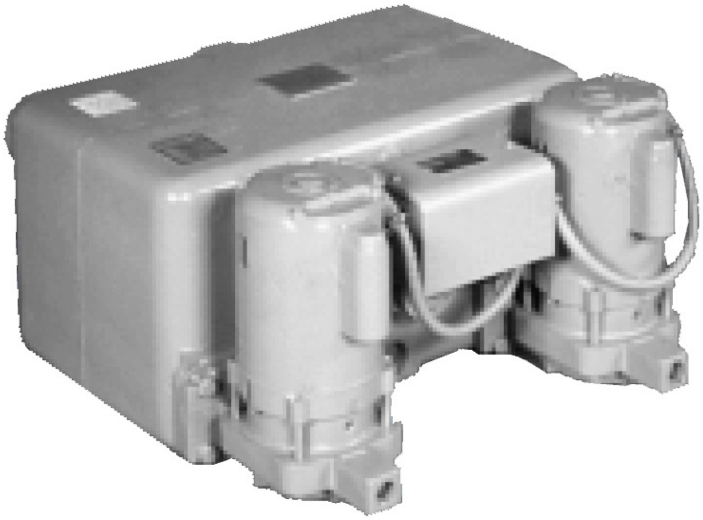
TECHNICAL MANUAL

TES-676B



Domestic® Pump Product Application and Sizing Manual

Bell & Gossett

a xylem brand

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INTRODUCTION

ADVANTAGES OF HEATING WITH STEAM

The widespread use of steam for heating points to a long recognized fact that steam, as a heating medium, has numerous characteristics which can be advantageously employed. Some of the most important advantages are as follows:

1. STEAM'S ABILITY TO GIVE OFF HEAT

Properties of saturated steam are shown in Steam Tables and give much information regarding the temperature and the heat (energy) contained in one pound of steam for any pressure. For example, to change one pound of water from 212°F into steam at the same temperature of 212°F at Atmospheric Pressure (14.7 PSIA) requires a heat content of 1150.4 BTU which is made up of 180.1 BTU Sensible Heat (the heat required to raise the one pound of water from 32°F, freezing, to 212°F) and 970.3 BTU of Latent Heat. The Latent Heat is the heat added to change the one pound of water from 212°F into steam at 212°F. This stored up Latent Heat is required to transform the water into steam and it reappears as heat when the process is reversed to condense the steam into water.

Because of this basic fact, the high Latent Heat of vaporization of a pound of steam permits a large quantity of heat to be transmitted efficiently from the boiler to the heating unit with little change in temperature.

2. STEAM PROMOTES ITS OWN CIRCULATION THROUGH PIPING

For example, steam will flow naturally from a higher pressure (as generated in the boiler) to a lower pressure (existing in the steam mains). Circulation or flow is caused by the lowering of the steam pressure along the steam supply mains and the heating units due to pipe friction and to the condensing process of steam as it gives up heat to the space being heated.

3. STEAM HEATS MORE READILY

Steam circulates through a heating system faster than other fluid mediums. This can be important where fast pick-up of the space temperature is desired. It will also cool down more rapidly when circulation is stopped. This is an important consideration in Spring and Fall when comfort conditions can be adversely affected by long heating-up or slow cooling-down periods.

4. RECOMMENDED STEAM APPLICATIONS

The following applications for the use of steam are recommended to provide trouble-free and efficient heating systems.

(a) Where there is more than one job to do, such as providing comfort heating as well as steam for processes in:

- Industrial Plants
- Hospitals
- Institutions
- Restaurants
- Dry Cleaning Plants
- Laundries

(b) Where outdoor air is heated for ventilation (especially in cold climates...as in:

- Factories
- School Classrooms
- Auditoriums
- Buildings with Central Air Conditioning or Ventilating Gymnasiums

(c) Where there is a surplus of steam from processes which can be used for air cooling or water chilling.

(d) Where the heating medium must travel a great distance from the boiler to the heating units, as found in:

- High Multi-Story Buildings
- Long, Rambling Buildings
- Scattered Buildings Supplied from a Central Station

(e) Where intermittent changes in heat loads are required...as in:

- Schools
- Churches
- Office Buildings

(f) Where central heat control or individual room control of temperature is important as found in:

- Schools
- Hospitals
- Office Buildings
- Hotels and Motels

(g) Where there is a chance of freezing, in cold climates or where sub-freezing air is handled.

(h) Where there may be additions or alterations of space or change of occupancy in a building.

(i) Where extra heat is needed as in buildings with large or frequently used doors as in:

- Department Stores
- Garages
- Airplane Hangars
- Shipping Departments or Warehouses

CONDENSATE RETURN TO THE STEAM BOILER IN A STEAM SYSTEM

The purpose of this manual is to provide a solid base for the selection of equipment to return the condensate from a steam system and return it to the steam boiler. Many older small steam systems used a gravity return to the boiler. These systems are not employed in modern systems and will not be covered in this manual.

The selection of condensate handling equipment should be given careful consideration to maintain a properly balanced efficient steam system. Several factors should be considered in the system to determine the proper selection.
These factors include:

1. The System Size
2. Temperature of the Return Condensate
3. Operating Pressure of the Boiler
4. The Amount of Make -up Water Required to Replace Steam Lost Through Leaks
5. Vent Valves
6. Flash Steam and Steam Consumed in Industrial Processes
7. The Change in Load Rate During Various Time Periods

In many applications condensate return temperatures may exceed the saturation temperature at atmospheric pressure. The selection of return equipment should give consideration to operating efficiencies and flash steam should be avoided.

The condensate return rate can be easily calculated from the conversion Table 4, page 42. Most steam heating systems are rated in square feet of direct radiation, usually expressed as Sq. Ft. E.D.R. In simple terms, this is the square feet of heating surface or radiator surface. For example, a cast iron radiator 12" deep x 3' high, consisting of 8 sections will have approximately 48 square feet of radiation. All irregularities of the surface should be included in the calculation. By definition, each square foot of radiation will give off 240 BTU when filled with a heating medium at 215°F and surrounded by 70° F ambient air temperature. For purposes of calculating the return rate, each 1, 000 sq. ft. E.D.R. will condense and return 0.5 GPM of condensate.

In applications other than steam heating, the steam consumption is normally expressed in pounds per hour of steam. The return rate can be calculated using the formula each 1,000 Ibs /hr. will condense into 2 GPM of condensate.

CONDENSATE TRANSFER UNITS

There are two phases of condensate handling from a steam system. The first is returning condensate to the boiler room, and second, the feeding of the condensate into the boiler.

Returning Condensate to the Boiler Room

As the steam is distributed through the system and gives up its latent heat, the steam will change back into condensate (water). The condensate is drained through the traps and flows into a condensate return pipe. When the elevation of the return pipe permits gravity flow to the boiler room or boiler feed unit, condensate transfer equipment may not be required. In most applications, gravity flow cannot be provided and condensate transfer units must be provided to return the condensate to the boiler room.

CONDENSATE FEED INTO THE BOILER

The second phase of condensate handling to be considered is the feed or return into the steam boiler.

The condensate feed into the boiler deserves careful consideration to maintain a proper water level in the steam boiler during various load rates and operating cycles.

In any steam system, there is a time lag between when steam leaves the boiler until it returns in the form of condensate. The greatest time lag exists during a cold start-up. In a cold system, the steam mains, radiators, and return piping are completely drained. When the system is put into operation, the steam mains and radiators require a volume of steam to fill the system. The volume of steam must come from the boiler during this period and causes a drop of water level in the boiler. Additional time is required for the condensate to flow through the return lines back to the boiler room either by gravity or to be pumped back from condensate transfer units. The opposite condition occurs when the system is shut down; all the steam in the mains and radiators is returned in the form of condensate and must be stored for the next system start-up.

During normal operation fluctuating load rates will cause surges of steam output and condensate return to occur in the system.

