.7
13.0	13.0	14.5	15.40	16.0	17.2	18.4	19.5	20.6	21.5	22.5
14.0	14.0	15.5	16.60	17.0	18.4	19.8	21.0	22.0	23.1	24.0
15.0	15.0	16.8	17.70	18.4	19.8	21.3	22.5	23.6	24.8	25.9
16.0	16.0	17.8	18.90	19.5	21.0	22.6	24.0	25.3	26.4	27.7
17.0	17.0	19.0	20.1	20.7	22.5	24.1	25.5	26.9	28.0	29.3
18.0	18.0	20.1	21.30	22.0	23.7	25.3	27.0	28.4	29.7	31.2
20.0	20.0	22.3	23.70	24.4	26.4	28.2	30.0	31.7	33.1	34.6
22.0	22.0	24.6	26.0	26.9	29.0	31.2	33.0	34.8	36.4	38.0

NOTES:

To determine the nozzle flow rate at a higher pump pressure

$FR = NF \times \sqrt{\frac{OP}{100}}$

Where;

FR = Flow Rate

NF = Nominal Flow @ 100 psi

OP = Operating Pump Pressure

To determine pump pressure to get required flow rate

$PP = \left(\frac{DFR}{NF}\right)^2$

Where;

PP = Pump Pressure

DFR = Desired Flow Rate

NF = Nominal Flow @ 100 psi

These delivery rates are approximate values. Actual rates will vary slightly between different nozzles of the same nominal rating. Delivery tends to increase with higher viscosity, or lower oil temperature, or lower specific gravity.

CHAPTER 10 - MISCELLANEOUS

ACIDITY AND ALKALINITY - (pH)

pH is the logarithm of the reciprocal of the Hydrogen concentration.

$$pH = \log_{10} \frac{1}{H+} \quad \text{(gram/liter equiv.)}$$

Since 1 hydroxyl ion is formed whenever a hydrogen ion develops, the pH scale also is used to measure the formation of hydroxyl ions.

Typical pH values, relative strength:

1	1,000,000	1/10 normal HCl sol
2	100,000	Gastric Fluid
3	10,000	Vinegar (4% acetic acid)
4	1,000	Orange or grape juice
5	100	Molasses
6	10	Milk (6.8 pH)
7	1	Pure Water, saliva
8	10	Baking Soda, sea water
9	100	Borax solutioin
10	1,000	Soap - Milk of magnesia
11	10,000	Tri-sodium phosphate
12	100,000	Household ammonia (10%)
13	1,000,000	Lye - Na O H

Manufacturers of hydronic and air conditioning equipment recommend a pH value of 7.5 to 8.5 in the circulating water.

The pH levels in all industrial cooling and heating systems are closely supervised. Excessive acidity (pH 5-6) causes corrosion and high alkalinity (pH 8-10) results in heavy scale deposits on hot heat transfer surfaces.

GAS PIPE SIZING - RESIDENTIAL

Interior gas piping must be examined before installing a new gas boiler. A typical winter load and even a summer load (indirect hot water supply) must be considered. Listed below are average inputs of various gas appliances that may be on-line. Also listed is a chart to determine whether the existing piping can carry the seasonal load.

For specific appliances or appliances not shown below, the input should be determined from the manufacturer's rating.

Approximate Gas Input for Some Common Appliances

Appliance	Input BTU Per Hr. (Approx.)
Range, Free Standing, Domestic	65,000
Built-In Oven or Broiler Unit, Domestic	25,000
Built-In Top Unit, Domestic	40,000
Water Heater, Automatic Storage - 30 to 40 Gal. Tank	45,000
Water Heater, Automatic Storage - 50 Gal. Tank	55,000
Fireplace/Gas Log	21,000 - 55,000
Grill	30,000 - 40,000
Boiler	----
Clothes Dryer, Type 1 (Domestic)	20,000 - 35,000
Gas Light	2,500
Incinerator, Domestic	35,000

Maximum Capacity of Pipe in Cubic Feet of Gas per Hour

(Based on a pressure drop of 0.3 inch water column and 0.6 specific gravity gas)

Length (feet)	Nominal Iron Pipe Size (inches)								
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
10	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500
20	92	190	350	730	1,100	2,100	3,300	5,900	12,000
30	73	152	285	590	890	1,650	2,700	4,700	9,700
40	63	130	245	500	760	1,450	2,300	4,100	8,300
50	56	115	215	440	670	1,270	2,000	3,600	7,400
60	50	105	195	400	610	1,150	1,850	3,250	6,800
70	46	96	180	370	560	1,050	1,700	3,000	6,200
80	43	90	170	350	530	990	1,600	2,800	5,800
30	40	84	160	320	490	930	1,500	2,600	5,400
100	38	79	150	305	460	870	1,400	2,500	5,100
125	34	72	130	275	410	780	1,250	2,200	4,500
150	31	64	120	250	380	710	1,130	2,000	4,100
175	28	59	110	225	350	650	1,050	1,850	3,800
200	26	55	100	210	320	610	980	1,700	3,500

Correction Factors for Specific Gravity Other Than 0.60

Specific Gravity	Multiplier	Specific Gravity	Multiplier
.35	.763	1.00	1.29
.40	.813	1.10	1.35
.45	.862	1.20	1.40
.50	.909	1.30	1.47
.55	.962	1.40	1.53
.60	1.00	1.50	1.58
.65	1.04	1.60	1.63
.70	1.08	1.70	1.68
.75	1.12	1.80	1.73
.80	1.15	1.90	1.77
.85	1.19	2.00	1.83
.90	1.22	2.10	1.87

CHAPTER 10 - MISCELLANEOUS

ABBREVIATIONS USED IN HEATING

Absolute .... abs
Alternating-Current .... a-c
Ampere .... amp
Atmosphere .... atm
Average .... avg
Avoirdupois .... avdp
Barometer .... bar
Boiling Point .... bp
Brake Horsepower .... bhp
Brake Horsepower, Hour .....bhp-hr
British Thermal Unit .... Btu
per hour .... Btuh
Calorie .... cal
Centigram .... cg
Centimeter .... cm
Cubic .... cu
Cubic Centimeter cc
Cubic Foot .... cu ft
Cubic Feet per Minute .... cfm
Cubic Feet per Second .... cfs
Degree .... deg or °
Degree, Centigrade C
Degree, Fahrenheit .... F
Diameter .... diam
Direct-Current .... d - c
Feet per Minute .... fpm
Feet per Second .... fps
Foot .... ft
Foot-Pound .... ft lb
Freezing Point .... fp
Gallon .... gal
Gallons per Minute .... gpm
Gallons per Second .... gps
Gram .... g
Horsepower .... hp
Horsepower-Hour .... hp-hr
Hour .... hr
Inch .... in
Inch-Pound .... in-lb
Kilogram .... kg
Kilowatt .... kw
Melting Point .... mp
Meter .... m
Miles per Hour .... mph
Millimeter .... mm
Minute .... min
Ounce .... oz
Pound .... lb
Pounds per Square Inch .... psi
Pounds per Square Inch, Gage .... psig
Pounds per Square Inch, Absolute ...psia
Revolutions per Minute .... rpm
Revolutions per Second .... rps
Second .... sec
Specific Gravity .... sp gr
Specific Heat .... sp ht
Square Foot .... sq ft
Square Inch .... sq in
Volt v
Watt .... w
Watt Hour .... whr