The steam boiler system should be designed to have a storage area to store an ample supply of water for the variations in flow rate. There are two types of condensate feed systems commonly used.

1. Condensate units controlled by a float switch on the pump receiver.
2. Boiler feed units having the pumps controlled by a level switch on the boiler.

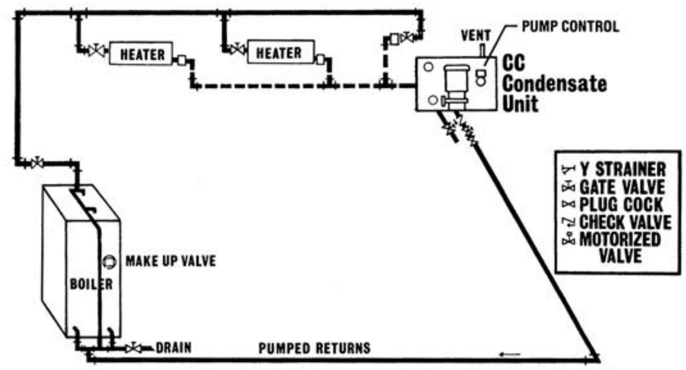
The advantages and functions of the two types of systems are as follows:

CONDENSATE UNITS USED TO FEED INTO A STEAM BOILER

One approach to returning condensate to a steam boiler is to use a condensate unit. With this arrangement, condensate is fed into the boiler in response to the water level in the pump receiver. The receiver is sized the same as a condensate transfer unit to provide one minute storage capacity based on the boiler steaming rate. A float switch on the pump receiver controls the pump. With this type of system, the system surges occur in the boiler due to change in boiler load. The boiler is equipped with an automatic water feeder to add city make-up into the boiler on low level to replace condensate lost in the system.

The condensate unit feed system has proven successful in small steam space heating applications. On larger installations, the boiler does not have an adequate storage area to handle the system surges. When the condensate unit feed system is applied to a system where the boiler does not have an adequate storage area, the make-up water valve on the boiler will add additional make-up water during start-up or heavy system steam demand. When the condensate is later returned, the boiler will flood and shut off on high water. This may cause a constant adding of make-up water and boiler flooding condition.

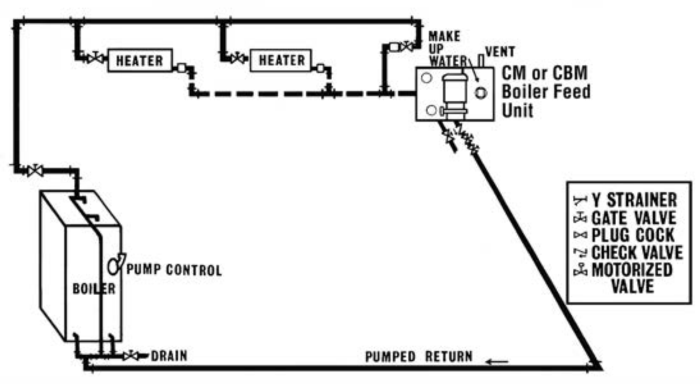
The practical system size limit for a condensate feed system is approximately 8,000 sq. ft. E.D.R. or 60 boiler horsepower system size. The maximum system size will vary with different types of boilers having various storage capacities between the high and low operating levels. The boiler storage or working capacity can be obtained from the boiler manufacturer. Quite frequently when older boilers having a large storage area are replaced with modern boilers generally having a smaller storage capacity, the existing condensate feed system causes problems as previously stated. The condensate feed system also is not practical in feeding multiple boilers, or where a large percentage of make-up water is required.



Condensate Unit Feeding Boiler

Boiler Feed Units

The boiler feed unit is preferable over a condensate unit for all systems. The boiler feed unit consists of a storage receiver sized to store an adequate volume of water to handle the system surges or system time lag and pumps wired to operate in response to a level control switch on the boiler. The normal boiler level control switch maintains a boiler water level within one inch differential. When a boiler feed unit is used, the make-up water is added into the pump receiver on low water level and pumped into the boiler as required. When a boiler feed unit is used to feed the boiler in response to the boiler water level, the system surges occur in the pump receiver. The boiler feed receiver should be sized large enough to prevent an overflow of return condensate. The normal receiver sizing is to provide five minutes storage area for systems up to 30,000 sq. ft. E.D.R. or equal to approximately 200 boiler horsepower. Larger systems should provide a minimum of ten minutes storage volume. Large single story buildings requiring over 100,000 sq. ft. E.D.R. and campus complexes should provide a minimum of 15 minutes storage volume. Oversizing the boiler feed unit receiver does not affect the system operation, it only adds slightly to the initial system cost. Undersizing of boiler feed receivers can cause an overflow of returned condensate which must be replaced with raw make-up water. This wastes heat, make-up water and chemical treatment.



Boiler Feed Unit Feeding Boiler

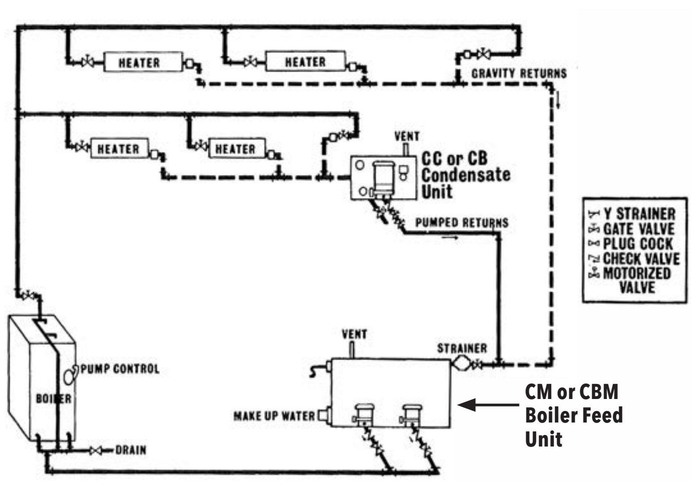
When the elevation of all return lines permit gravity return to the boiler feed unit, only a boiler feed unit is required to return condensate. In many installations, some of the return lines may not permit gravity return and condensate transfer units may be required to pump the returns back to the boiler feed unit.

PUMPS FOR HANDLING HOT CONDENSATE IN STEAM SYSTEMS

Pump selection should be given careful consideration to provide pumps capable of handling high temperature condensate without cavitation. The pumps should provide maximum system efficiency, retain their original capacity and require a minimum amount of maintenance.

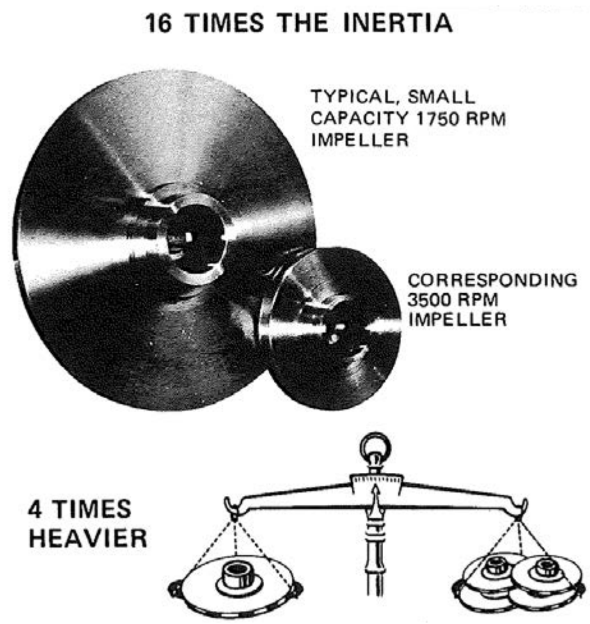
Centrifugal pumps and turbine pumps are commonly used for condensate handling. Centrifugal pumps are preferred for most applications as they provide generous running clearances and retain near their original capacity after years of service.

The conditions commonly found in a steam system requires a high pressure, low capacity pump as compared to a hot water heating application. To meet these conditions, 3500 RPM Centrifugal pumps are usually the logical choice. The following comparison shows the advantages of 3500 RPM Centrifugal pumps.



Boiler Feed Unit
Feeding the Boiler with Condensate Transfer Unit
Transferring Condensate from Low Return Lines
Back to Boiler Feed Unit

Characteristically, small capacity 3500 rpm pumps (less than 150 gpm and pressures greater than 20 psi) have several advantages over 1750 rpm pumps. This is true of any manufacturer's centrifugal pump, particularly when operated intermittently as are condensate, vacuum and low pressure boiler feed pumps.



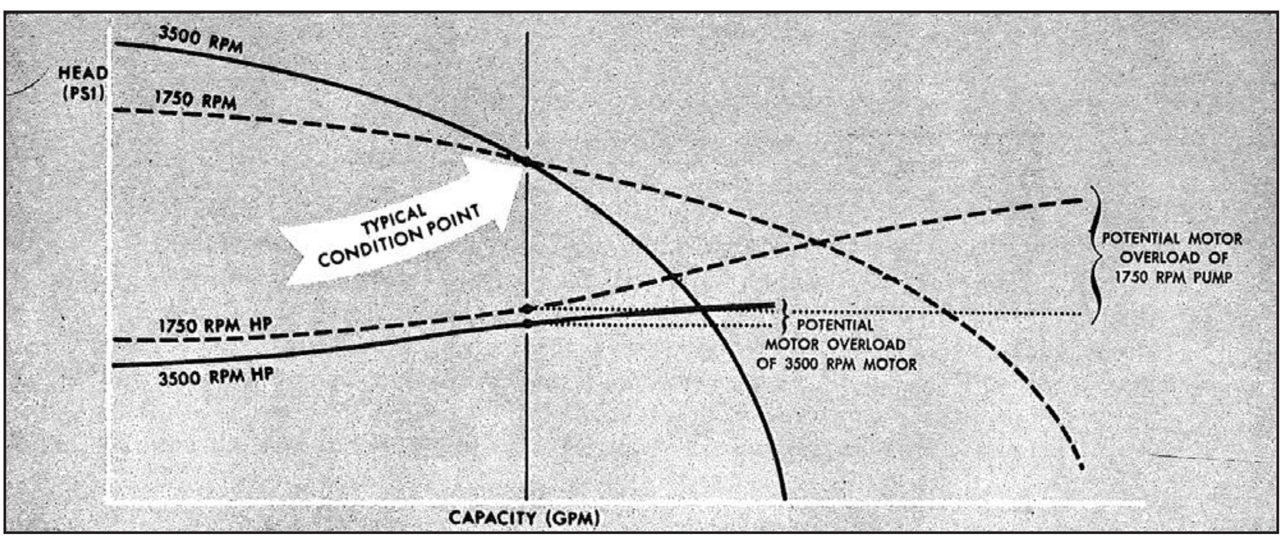
1. The motor is much less likely to overload when the pump is operated at less than the specified pressure, which is usually the case. 3500 rpm pumps characteristically have steeper head-capacity and flatter horsepower curves, both highly desirable for this service. See typical curves below.

2. 3500 rpm pumps have a higher hydraulic efficiency, so operating expenses are lower.

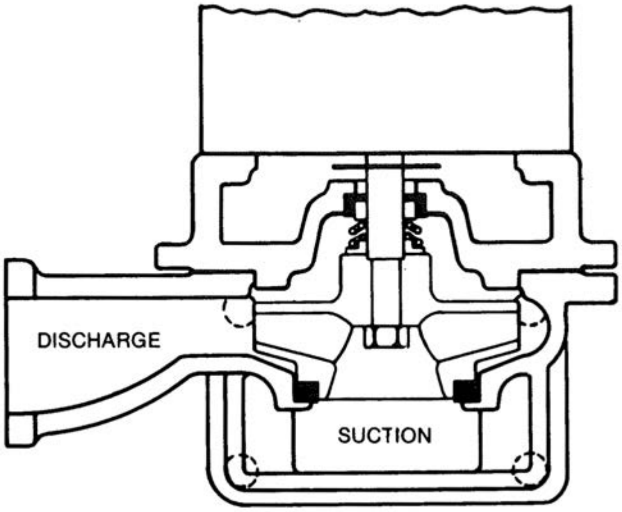
3. The inertial loads imposed on the motor shaft by the 1750 impeller are 16 times greater than for a 3500 rpm impeller:

An impeller approximates a disc and the formula for the inertia of a disc about its axis is $I = \frac{Wr^2}{2g}$ or 1/2 the weight times the radius squared, divided by the acceleration due to gravity. Since a 1750 impeller must be twice the diameter of a 3500 impeller to develop the required pressure, the disc area and weight are four times that of the 3500 rpm impeller, making the inertia 16 times that of the 3500 rpm impeller.

4. 3500 rpm motors are just as quiet , reliable and long lived as 1750 rpm motors. 3500 rpm is not very fast today in view of the 15,000 rpm or faster speeds of jet engine rotating assemblies.

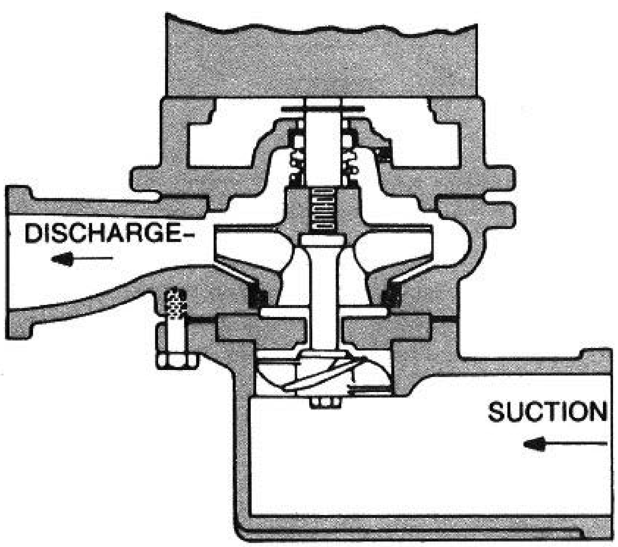


3500 or 1750 RPM Centrifugal Pumps



Standard Centrifugal Pump

The above illustration shows a standard Centrifugal pump designed for condensate handling. Standard pumps for this service are designed with large suction areas in the pump casing and impeller to reduce cavitation. The Domestic Type PF Pump shown can pump condensate at 195°F or hotter depending on the pump combination selected. In some condensate handling requirements, this arrangement may not handle the temperature requirements.



2 Ft. NPSH Centrifugal Pump

Centrifugal pumps specially designed for 2 ft. NPSH (Net Positive Suction Head) requirements are available to handle boiling condensate with only 2 feet of elevation between the pump suction and the receiver water level. The Domestic Type B Pump shown uses an axial flow impeller in the suction of the centrifugal pump. The axial flow impeller provides a 5 to 10 PSI suction pressure into the centrifugal impeller to prevent cavitation.

Cavitation - Cavitation is the high temperature water flashing into steam as it enters the impeller suction. As the steam vapors mixed with water enter the centrifugal impeller, they collapse rapidly and cause a noise in the pump which sounds like marbles were being pumped through the impeller.

All pump suctions create a negative pressure as they draw the water into the impeller. The amount of negative pressure is a function of the pump design and is determined by testing. The pump required NPSH is usually measured in feet of water required. To prevent cavitation or flashing the pump suction must be supplied with the required NPSH which may be obtained from the elevation of the water above the pump suction (Static Head) or from the temperature of the water below the flash temperature. The following chart shows the NPSH available from the temperature and elevation to calculate the total available NPSH. When the available NPSH is greater than the required NPSH of the pump, the problem of cavitation is eliminated. Pumps requiring 2 ft. NPSH will pump boiling water with only two feet of elevation to the water line above the pump suction. The 2 ft. NPSH pumps will also handle water temperatures within 3°F of boiling with no elevation or static head as some static head exist even on heightless receivers. They are usually recommended for pumping within 2°F or 210°F condensate at sea level.