CAPACITY OF ROUND STORAGE TANKS

Number of Gallons

Depth or Length (feet)	Inside Diameter (inches)									
	18	24	30	36	42	48	54	60	66	72
1	1.10	1.96	3.06	4.41	5.99	7.83	9.91	12.24	14.81	17.62
2	26	47	73	105	144	188	238	294	356	423
2-1/2	33	59	91	131	180	235	298	367	445	530
3	40	71	100	158	216	282	357	440	534	635
3-1/2	46	83	129	184	252	329	416	513	623	740
4	53	95	147	210	288	376	475	586	712	846
4-1/2	59	107	165	238	324	423	534	660	800	952
5	66	119	181	264	360	470	596	734	899	1057
5-1/2	73	130	201	290	396	517	655	808	978	1163
6	79	141	219	315	432	564	714	880	1066	1268
6-1/2	88	155	236	340	468	611	770	954	1156	1374
7	92	165	255	368	504	658	832	1028	1244	1480
7-1/2	99	179	278	396	540	705	889	1101	1335	1586
8	106	190	291	423	576	752	949	1175	1424	1691
9	119	212	330	476	648	846	1071	1322	1599	1903
10	132	236	366	529	720	940	1189	1463	1780	2114
12	157	282	440	634	864	1128	1428	1762	2133	2537
14	185	329	514	740	1008	1316	1666	2056	2490	2960
16	211	376	587	846	1152	1504	1904	2350	2844	3383
18	238	423	660	952	1296	1692	2140	2640	3200	3806
20	264	470	734	1057	1440	1880	2380	2932	3556	4230

CAPACITY OF RECTANGULAR TANKS

To find the capacity in U.S. gallons of rectangular tanks, reduce all dimensions to inches, then multiply the length by the width by the height and divide the product by 231.

Example: Tank 56” long x 32” wide x 20” deep

Then 56” x 32” x 20” = 35,840 cu. in.

35,840 ÷ 231 = 155 gallon capacity

GRAINS OF MOISTURE PER CUBIC FOOT OF AIR AT VARIOUS TEMPERATURES AND HUMIDITIES

Temp. °F	Relative Humidity, Percent %									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
75	9.35	8.42	7.49	6.55	5.61	4.68	3.74	2.81	1.87	0.94
72	8.51	7.66	6.81	5.96	5.11	4.25	3.40	2.55	1.70	0.85
70	7.98	7.18	6.38	5.59	4.79	3.99	3.19	2.39	1.60	0.80
67	7.24	6.52	5.79	5.07	4.35	3.62	2.90	2.17	1.45	0.72
65	6.78	6.10	5.43	4.75	4.07	3.39	2.71	2.04	1.36	0.68
60	5.74	5.17	4.60	4.02	3.45	2.87	2.30	1.72	1.15	0.57
50	4.08	3.67	3.26	2.85	2.45	2.04	1.63	1.22	0.82	0.41
40	2.85	2.56	2.28	1.99	1.71	1.42	1.14	0.86	0.57	0.29
30	1.94	1.74	1.55	1.35	1.16	0.97	0.78	0.58	0.39	0.19
20	1.23	1.11	0.99	0.86	0.74	0.62	0.49	0.37	0.25	0.12
10	0.78	0.70	0.62	0.54	0.47	0.39	0.31	0.23	0.16	0.08
0	0.48	0.43	0.39	0.34	0.29	0.24	0.19	0.14	0.10	0.05

7000 Grains of moisture = 1 pound of water

HEATING CONVERSION FACTORS

BTUs	X	1054.8	=	Joules
BTUs	X	0.2520	=	Kg. Cal.
Calories	X	4.186	=	Joules
Joules	X	0.23889	=	Calories
Joules	X	.0002389	=	Kg. Cal.
Kg. Cal.	X	3.9685	=	BTUs
KW-hr	X	860.01	=	Kg. Cal.
KW-hr	X	3413.0	=	BTUs
Watt-hr	X	3.413	=	BTUs

QUANTITY OF HEAT IN BTU REQUIRED TO RAISE 1 CU. FT. OF AIR THROUGH A GIVEN TEMPERATURE INTERVAL

External Temp.°F	Temperature of Air in Room							
	40	50	60	70	80	90	100	110
-40	1.802	2.027	2.252	2.479	2.703	2.928	3.154	3.379
-30	1.540	1.760	1.980	2.200	2.420	2.640	2.860	3.080
-20	1.290	1.505	1.720	1.935	2.150	2.365	2.580	2.795
-10	1.051	1.262	1.473	1.684	1.892	2.102	2.311	2.522
0	0.822	1.028	1.234	1.439	1.645	1.851	2.056	2.262
10	0.604	0.805	1.007	1.208	1.409	1.611	1.812	2.013
20	0.393	0.590	0.787	0.984	1.181	1.378	1.575	1.771
30	0.192	0.385	0.578	0.770	0.963	1.155	1.345	1.540
40	—	0.188	0.376	0.564	0.752	0.940	1.128	1.316
50	—	—	0.184	0.367	0.551	0.735	0.918	1.102
60	—	—	—	0.179	0.359	0.538	0.718	0.897
70	—	—	—	—	0.175	0.350	0.525	0.700

MELTING POINTS OF METALS

	Degrees °F		Degrees °F
Aluminum	1220	Iron (Cast) Gray	2460-2550
Antimony	1167	Iron (Cast) White	1920-2010
Bismuth	520	Iron, Wrought	2460-2640
Brass (Red)	1870	Lead	622
Bronze	1900	Silver (Pure)	1761
Copper	1981	Steel	2370-2550
Glass	2377	Tin	449
Gold (Pure)	1945	Zinc	787
Solder (Lead-Tin)	250-570		