Temp. °F	Static Suction Head in Feet										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Net Positive Suction Head Available (NPSHA)										
212°	0	1	2	3	4	5	6	7	8	9	10
211°	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
210°	1.4	2.4	3.4	4.4	5.4	6.4	7.4	8.4	9.4	10.4	11.4
208°	2.6	3.6	4.6	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6
207°	3.6	4.6	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6	13.6
206°	4.0	5.0	6.0	7.0	8.0	9.0	10	11.0	12.0	13.0	14.0
205°	4.7	5.7	6.7	7.7	8.7	9.7	10.7	11.7	12.7	13.7	14.7
204°	5.1	6.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1
200°	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5
190°	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5
155°	24.3	25.3	26.3	27.3	28.3	29.3	30.3	31.3	32.3	33.3	34.3
116°	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5
100°	31.7	32.7	33.7	34.7	35.7	36.7	37.7	38.7	39.7	40.7	41.7
70°	33.1	34.1	35.1	36.1	37.1	38.1	39.1	40.1	41.1	42.1	43.1

Net Positive Suction Head Available (NPSHA) Table For Water at Sea Level* and Atmospheric Vented Supply Tank

*Boiling point decreases 1°F for every 500 feet of elevation above sea level.
(@ 500' above sea level, boiling point is 211°F)

CONDENSATE TRANSFER UNITS SELECTION AND SIZING

The condensate transfer unit should be selected as shown in the following steps:

1. Determine the Condensate Return Rate
2. Calculate Discharge Pressure
3. Determine the Condensate Return Temperature
4. Select the Basic Unit
5. Select the Accessory Equipment Desired

STEP 1

DETERMINE THE CONDENSATE RETURN RATE

Conversion tables are provided to calculate the condensate return rate on page 42, Table 4. The condensate return rate can be calculated from Sq. Ft. E.D.R., Lbs. /Hr. of steam, BTU heat load or boiler horsepower required.

STEP 2

CALCULATE THE DISCHARGE PRESSURE

The required discharge pressure includes static head lift required plus friction loss in the piping, fittings and valves, any pressure to be overcome in the vessel to which the unit discharges. It is normal practice to add an additional 5 PSI on any installation requiring up to 50 PSI and 10 PSI extra on installations requiring over 50 PSI.

Static Head: This is the elevation difference between the pump discharge and the highest point in piping. For example, a condensate unit installed in the basement area must pump into an elevated boiler feed receiver in the boiler room. The elevation difference in the two locations is 23 feet. The static head required would be 23 feet.

Friction Loss :Tables 7 & 9 on page 45 in the back of this manual show the friction loss in feet for pipe fittings. Example: 25 GPM are to be discharged in a 1½" pipe 500' long. The piping includes eight (8) 90° elbows, two (2) gate valves, a swing type check valve, and a plug cock. Each 90° elbow has a friction loss equal to 7.4 ft. of pipe. Each gate valve has a loss equal to 1. 2 ft. of pipe. A swing check valve has a loss equal to 15 ft. of pipe and a plug cock has a loss equal to 42 ft. of pipe.

The total equivalent length of pipe is as follows: 500' + (8 x 7.4) + (2 x 1.2) + 15 + 42 = 618.6' equivalent length. The friction loss of 1½" pipe at 25 GPM is 4.4 ft. per 100' or .044 per ft. 618.6 x .044 = 27.22 ft. loss.

If the condensate transfer unit discharges into a vented boiler feed unit, no extra pressure is required to overcome the vessel pressure. If the unit discharges into a pressurized deaerator, the maximum deaerator pressure plus the pressure drop across the spray nozzle (on some types) must be added. Assuming that the unit is discharging into a vented boiler feed receiver, the total discharge pressure required is as follows:

	23	ft.	static head
	27. 22	ft.	friction loss
Total	50.22	ft.	

To convert ft. head into PSIG, divide by 2.31 or 50.22 divided by 2.31 = 21. 74 PSI required. Add the safety margin of 5 PSI. The pump should be selected for a discharge pressure of 27 PSI.

STEP 3

DETERMINE THE CONDENSATE RETURN TEMPERATURE

This is probably the most difficult value to determine. If the unit being selected is an existing installation, it is best to observe the actual installation and measure the condensate temperature. Most steam heating applications use thermostatic traps which drain condensate at approximately 160°F to 180°F temperature. The normal condensate temperature from a steam space heating can be figured using 140°F to 160°F.

When steam is used for heating water as in a Domestic water heater or shell and tube heat exchanger, the return condensate return temperature can be calculated by subtracting the BTU load requirement from the BTU value of the steam consumed. If the unit is for an existing application, the condensate temperature may be determined by installing a pressure gauge ahead of the discharge trap. The condensate temperature will be equal to the saturation temperature at the corresponding pressure.

The properties of saturated steam in Table 1, page 40 in the back of this manual shows the corresponding temperatures in relation to the pressure.

Additional cooling will occur in the return piping. Chart 3, page 44 is provided in the back of this manual showing heat loss from bare steel pipe which may be used to calculate the BTU removed in the return piping.

STEP 4

SELECTING THE BASIC UNIT

Select the unit based on the load rate, discharge pressure, and return temperature. For most applications where the return temperature is 195°F or less, the Domestic Type CC Unit may be applied.

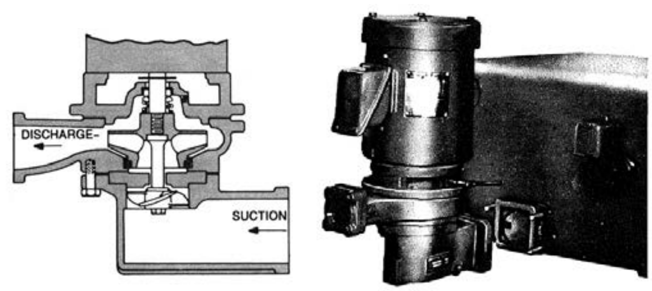
Type CC Condensate Pump
Duplex Float Switch Operated

The standard sizing for condensate units is to select the pump for a rate equal to 2 or 3 times the system condensing rate. The 2 or 3 times rate allows for intermittent operation of the pump and allows for extra capacity during a cold system startup. The pumps on the type CC are preselected for 2 times the system condensing rate.

Receivers for condensate units should be sized as small as practical to return condensate as quick as possible to the boiler room or boiler feed unit. Standard sizing of receivers for condensate units provide one minute net storage capacity based on the system return rate.

Example: A 30,000 sq. ft. E.D.R. system returns condensate at the rate of 15 GPM. The receiver should have a net storage capacity of 15 gallons. The net storage capacity is defined as the capacity between where the float switch starts the pump on high water level and where it stops the pump on low water level. The total receiver capacity will be larger than the net. The following tables from the Domestic Type CC sales brochure show the units preselected based on sq. ft. E.D.R. having the pump sized 2 times the system condensing rate and the receiver selected to provide approximately one minute storage capacity.

When the condensate return temperature may exceed 195°F, a unit having low NPSH (Net Positive Suction Head) requirements should be selected. The Domestic Type CB Unit uses a pump designed for handling high temperature water. This is accomplished using an axial flow impeller in the pump suction.



Type CB Unit with 2' NPSH Pump
to Handle High Temperature Condensate

SYSTEM CAPACITY†	PUMP CAPACITY GPM (L/M)	DISCHARGE PRESSURE PSIG (kPa)	MOTOR HORSEPOWER 3500 RPM	MOTOR HORSEPOWER 1750 RPM	DISCHARGE SIZE IN. (mm)	SERIES CC™ CONDENSATE UNITS MODEL NUMBER	SERIES CC™ CONDENSATE UNITS RECEIVER CAPACITY GAL. (L)	SERIES CC™ CONDENSATE UNITS INLET SIZE IN. (mm)
1,000 thru 6,000 Sq. Ft. EDR / 250 thru 1,500 lb./hr. (113-680 kg/hr)	6 (23)	15* (103)	1/3	1/3	3/4 (19)	61.5CC	6 (23) Simplex / 14†† (53) Duplex	2 (51)
		20* (138)	1/3	1/2		62CC		
		25* (172)	1/2	3/4		62.5CC		
		30* (207)	1/2	1 1/2		63CC		
		40 (276)	1	**		64CC		
		50 (345)	1 1/2	**		65CC		
		60 (414)	2	**		66CC		
		75 (518)	3	**		67.5CC	23 (87)	
		90 (621)	3	**		69CC		
1,000 thru 9,000 Sq. Ft. EDR / 250 thru 2,250 lb./hr. (113-1,021 kg/hr)	9 (34)	15* (103)	1/3	1/3	3/4 (19)	91.5CC	9 (34) Simplex / 14†† (53) Duplex	2 (51)
		20* (138)	1/3	1/2		92CC		
		25* (172)	1/2	3/4		92.5CC		
		30* (207)	3/4	1 1/2		93CC		
		40 (276)	1	**		94CC		
		50 (345)	1 1/2	**		95CC		
		60 (414)	2	**		96CC		
		75 (518)	3	**		97.5CC	23 (87)	
		90 (621)	3	**		99CC		
12,000 Sq. Ft. EDR / 3,000 lb./hr. (1,361 kg/hr)	12 (45)	15* (103)	1/3	1/3	3/4 (19)	121.5CC	14†† (53)	2 (51)
		20* (138)	1/3	1/2		122CC		
		25* (172)	1/2	3/4		122.5CC		
		30* (207)	3/4	1 1/2		123CC		
		40 (276)	1	**		124CC		
		50 (345)	1 1/2	**		125CC		
		60 (414)	2	**		126CC		
		75 (518)	3	**		127.5CC	23 (87)	
		90 (621)	5	**		129CC		
15,000 Sq. Ft. EDR / 3,750 lb./hr. (1,701 kg/hr)	15 (57)	15* (103)	1/3	1/2	3/4 (19)	151.5CC	14†† (53)	2 (51)
		20* (138)	1/3	3/4		152CC		
		25* (172)	1/2	1		152.5CC		
		30* (207)	3/4	1 1/2		153CC		
		40 (276)	1	**		154CC		
		50 (345)	1 1/2	**		155CC		
		60 (414)	2	**		156CC		
		75 (518)	3	**		157.5CC	23 (87)	
		90 (621)	5	**		159CC		
22,000 Sq. Ft. EDR / 5,500 lb./hr. (2,495 kg/hr)	22 (83)	15* (103)	1/3	1/2	1 1/2 (38)	221.5CC	23 (87)	2 (51)
		20* (138)	1/2	3/4		222CC		
		25* (172)	3/4	1		222.5CC		
		30* (207)	3/4	1 1/2		223CC		
		40 (276)	1 1/2	**		224CC		
		50 (345)	2	**		225CC		
		60 (414)	3	**		226CC		
		75 (518)	3	**		227.5CC		
		90 (621)	5	**		229CC		
30,000 Sq. Ft. EDR / 7,500 lb./hr. (3,402 kg/hr)	30 (114)	15 (103)	1/2	3/4	1 1/2 (38)	301.5CC	36 (136)	3 (76)
		20 (138)	3/4	3/4		302CC		
		25 (172)	3/4	1 1/2		302.5CC		
		30 (207)	1	1 1/2		303CC		
		40 (276)	1 1/2	**		304CC		
		50 (345)	2	**		305CC		
		60 (414)	3	**		306CC		
		75 (518)	5	**		307.5CC		
		90 (621)	5	**		309CC		
37,000 Sq. Ft. EDR / 9,250 lb./hr. (4,196 kg/hr)	37 (140)	15 (103)	1/2	3/4	1 1/2 (38)	371.5CC	36 (136)	3 (76)
		20 (138)	3/4	1		372CC		
		25 (172)	3/4	1 1/2		372.5CC		
		30 (207)	1 1/2	1 1/2		373CC		
		40 (276)	2	**		374CC		
		50 (345)	3	**		375CC		
		60 (414)	3	**		376CC		
		75 (518)	5	**		377.5CC		
		90 (621)	5	**		379CC		
45,000 Sq. Ft. EDR / 11,250 lb./hr. (5,103 kg/hr)	45 (170)	15 (103)	3/4	3/4	1 1/2 (38)	451.5CC	36 (136)	3 (76)
		20 (138)	1	1		452CC		
		25 (172)	1	1 1/2		452.5CC		
		30 (207)	1 1/2	2		453CC		
		40 (276)	2	**		454CC		
		50 (345)	3	**		455CC		
		60 (414)	3	**		456CC		
		75 (518)	5	**		457.5CC		
		90 (621)	5	**		459CC		

† $\frac{\text{Sq. Ft. EDR}}{4}$ = Lb./hr. Condensate

* Maximum Condensate Temperature: 209°F (98°C) **3500 RPM ONLY**.
** 3500 RPM is standard. 1750 RPM is not available.
†† 3500 RPM units to 50 psi discharge pressure use "B" design receiver as standard. 3500 RPM units 60 psi or more use "A" design receiver. 1750 RPM units use "A" design receiver.

SYSTEM CAPACITY†	PUMP CAPACITY GPM (L/M)	DISCHARGE PRESSURE PSIG (kPa)	MOTOR HORSEPOWER 3500 RPM	MOTOR HORSEPOWER 1750 RPM	DISCHARGE SIZE IN. (mm)	SERIES CC™ CONDENSATE UNITS MODEL NUMBER	SERIES CC™ CONDENSATE UNITS RECEIVER CAPACITY GAL. (L)	SERIES CC™ CONDENSATE UNITS INLET SIZE IN. (mm)
60,000 Sq. Ft. EDR 15,000 lb./hr. (6,804 kg/hr)	60 (227)	15 (103)	1	1	2 (51)	601.5CC	52 (197)	3 (76)
		20 (138)	1 1/2	1 1/2		602CC		
		25 (172)	1 1/2	1 1/2		602.5CC		
		30 (207)	2	2		603CC		
		40 (276)	3	**		604CC		
		50 (345)	3	**		605CC		
		60 (414)	5	**		606CC		
		75 (518)	5	**		607.5CC		
		90 (621)	7 1/2	**		609CC		
75,000 Sq. Ft. EDR 18,750 lb./hr. (8,505 kg/hr)	75 (284)	15 (103)	1 1/2	1 1/2	2 (51)	751.5CC	75 (284)	4 (102)
		20 (138)	1 1/2	1 1/2		752CC		
		25 (172)	2	2		752.5CC		
		30 (207)	3	**		754CC		
		50 (345)	5	**		755CC		
		60 (414)	5	**		756CC		
		75 (518)	7 1/2	**		757.5CC		
		90 (621)	7 1/2	**		759CC		
90,000 Sq. Ft. EDR 24,250 lb./hr. (11,000 kg/hr)	90 (341)	15 (103)	1 1/2	1 1/2	2 (51)	901.5CC	75 (284)	4 (102)
		20 (138)	2	2		902CC		
		25 (172)	2	2		902.5CC		
		30 (207)	3	3		903CC		
		40 (276)	5	**		904CC		
		50 (345)	5	**		905CC		
		60 (414)	7 1/2	**		906CC		
		75 (518)	7 1/2	**		907.5CC		
112,000 Sq. Ft. EDR 28,000 lb./hr. (12,701 kg/hr)	112 (424)	15 (103)	1 1/2	2	2 (51)	1121.5CC	120 (454)	4 (102)
		20 (138)	2	2		1122CC		
		25 (172)	3	3		1122.5CC		
		30 (207)	3	3		1123CC		
		40 (276)	5	**		1124CC		
		50 (345)	5	**		1125CC		
		60 (414)	7 1/2	**		1126CC		
		75 (518)	10	**		1127.5CC		
150,000 Sq. Ft. EDR 37,500 lb./hr. (17,010 kg/hr)	150 (568)	15 (103)	3	2	2 (51) for 3500 RPM units 3 (76) for 1750 RPM units	1501.5CC	120 (454)	4 (102)
		20 (138)	3	3		1502CC		
		25 (172)	5	5		1502.5CC		
		30 (207)	5	5		1503CC		
		40 (276)	7 1/2	**		1504CC		
		50 (345)	7 1/2	**		1505CC		
		60 (414)	10	**		1506CC		
		75 (518)	15	**		1507.5CC		