CHAPTER 10 - MISCELLANEOUS

CONVERSION FACTORS

WATER

U.S. Gallons	x	8.34	=	Pounds
U.S. Gallons	x	0.13368	=	Cubic Feet
U.S. Gallons	x	231.00	=	Cubic Inches
U.S. Gallons	x	3.78	=	Liters
Imperial Gallons	x	277.3 Cubic Inches		
Imperial Gallons at 62°F	=	10.0 Pounds		
Cubic In. of Water (39.2°)	x	0.036130	=	Pounds
Cubic In. of Water (39.2°)	x	0.004329	=	U.S. Gallons
Cubic In. of Water (39.2°)	x	0.576384	=	Ounces
Cubic Feet of Water (39.2°)	x	62.427	=	Pounds
Cubic Feet of Water (39.2°)	x	7.48	=	U.S. Gallons
Cubic Feet of Water (39.2°)	x	0.028	=	Tons
Pounds of Water	x	27.72	=	Cubic Inches
Pounds of Water	x	0.01602	=	Cubic Feet
Pounds of Water	x	0.12	=	U.S. Gallons

PRESSURE

1 Pound Per Square Inch	=	144 Pounds Per Square Foot
		2.0355 Inches of Mercury at 32°F.
		2.0416 Inches of Mercury at 62°F.
		2.309 Feet of Water at 62°F.
		27.71 Inches of Water at 62°F
		6.895 kPA (kilopascal)
1 Ounce Per Square Inch	=	0.1276 Inches of Mercury at 62°F.
		1.732 Inches of Water at 62°F.
1 Atmosphere	=	2116.3 Pounds Per Square Foot
(14.7 Lbs. Per Sq. In.)		33.947 Feet of Water at 62°F.
		30 Inches of Mercury at 62°F.
		29.922 Inches of Mercury at 32°F.
		760 Millimeters of Mercury at 32°F.
		101.3 kilopascal
	=	235.1 ounces per sq. in.
1 Inch Water	=	0.03609 Lbs. or 0.5774 oz Per Sq. In.
(at 62°F.)		5.196 Pounds Per Square Foot
		0.248 kilopascal
	=	235.1 oz/in^2
1 Foot Water	=	0.433 Pounds Per Square Inch
(at 62°F.)		62.355 Pounds Per Square Foot
1 Inch Mercury	=	0.491 Lbs. or 7.86 oz. Per Sq. In
(at 62°F.)		1.132 Feet Water at 62°F.
		13.58 Inches Water at 62°F.

EQUIVALENT VALUE IN DIFFERENT UNITS

1 H.P.	=	746 watts
		.746 K.W.
		33,000 ft.-lbs. per minute
		550 ft.-lbs. per second
1 H.P.	=	33.475 BTU/hr
	=	34.5 lb steam/hr from and at 212°F
1 Kilowatt	=	1,000 watts
		1.34 H.P.
		3.53 lbs. water evaporated per hour f rom and at 212°F.
1 Watt	=	.00134 H.P.
		.0035 lb. water evaporated per hour
1 K.W. Hour	=	1,000 watt hours
		1.34 H.P. Hours
		3,600,000 joules
		3.53 lbs. water evaporated from and at 212°F.
		22.75 lbs. of water raised from 62°F to 212°F
1 Joule	=	1 watt second
		.000000278 K.W. hour
MJ = Megajoule	=	1,000,000 Joule = 948 BTU
		239 Kcal

EQUIVALENTS OF ELECTRICAL UNITS

1 Kilowatt	=	1.34 H.P.
		0.955 BTU per second
		57.3 BTU per minute
		3438 BTU per hour
1 Horse Power	=	746 watts
		42.746 BTU per minute
		2564.76 BTU per hour
1 BTU	=	17.452 watt minutes
		0.2909 watt hour

CHAPTER 10 - MISCELLANEOUS

STANDARD SYMBOLS IN HEATING SPECIFICATIONS

Δ(delta)	=	differential, difference in, change in, increment
Δ**P**	=	pressure drop, differential, or loss usually in psi
Δ**T**	=	difference, change or drop in temperature
π(pi)	=	3.141592654 = ratio of circumference of a circle to the diameter of that circle
Σ(sigma)	=	sum, summation, total of
Ω(omega)	=	ohm, unit of electric resistance = 1 V/A
$\pm$	=	plus or minus, tolerance
$\neq$	=	not equal to
$<$	=	(is) less than
$\leq$	=	smaller than or equal to
$>$	=	(is) greater than
$\geq$	=	greater than or equal to
$\ll$	=	much smaller than
$\gg$	=	much larger than
α	=	proportional to, similar to
$\approx$	=	approximately equal to
$\cong$	=	congruent to
$\therefore$	=	therefore
$\angle$	=	angle
$\|\|$	=	parrallel to
$\perp$	=	perpendicular to, at right angles to
∞	=	infinity, infinite

CONDENSING GAS BOILERS

Alpine™ - Gas, Stainless Steel, Condensing, High Efficiency

Model Number	AFUE %	Input (Min-Max) MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
ALP080	95.0	16-80	73	63
ALP105	95.0	21-105	96	83
ALP150	95.0	30-150	137	119
ALP210	95.0	42-210	193	168
ALP285	95.0	57-285	263	229
ALP399	94.1/94.5	80-399	377	328
ALP500	95.0	100-500	475	413

Freedom™ - Gas, Cast Aluminum, Condensing, High Efficiency

Model Number	AFUE %	Input (Min-Max) MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
FCM070	95.4	30-70	63	55
FCM090	94.5	30-90	80	70
FCM120	95.2	40-120	107	93

CHG™ - Gas, Cast Aluminum, Condensing, High Efficiency

Model Number	AFUE %	Input (Min-Max) MBH	DOE Heat. Cap. MBH	Net I=B-R MBH
CHG150	93.10	30-150	135	117
CHG225	94.20	56.25-225	202	176

GAS BOILERS

Revolution® - Gas, Cast Iron, High Efficiency

ENERGY STAR

Model Number	AFUE%	Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
RV3	88.0	62	55	48
RV4	87.6	96	84	73
RV5	87.4	130	114	99
RV6	87.2	164	143	124
RV7	87.0	190	166	144

PVG™ & SCG™ - Gas, Cast Iron, High Efficiency

ENERGY STAR

Model Number	AFUE %	Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
PVG3 / SCG3	85.5	70	60	52
PVG4 / SCG4	85.4	105	90	78
PVG5 / SCG5	85.3	140	120	104
PVG6 / SCG6	85.2	175	150	130
PVG7 / SCG7	85.0	210	179	156
PVG8 / SCG8	84.5*	245	208	181
PVG9 / SCG9	84.0*	280	238	207

* Only PVG3/SCG3 - PVG7/SCG7 are ENERGY STAR certified at 85+% AFUE

ES2™ - Gas, Cast Iron, High Efficiency

Model Number	AFUE %	Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
ES23	85.0	70	59	51
ES24	85.0	105	88	77
ES25	85.0	140	118	102
ES26	85.0	175	147	128
ES27	85.0	210	176	153
ES28	85.0	245	206	179
ES29	85.0	280	235	205

Series 3™ - Gas, Cast Iron

Model Number	AFUE %	Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
303	84.0	70	59	51
304	84.0	105	88	77
305	84.0	140	118	102
306	84.0	175	147	128
307	84.0	210	176	153
308	84.0	245	206	179
309	84.0	280	235	205

Series 2® - Gas, Cast Iron

Model Number	AFUE %		Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
	SP	EI			
202	80.0	82.3	38	31	27
202X	80.2	83.2	50	42	37
203	80.0	82.6	62	52	45
204	80.1	82.3	96	80	70
205	80.2	82.0	130	108	94
206	80.3	81.7	164	136	118
207	80.4	81.4	198	163	142
208	80.4	81.2	232	191	166
209	80.5	80.9	266	218	190
210	80.7	80.6	299	244	212
203H	N/A	84.0	62	52	45
204H	N/A	84.0	96	80	70
205H	N/A	84.0	130	108	94
206H	N/A	84.0	164	136	118

Independence® - Gas, Cast Iron, Steam

Model Number	Steam AFUE%		Input MBH	DOE Heat. Cap. MBH	Net I=B=R	
	24V	EI			MBH	Sq.Ft
IN3	80.0	81.9	62	51	38	158
IN4	80.0	82.0	105	87	65	271
IN5	80.3	82.0	140	115	86	358
IN6	80.6	82.1	175	144	108	450
IN7	80.9	82.1	210	173	130	542
IN8	80.0	82.2	245	202	152	633
IN9	80.3	82.2	280	231	174	725
IN10	82.5 (Comb. Eff.)		315	260*	195	812
IN11	82.5 (Comb. Eff.)		349	288*	216	900
IN12	82.5		385	318*	239	996

* AGA Gross Out

Independence PV® - Gas, Cast Iron

Model Number	AFUE %	Input MBH	DOE Heat. Cap. MBH	Net I=B=R	
				MBH	Sq.Ft
PIN3PV	83.2	62	57	39	163
PIN4PV	82.2	105	87	65	271
PIN5PV	82.2	140	116	87	363
PIN6PV	82.2	175	145	109	454

Minuteman II® - Gas, Cast Iron

Model Number	AFUE %	Input MBH	DOE Heat. Cap. MBH	Net I=B=R MBH
MMII4-70	83.3	70	58	50
MMII4-105	80.5	105	84	73
MMII5-105	83.3	105	88	77
MMII5-140	80.1	140	112	97

OIL BOILERS

MPO™ -Oil, 3-Pass, Cast Iron, High Efficiency (*DV Optional)

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
MPO84	87.0	0.6	74	64
MPO115	87.0	0.8	98	85
MPO147*	87.0	1.05	129	112
MPO189*	87.0	1.35	167	145
MPO231*	87.0	1.65	203	177

MegaSteam™ - Oil, 3-Pass, Cast Iron, High Efficiency

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R	
				MBH	Sq.Ft
MST288	86.0	0.75	92	69	288
MST396	86.0	1.05	127	96	396
MST513	86.0	1.35	164	123	513
MST629	86.0	1.65	201	151	629

Near-boiler piping kits available

V8H Water™ - Oil, Cast Iron, High Efficiency

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
V8H2 (W)	82.1	0.60	70	61
V8H3 (W)	85.0	1.05	125	109
V8H4 (W)	85.3	1.35	162	141
V8H5 (W)	85.3	1.65	198	172
V8H6 (W)	85.3	1.90	228	198
V8H7 (W)	85.0	2.10	252	219
V8H8 (W)	Comb. Eff.	2.35	266*	239
V8H9 (W)	Comb. Eff.	2.60	298*	260

* I=B=R Gross Output

V8H Steam™ - Oil, Cast Iron, High Efficiency

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap MBH	Net I=B=R MBH	Net I=B=R Sq.Ft
V8H3 (S)	85.1	0.75	91	68	283
V8H4 (S)	85.3	1.05	127	95	396
V8H5 (S)	85.4	1.35	164	123	512
V8H6 (S)	85.7	1.65	201	151	629
V8H7 (S)	84.7	2.10	252	189	787
V8H8 (S)	Comb. Eff.	2.35	275*	200	833
V8H9 (S)	Comb. Eff.	2.60	299*	224	933

* I=B=R Gross Output

C3™ **& C4**™ - Oil, Cast Iron

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
C3	83.5	0.75	89	77
C4	81.7	1.20	140	121

LE Series™ - Steel, Cast Iron, *High Efficiency

Model Number	AFUE %	I=B=R Firing Rate GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
LEDV1*	86.7	0.60	74	64
LEDV2	83.0	1.00	119	102
LEDV3	81.5	1.25	143	124
LE1**	86.7	0.60	74	64
	83.0	1.00	117	102
LE2	81.5	1.25	143	124

** LE1 furnished w/components required for both firing rates

RSA Series™ - Oil, Steel

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
RSA85	82.5	0.85	100	87
RSA110	82.5	1.10	128	111
RSA125	82.5	1.25	144	125
RSA135	82.5	1.35	156	136
RSA170	81.9	1.70	197	171
RSA195	82.8	1.98	229	199
RSA240	—	2.40	268*	233
RSA285	—	2.85	318*	277
RSAH85**	84.0	0.75	89	77
RSAH110**	84.0	1.00	119	103
RSAH125**	84.0	1.10	131	113
RSAH135**	84.0	1.25	149	129

* I=B=R Gross Output (not rated for DOE Capacity or AFUE due to input)
** High Efficiency Kit (optional)

V1 RO/FO™ - Oil, Cast Iron

Model Number	AFUE %	Burner Cap. GPH	DOE Heat. Cap. MBH	Net I=B=R MBH
V13A RO/FO	83.5	.75	89	77
V14A RO/FO	83.4	1.05	124	108