† $\frac{\text{Sq. Ft. EDR}}{4}$ = Lb./hr. Condensate

**3500 RPM is standard. 1750 RPM is not available.

Series CC Standard Unit Features

- Cast Iron Receiver, sizes 14 gallon (53L) and larger have provision for second pump. Receiver sized for 1 minute net storage.
- Cast Iron Receivers are warranted for 20 years from date of shipment against failure due to corrosion.
- Centrifugal Pump(s) with drip-proof motors. Pump capacity sized 2 times system return rate.
- Float switch(es).

Ordering Instructions

Specify basic Model No., RPM, single or duplex, phase, operating voltage, special features. Note: TEFC and explosion proof motors available. The motor horsepower requirement is often greater using explosion proof as they have unity service factor. A horsepower increase is not necessary using TEFC motors.

Optional Features Available as Specified

- Water level gauge w/shut off valve*
- Dial Thermometer*
- Inlet Basket Strainer
- Discharge Pressure Gauges
- NEMA 4 or NEMA 7 Float Switches
- Mechanical alternator provides sequencing of duplex pumps and standby of second pump on high level. (Nema 4 or 7 mechanical alternators available on receiver sizes 36 gallons [136L] and larger)
- Control panels, (Control panels cannot be mounted on 6 & 9 gallon [23 & 34L] receivers, use 14 gallon [53L] minimum)
- Suction butterfly valve 3" (76mm) (available for pump capacities to 75 gpm [284 L/M])
- Suction butterfly valve 3 1/2" (89mm) (available for pump capacities to 76 to 115 gpm [288 to 435 L/M])
- TEFC or Explosion Proof Motors
- High Level Float Switch/Standby Float Switch (Consult factory for arrangement)
- Lifting Eyes (Available on receiver sizes 23 gallon [87L] and larger)
- Tapping/openings not drilled on 9 or 14 gallon (34 or 53L) unless option is specified.

*Not available on 6 gallon (23L) receivers.

Selection Data
All pumps are 3500 RPM

SYSTEM CAPACITY*	PUMP CAPACITY GPM (L/M)	DISCHARGE PRESSURE PSIG (kPa)	MOTOR HORSEPOWER 3500 RPM	DISCHARGE SIZE IN. (mm)	SERIES CB MODEL NO.	CB REC. CAP. GPM (L)	CB INLET SIZE IN. (mm)	SERIES CBE MODEL NO.	CBE REC. CAP. GAL (L)	CBE INLET SIZES IN. (mm)
1,000 to 9,000 Sq. Ft. EDR 250 thru 2,250 lb./hr. (113-1,021 kg/hr)	9 (34)	10-15 (69-103)	1/3	1 1/2 (38)	23CB9-15	23 (87)	2 (51)	23CBE9-15	23 (87)	2 (51)
		20 (138)	1/3		23CB9-20			23CBE9-20		
		25 (172)	1/2		23CB9-25			23CBE9-25		
		30 (207)	3/4		23CB9-30			23CBE9-30		
		40 (276)	1 1/2		23CB9-40			23CBE9-40		
		50 (345)	1 1/2		23CB9-50			23CBE9-50		
		60 (414)	3		23CB9-60			23CBE9-60		
		75 (518)	3		23CB9-75			23CBE9-75		
		85 (587)	5		23CB9-85			23CBE9-85		
		100 (690)	5		23CB9-100			23CBE9-100		
12,000 Sq. Ft. EDR 3,000 lb./hr. (1,361 kg/hr)	12 (45)	10-15 (69-103)	1/3	1 1/2 (38)	23CB12-15	23 (87)	2 (51)	23CBE12-15	23 (87)	2 (51)
		20 (138)	1/3		23CB12-20			23CBE12-20		
		25 (172)	1/2		23CB12-25			23CBE12-25		
		30 (207)	3/4		23CB12-30			23CBE12-30		
		40 (276)	1 1/2		23CB12-40			23CBE12-40		
		50 (345)	2		23CB12-50			23CBE12-50		
		60 (414)	3		23CB12-60			23CBE12-60		
		75 (518)	5		23CB12-75			23CBE12-75		
		85 (587)	5		23CB12-85			23CBE12-85		
		100 (690)	5		23CB12-100			23CBE12-100		
15,000 Sq. Ft. EDR 3,750 lb./hr. (1,701 kg/hr)	15 (56)	10-15 (69-103)	1/3	1 1/2 (38)	23CB15-15	23 (87)	2 (51)	23CBE15-15	23 (87)	2 (51)
		20 (138)	1/2		23CB15-20			23CBE15-20		
		25 (172)	3/4		23CB15-25			23CBE15-25		
		30 (207)	3/4		23CB15-30			23CBE15-30		
		40 (276)	1 1/2		23CB15-40			23CBE15-40		
		50 (345)	2		23CB15-50			23CBE15-50		
		60 (414)	3		23CB15-60			23CBE15-60		
		75 (518)	5		23CB15-75			23CBE15-75		
		85 (587)	5		23CB15-85			23CBE15-85		
		100 (690)	5		23CB15-100			23CBE15-100		
22,000 Sq. Ft. EDR 5,500 lb./hr. (2,495 kg/hr)	22 (83)	10-15 (69-103)	1/2	1 1/2 (38)	23CB22-15	23 (87)	2 (51)	23CBE22-15	23 (87)	2 (51)
		20 (138)	1/2		23CB22-20			23CBE22-20		
		25 (172)	3/4		23CB22-25			23CBE22-25		
		30 (207)	3/4		23CB22-30			23CBE22-30		
		40 (276)	1 1/2		23CB22-40			23CBE22-40		
		50 (345)	2		23CB22-50			23CBE22-50		
		60 (414)	3		23CB22-60			23CBE22-60		
		75 (518)	5		23CB22-75			23CBE22-75		
		85 (587)	5		23CB22-85			23CBE22-85		
		100 (690)	5		23CB22-100			23CBE22-100		
30,000 Sq. Ft. EDR 7,500 lb./hr. (3,402 kg/hr)	30 (114)	10-15 (69-103)	1/2	1 1/2 (38)	36CB30-15	36 (136)	3 (76)	36CBE30-15	36 (136)	3 (76)
		20 (138)	3/4		36CB30-20			36CBE30-20		
		25 (172)	3/4		36CB30-25			36CBE30-25		
		30 (207)	1		36CB30-30			36CBE30-30		
		40 (276)	2		36CB30-40			36CBE30-40		
		50 (345)	3		36CB30-50			36CBE30-50		
		60 (414)	3		36CB30-60			36CBE30-60		
		75 (518)	5		36CB30-75			36CBE30-75		
		85 (587)	5		36CB30-85			36CBE30-85		
		100 (690)	7 1/2		36CB30-100			36CBE30-100		
37,000 Sq. Ft. EDR 9,250 lb./hr. (4,196 kg/hr)	37 (140)	10-15 (69-103)	1/2	1 1/2 (38)	36CB37-15	36 (136)	3 (76)	36CBE37-15	36 (136)	3 (76)
		20 (138)	3/4		36CB37-20			36CBE37-20		
		25 (172)	1		36CB37-25			36CBE37-25		
		30 (207)	1		36CB37-30			36CBE37-30		
		40 (276)	3		36CB37-40			36CBE37-40		
		50 (345)	3		36CB37-50			36CBE37-50		
		60 (414)	5		36CB37-60			36CBE37-60		
		75 (518)	5		36CB37-75			36CBE37-75		
		85 (587)	5		36CB37-85			36CBE37-85		
		100 (690)	7 1/2		36CB37-100			36CBE37-100		
45,000 Sq. Ft. EDR 11,250 lb./hr. (5,130 kg/hr)	45 (170)	10-15 (69-103)	3/4	1 1/2 (38)	52CB45-15	52 (197)	3 (76)	52CBE45-15	52 (197)	3 (76)
		20 (138)	3/4		52CB45-20			52CBE45-20		
		25 (172)	1		52CB45-25			52CBE45-25		
		30 (207)	1 1/2		52CB45-30			52CBE45-30		
		40 (276)	3		52CB45-40			52CBE45-40		
		50 (345)	3		52CB45-50			52CBE45-50		
		60 (414)	5		52CB45-60			52CBE45-60		
		75 (518)	5		52CB45-75			52CBE45-75		
		85 (587)	7 1/2		52CB45-85			52CBE45-85		
		100 (690)	7 1/2		52CB45-100			52CBE45-100		