ELECTRIC BOILERS

Carefree™ - Electric, Cast Iron

Model Number	AFUE %	DOE Heat. Cap. MBH			Amps	Water Flow Rate GPM*		
		240V	220V	208V	240V	240V	220V	208V
E412	100	41	35	31	50	4.1	3.5	3.1
E416	100	55	46	41	70	5.5	4.6	4.2
E420	100	68	58	52	85	6.8	5.8	5.2

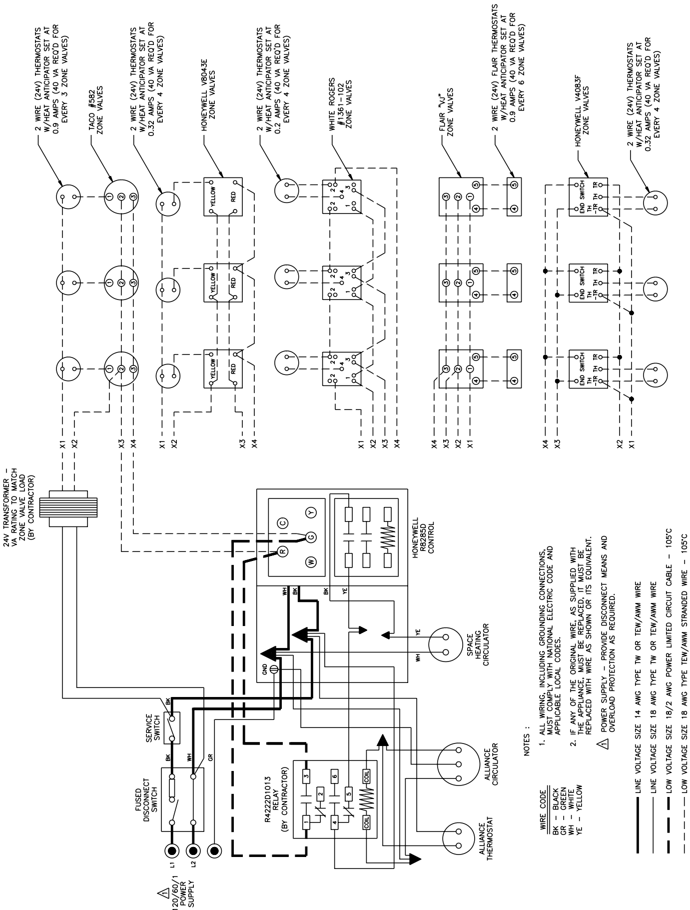
* Based on 20°F temp. rise and boiler capacity at:

INDIRECT WATER HEATERS

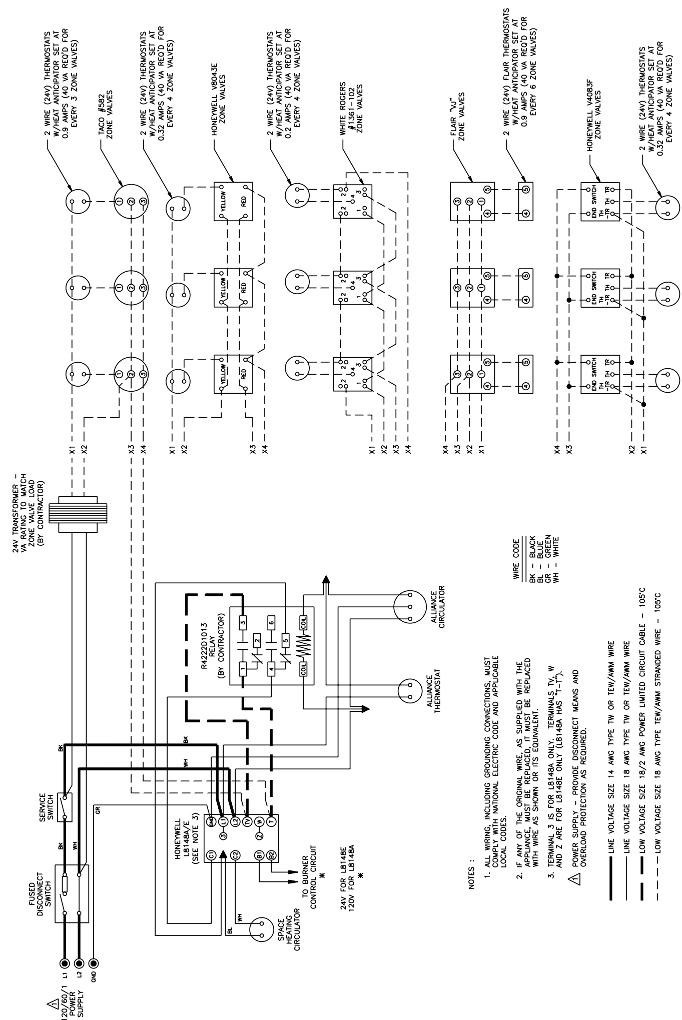
Alliance SL™ - Hydrastone-lined Indirect-Fired Water Heaters

Model Number	Storage Capacity (gal)	Max 1st Hr (gal. hr)	Cont. Draw (gal/hr)	Standby Loss (°F/hr)	Min Boiler Output (MBtu/ hr)	Boiler Water Flow Rate (gal./min.)	Pressure Drop Through Coil (ft. w.c.)
AL27SL	27	192	162	0.97	99	6	9.0
AL35SL	35	200	162	0.72	99	6	9.0
AL50SL	50	225	171	0.56	110	6	9.5
AL70SL	70	294	217	0.45	120	6	10.0
AL119SL	119	339	235	0.39	149	14	17.0

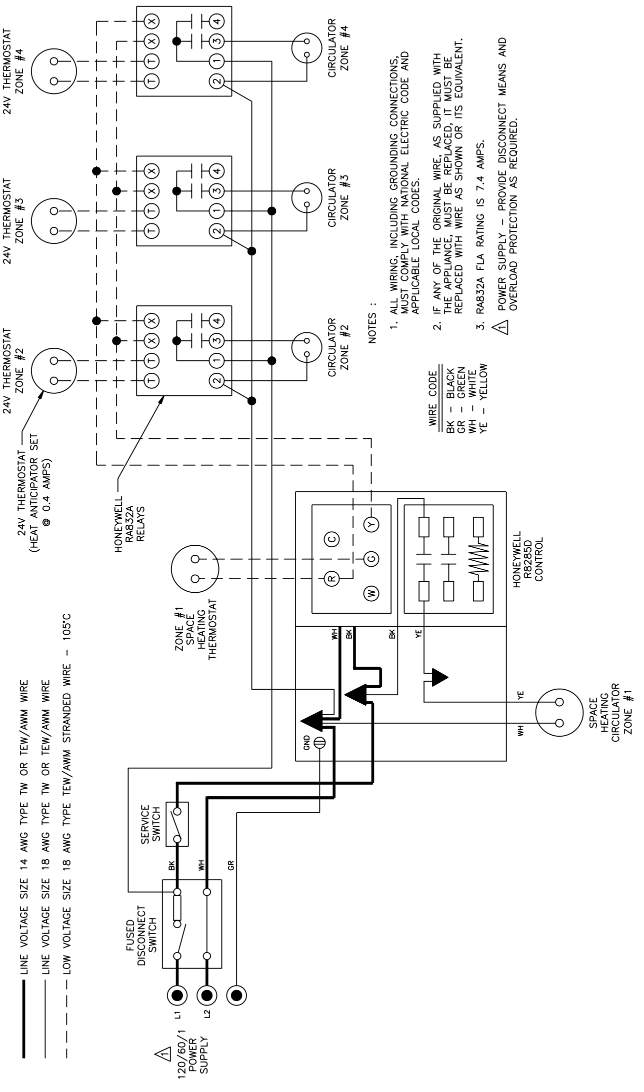
Wiring: R8285D w/ Zone Valves



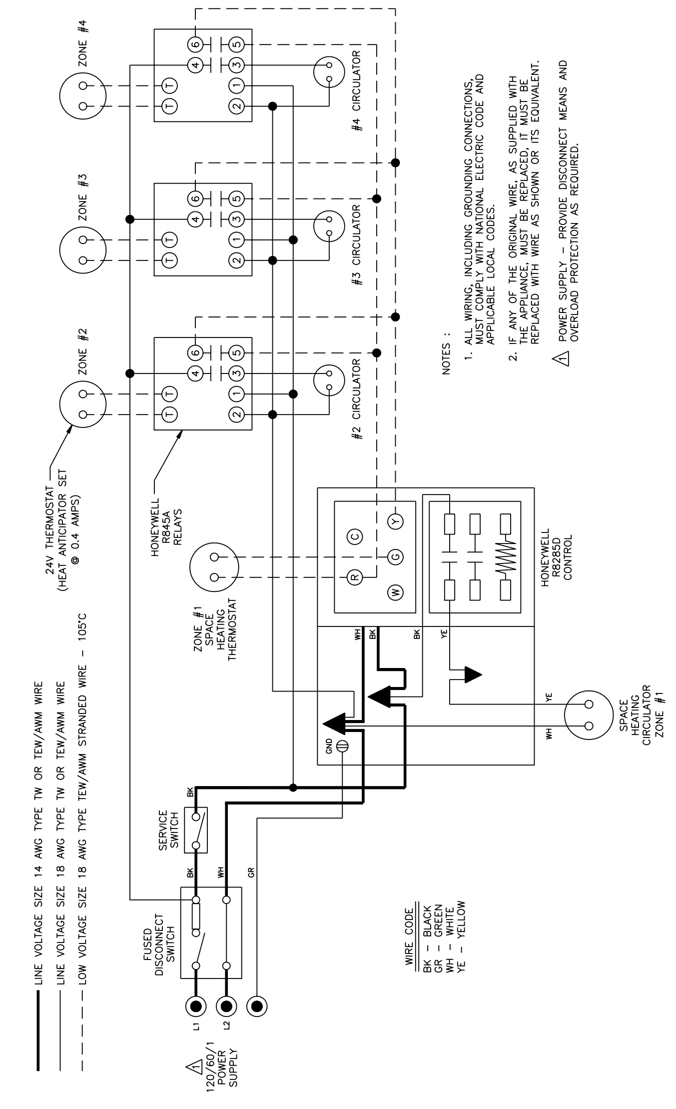
Wiring: L8148A/E w/ Zone Valves



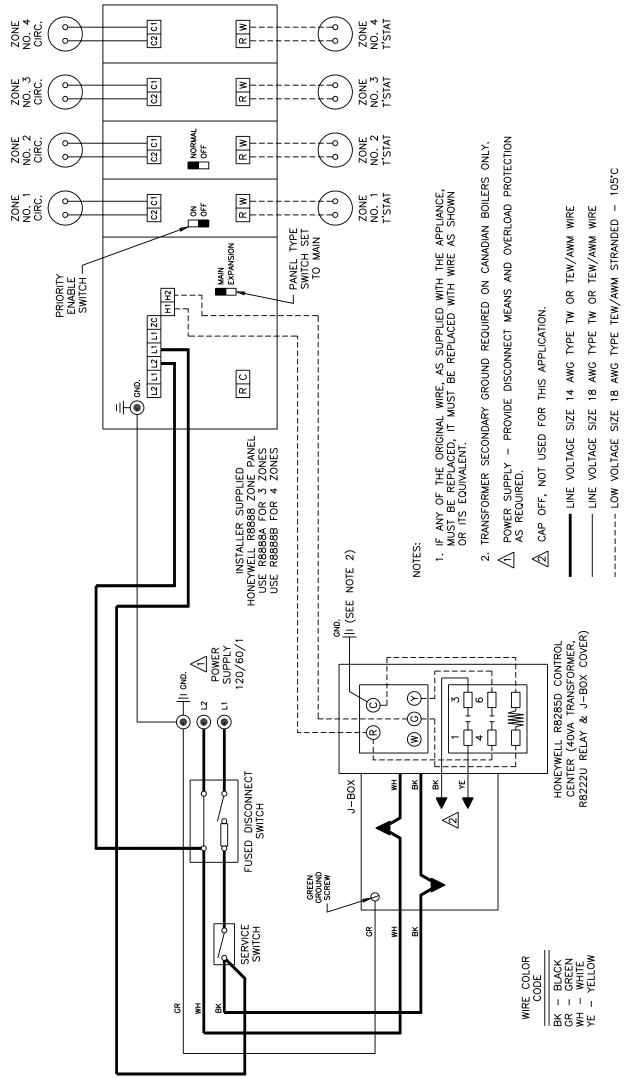
Wiring: R8285D w/ RA832A



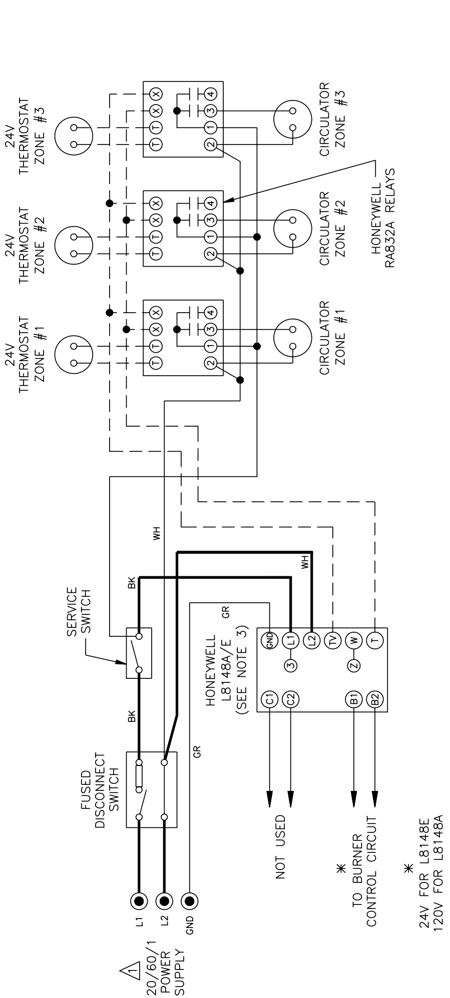
Wiring:R8285D w/R845A



Wiring:R8285D w/R8888A/B



Wiring: L8148A/E w/ RA832A



LINE VOLTAGE SIZE 14 AWG TYPE TW OR TEW/AWM WIRE

LINE VOLTAGE SIZE 18 AWG TYPE TW OR TEW/AWM WIRE

LOW VOLTAGE SIZE 18 AWG TYPE TEW/AWM STRANDED WIRE - 105°C

WIRE CODE

BK - BLACK
GR - GREEN
WH - WHITE

NOTES :

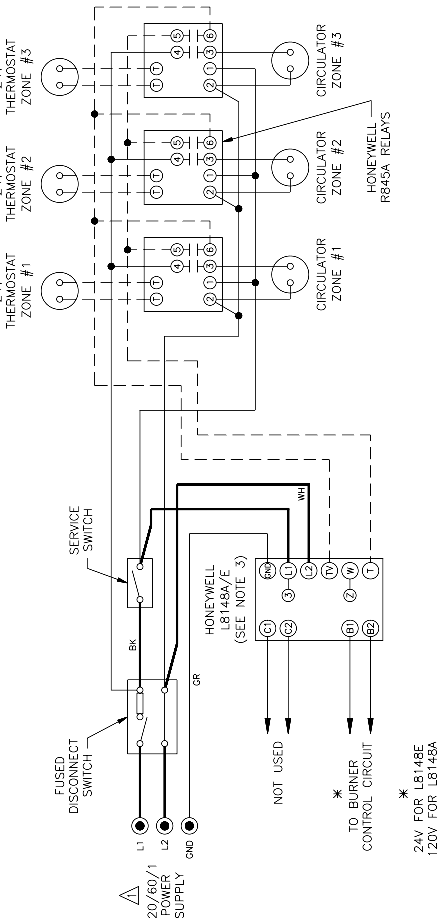