*$\frac{\text{Sq. Ft. EDR}}{4}$ = Lb./hr.

SYSTEM CAPACITY*	PUMP CAPACITY GPM (L/M)	DISCHARGE PRESSURE PSIG (kPa)	MOTOR HORSEPOWER 3500 RPM	DISCHARGE SIZE IN. (mm)	SERIES CB MODEL NO.	CB REC. CAP. GPM (L)	CB INLET SIZE IN. (mm)	SERIES CBE MODEL NO.	CBE REC. CAP. GAL (L)	CBE INLET SIZES IN. (mm)
60,000 Sq. Ft. EDR 15,000 lb./hr. (6,804 kg/hr)	60 (227)	15 (103)	1½	2 (51)	75CB60-15	75 (284)	4 (102)	75CBE60-15	75 (284)	4 (102)
		20 (138)	1½		75CB60-20			75CBE60-20		
		25 (172)	2		75CB60-25			75CBE60-25		
		30 (207)	2		75CB60-30			75CBE60-30		
		40 (276)	3		75CB60-40			75CBE60-40		
		50 (345)	5		75CB60-50			75CBE60-50		
		60 (414)	5		75CB60-60			75CBE60-60		
		75 (518)	7½		75CB60-75			75CBE60-75		
		85 (587)	7½		75CB60-85			75CBE60-85		
		100 (690)	7½		75CB60-100			75CBE60-100		
75,000 Sq. Ft. EDR 18,750 lb./hr. (8,505 kg/hr)	75 (284)	15 (103)	1½	2 (51)	75CB75-15	75 (284)	4 (102)	75CBE75-15	75 (284)	4 (102)
		20 (138)	2		75CB75-20			75CBE75-20		
		25 (172)	2		75CB75-25			75CBE75-25		
		30 (207)	3		75CB75-30			75CBE75-30		
		40 (276)	5		75CB75-40			75CBE75-40		
		50 (345)	5		75CB75-50			75CBE75-50		
		60 (414)	7½	2½ (64)	Not Available			75CBE75-60		
		75 (518)	10		Not Available			75CBE75-75		
		85 (587)	10		Not Available			75CBE75-85		
		100 (690)	15		Not Available			75CBE75-100		
90,000 Sq. Ft. EDR 22,500 lb./hr. (11,000 kg/hr)	90 (341)	15 (103)	1½	2 (51)	120CB90-15	120 (454)	4 (102)	120CBE90-15	120 (454)	4 (102)
		20 (138)	2		120CB90-20			120CBE90-20		
		25 (172)	3		120CB90-25			120CBE90-25		
		30 (207)	3		120CB90-30			120CBE90-30		
		40 (276)	5		120CB90-40			120CBE90-40		
		50 (345)	7½		Not Available			120CBE90-50		
		60 (414)	7½		Not Available			120CBE90-60		
		75 (518)	10		Not Available			120CBE90-75		
		85 (587)	10		Not Available			120CBE90-85		
112,000 Sq. Ft. EDR 28,000 lb./hr. (12,701 kg/hr)	112 (424)	15 (103)	3	2 (51)	NOT AVAILABLE	–	–	120CBE112-15	120 (454)	4 (102)
		20 (138)	3					120CBE112-20		
		25 (172)	5					120CBE112-25		
		30 (207)	5					120CBE112-30		
		40 (276)	7½	2½ (64)				120CBE112-40		
		50 (345)	7½					120CBE112-50		
		60 (414)	10	2 (51)				120CBE112-60		
		75 (518)	10					120CBE112-75		
		85 (587)	15					120CBE112-85		
140,000 Sq. Ft. EDR 34,748 lb./hr. (15,762 kg/hr)	140 (530)	25 (172)	5	2½ (64)	NOT AVAILABLE	–	–	120CBE140-25	120 (454)	4 (102)
		30 (207)	5					120CBE140-30		
		40 (276)	7½					120CBE140-40		
		50 (345)	7½					120CBE140-50		
		60 (414)	10	2 (51)				120CBE140-60		
		75 (518)	15					120CBE140-75		
		85 (587)	15					120CBE140-85		

$^{*}\frac{\text{Sq. Ft. EDR}}{4}$ = Lb./hr.

Series CB Standard Unit Features

- Cast iron receiver.
- All simplex receivers have a blanked opening for second pump.
- Cast Iron Receivers are warranted for 20 years from date of shipment against failure due to corrosion.
- Series B35 centrifugal pump(s) with drip-proof motors. Pump capacity sized 2 times system return rate.
- Float switch(es).

Series CBE Standard Unit Features

- Cast iron receiver mounted on a welded steel stand.
- All simplex receivers have a blanked opening for second pump.
- Cast Iron Receivers are warranted for 20 years from date of shipment against failure due to corrosion.
- Series B35 centrifugal pump(s) with drip-proof motors. Pump capacity sized 2 times system return rate.
- Float switch{es).
- Suction piping isolation valves.

Optional Features

- Water level gauge w/shut off valve
- Dial Thermometer
- Inlet Basket Strainer
- Discharge Pressure Gauges
- Mechanical Alternator provides sequencing of duplex pumps and stand-by of second pump on high level.
- NEMA 2- U.L. Listed Control Panels
- Suction Butterfly Valve (optional on Series CB Units only, on capacities to 75 gpm)
- Lifting Eyes

Ordering Instructions

Specify Model No., single or duplex, phase, operating voltage, special features.

Note: TEFC and explosion proof motors are available. The motor horsepower requirement is often greater using explosion proof motors as they have unity service factor. A horsepower increase is not necessary when using TEFC Motors.

The type CB unit may be supplied as a heightless unit capable of handling condensate return temperatures within 2°F of boiling. It may also be supplied with the receiver elevated 24 inches above the floor to handle condensate at the full boiling temperature.

The type CB units have the pumps selected for 2 times condensing rate. The smaller value has proven adequate in the years of experience using low NPSH pumps, loss of pump capacity due to cavitation need not be considered when using the type CB units. Receiver sizing is based on one minute net storage capacity. The previous tables on page 14 and 15 show the selection of type CB units.

Condensate transfer units are available using underground receivers to handle condensate from low return lines below floor level. Larger systems are available using steel receivers.