1. ALL WIRING, INCLUDING GROUNDING CONNECTIONS, MUST COMPLY WITH NATIONAL ELECTRIC CODE AND APPLICABLE LOCAL CODES.

2. IF ANY OF THE ORIGINAL WIRE, AS SUPPLIED WITH THE APPLIANCE, MUST BE REPLACED, IT MUST BE REPLACED WITH WIRE AS SHOWN OR ITS EQUIVALENT.

3. TERMINAL 3 IS FOR L8148A ONLY. TERMINALS TV, W AND Z ARE FOR L8148E ONLY (L8148A HAS "T-T").

⚠1 POWER SUPPLY - PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.

Wiring: L8148A/E w/ R845A



LINE VOLTAGE SIZE 14 AWG TYPE TW OR TEW/AWM WIRE

LINE VOLTAGE SIZE 18 AWG TYPE TW OR TEW/AWM WIRE

LOW VOLTAGE SIZE 18 AWG TYPE TEW/AWM STRANDED WIRE – 105°C

WIRE CODE

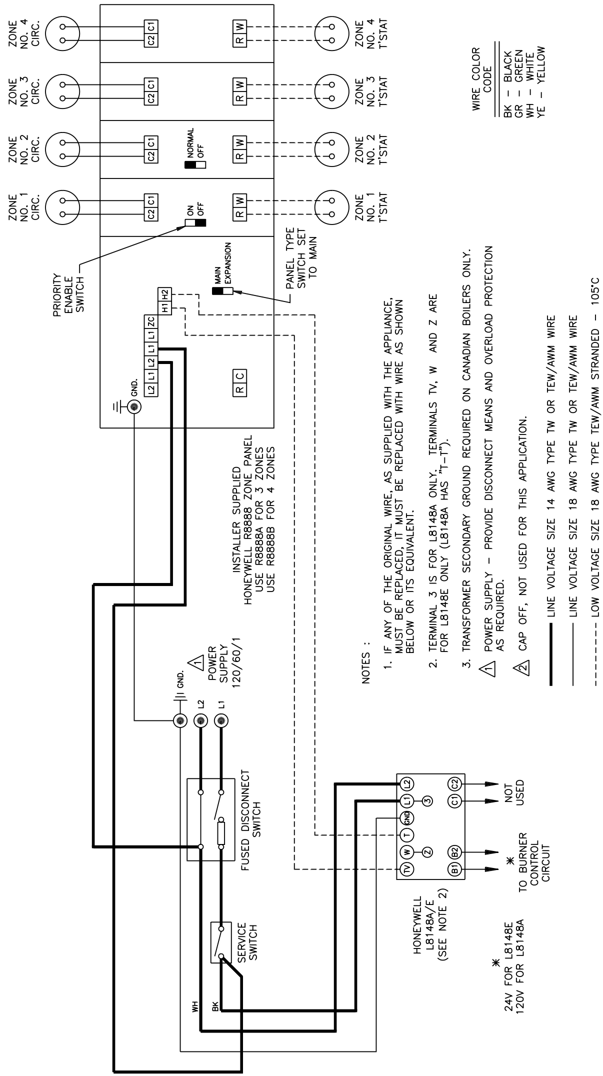
BK – BLACK
GR – GREEN
WH – WHITE

NOTES :

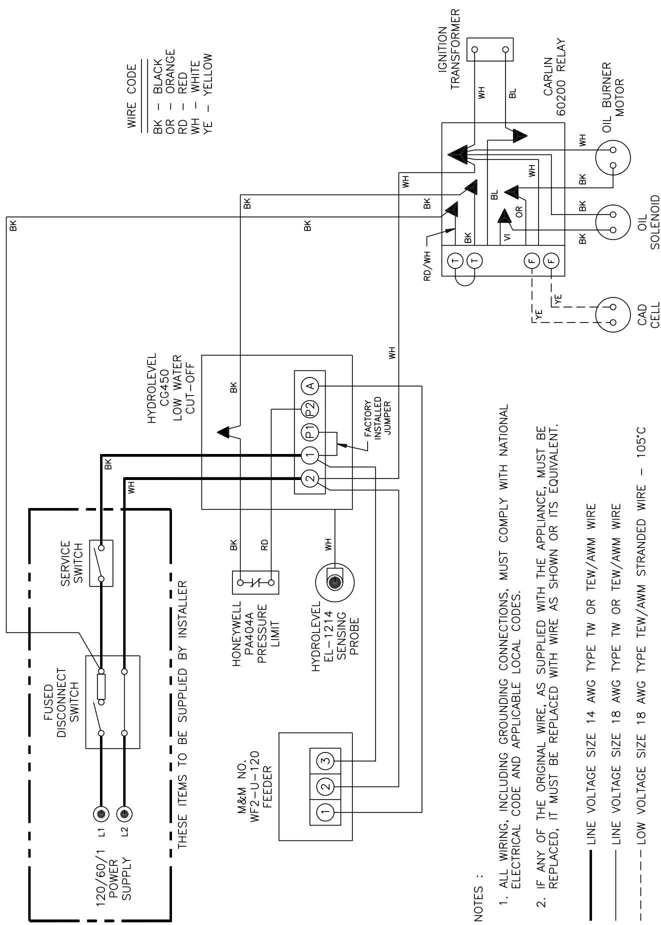
1. ALL WIRING, INCLUDING GROUNDING CONNECTIONS, MUST COMPLY WITH NATIONAL ELECTRIC CODE AND APPLICABLE LOCAL CODES.
2. IF ANY OF THE ORIGINAL WIRE, AS SUPPLIED WITH THE APPLIANCE, MUST BE REPLACED, IT MUST BE REPLACED WITH WIRE AS SHOWN OR ITS EQUIVALENT.
3. TERMINAL 3 IS FOR L8148A ONLY. TERMINALS TV, W AND Z ARE FOR L8148E ONLY (L8148A HAS "T–T").

⚠1 POWER SUPPLY – PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.

Wiring: L8148A/E w/R8888A/B



Wiring: Oil Steam Boiler w/ CG450 LWCO & WF2-U-120 Water Feeder



NOTES :

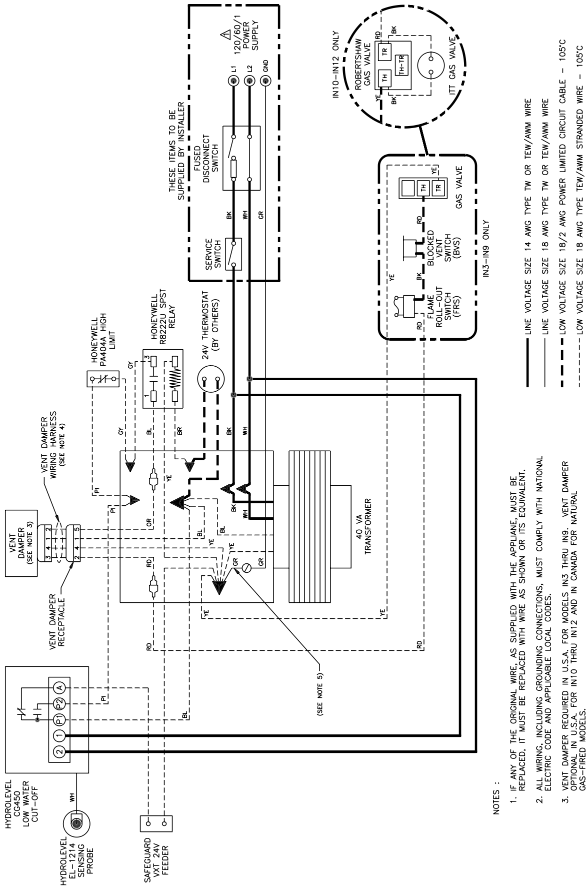
1. ALL WIRING, INCLUDING GROUNDING CONNECTIONS, MUST COMPLY WITH NATIONAL ELECTRICAL CODE AND APPLICABLE LOCAL CODES.
2. IF ANY OF THE ORIGINAL WIRE, AS SUPPLIED WITH THE APPLIANCE, MUST BE REPLACED, IT MUST BE REPLACED WITH WIRE AS SHOWN OR ITS EQUIVALENT.

LINE VOLTAGE SIZE 14 AWG TYPE TW OR TEW/AWM WIRE

LINE VOLTAGE SIZE 18 AWG TYPE TW OR TEW/AWM WIRE

LOW VOLTAGE SIZE 18 AWG TYPE TEW/AWM STRANDED WIRE - 105°C

Wiring: Gas Steam Boiler w/ CG450 LWCO & VXT-24 Water Feeder



NOTES :

1. IF ANY OF THE ORIGINAL WIRE, AS SUPPLIED WITH THE APPLIANE, MUST BE REPLACED, IT MUST BE REPLACED WITH WIRE AS SHOWN OR ITS EQUIVALENT.
2. ALL WIRING, INCLUDING GROUNDING CONNECTIONS, MUST COMPLY WITH NATIONAL ELECTRIC CODE AND APPLICABLE LOCAL CODES.
3. VENT DAMPER REQUIRED IN U.S.A. FOR MODELS IN3 THRU IN9. VENT DAMPER OPTIONAL IN U.S.A. FOR IN10 THRU IN12 AND IN CANADA FOR NATURAL GAS-FIRED MODELS.
4. FOR BOILER LESS VENT DAMPER ONLY, VENT DAMPER WIRING HARNESS REPLACED WITH JUMPER PLUG.
5. CANADA ONLY – ATTACH GREEN GROUND WIRE FROM TRANSFORMER SECONDARY TO GREEN GROUND SCREW.

⚠ POWER SUPPLY – PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.

NOTES

Burnham®
by U.S. Boiler Company

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