Condensate return temperatures may exceed saturation temperature. To avoid flash steam (steam waste), a closed system should be employed to save the energy in the return temperature..

STEP 5

SELECT THE ACCESSORY EQUIPMENT DESIRED

One of the first options to be considered is the number of pumps. The Type CC and CB units are available with single or duplex pumps. The pump capacity is figured the same for either type. The duplex unit is intended to provide standby protection in the event of a pump failure. The basic unit includes a receiver, one or two pumps, and one or two float switches.

Single units are provided with one float switch to start the pump on high water level and stop the pump on low level.

Duplex units are available with several options for the level control. The basic unit has 2 float switches, the No. 1 float switch starts the number one pump usually one inch below the return or inlet connection. The No. 2 float switch starts the second or No. 2 pump approximately one inch higher, thus automatic standby of the second pump is provided.

The basic 2 float switch arrangement always starts the No. 1 pump first and the No. 2 pump operates only when a failure of No. 1 pump occurs or an abnormal load rate is encountered. With this arrangement, the No. 2 pump may remain idle for several years and scale may cause a seizure to occur. Some type of sequencing is recommended to provide equal wear and prevent scale build-up of the idle pump.

Duplex units are available with a mechanical alternator, electrical alternator or lead-lag manual selector switch. The mechanical alternator consists of two switch assemblies operated by one float and linkage assembly. As the water level rises one switch will close and start one pump as the level recedes the switch will open. The next cycle, the opposite switch will close starting the alternator pump, thus the mechanical alternator sequences the pump operation each operating cycle. In the event the first pump fails to operate and the water level continues to rise, both contacts on the mechanical alternator will close starting the second pump.

Electrical alternators are available to sequence the pump operation in response to the No. 1 float switch. The No. 2 float switch then operates both pumps when a high water level is reached. Electrical alternators require magnetic starters to start the motor as the contacts are single pole switches rated 10 amps or less. The standard float switch and mechanical alternator are provided with double pole bearing duty contacts rated to start 1 Phase Motors up to 1 H.P. direct without magnetic starters. These motors have built-in overload protection to protect against overcurrent conditions. Lead-lag selector switches may be used to manually sequence the pumps on a periodic time schedule. The use of lead-lag selector switches also require magnetic starters to start the motors.

Our recommendation is to use mechanical alternators on single phase units up to 1 H.P. On three phase applications and 1 phase applications 1½ H.P. and larger, use lead-lag selector switches as these units require magnetic starters.

Other desirable options include a gauge glass which permits visual monitoring of the operation and is an aid in adjusting the level switches. Thermometers permit the monitoring of return temperatures and provide an indication when steam traps have failed. Discharge pressure gauges provide a check on pump performance and are useful in adjusting the discharge plug cocks when balancing the flow for optimum pump performance. Shut-off valves in the pump suction of duplex units are recommended to permit servicing one pump without shutting off the system and draining the receiver. Domestic offers a suction butterfly valve on floor mounted units up to 75 GPM pump rate. Gate valves are available in the pump suction piping on units having elevated receivers. Strainers are recommended to be installed at the receiver inlet. Domestic offers basket strainers featuring large dirt pockets and vertical self-cleaning strainer screens.

Control Panels

Standard drip-proof motors up to 1 H.P., 1 phase have built-in overload protection. The float switches and mechanical alternators commonly used on condensate transfer units are double-pole, heavy duty type rated to start up to 1 H.P. motors direct without requiring magnetic starters or contactors. All 3 phase motors, 1 phase motors over 1-1/2 H.P. and all TEFC and explosion-proof motors regardless of H.P. or phase require magnetic starters to carry the motor current.

Condensate units are available with a control panel either mounted and wired on the unit or for wall mounting. Units having the control panel mounted and wired are preferred to provide a complete unit factory tested to reduce costly field errors.

Control panels may be furnished with magnetic starters or combination type magnetic starters including a disconnect switch or circuit breaker in the same enclosure. Selector switches may be furnished in the control panel having auto-off selector switches or lead-off lag selector switches. A test push button is normally supplied to permit testing pump operation and checking on pump rotation. A hand or continuous position on the selector switch is not recommended as this could cause the pump to operate dry and damage the pump seals.

Transformers to reduce the control voltage to 115 volts is required on units wired for 460 volts and are recommended for units operating at 200 or 230 volts. The reduced voltage 115 V power is then wired to the auxiliary control switches to reduce the hazard of high voltage shock.

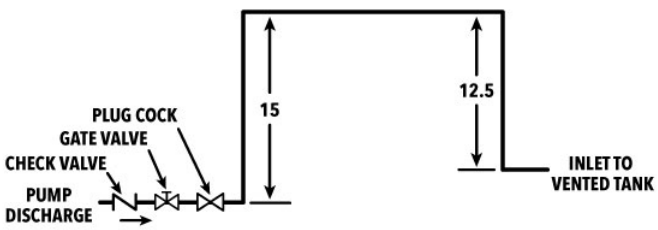
Pump running pilot lights are available to indicate pump operation. Electrical alternators, when used, are mounted in the control panel and require magnetic starters to carry the motor current.

The standard control panel furnished by Bell & Gossett Domestic Pump are rated NEMA 2 or drip tight. The NEMA 2 design protects against moisture getting in the panel from overhead drips such as sweating pipes, etc. Control panels are available to meet other NEMA requirements and JIC requirements.

HIGH TEMPERATURE CONDENSATE PIPING

Special consideration should be given to the pumping of high temperature condensate to prevent flashing in the discharge piping. If the pressure in the discharge line is below the saturation of the condensate, it will flash into steam when the flash steam either reaches colder condensate or if the line is pressurized, the steam will condense suddenly and cause water hammer to occur.

Discharge lines from condensate transfer units are often piped overhead and then drop down into a boiler feed unit or deaerator.

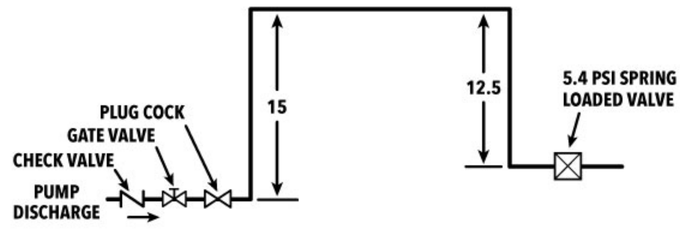


WRONG!
Overhead Discharge Piping to Vented Tank

In the illustration above, the 12.5' drop will cause a 12.5' negative pressure to occur in the vertical piping when the pump stops due to the leg of water in the vertical pipe. At a 12.5' negative pressure, condensate will flash at 190°F corresponding to the saturation temperature at 12. 5' negative pressure. When the condensate flashes, steam pockets will occur in the vertical pipe, the pump starts again and the pressure in the line is above the corresponding saturation temperature and the steam pockets will collapse suddenly and waterhammer will occur.

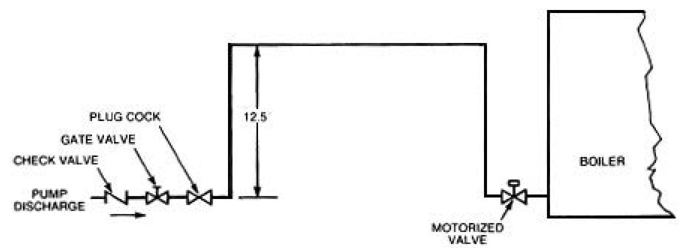
To prevent against waterhammer, a spring loaded back pressure valve having a 12.5' or 5.4 PSI back pressure may be used to hold a pressure in the line.

The spring-loaded valve will hold a back pressure to prevent flashing. Waterhammer in the discharge piping of preheat



CORRECT!
Overhead Discharge Piping to Vented Tank

units and deaerators pumping condensate at 210°F to 212°F often occurs when electric valves or check valves are used at the boiler.



Overhead Piping to Boiler

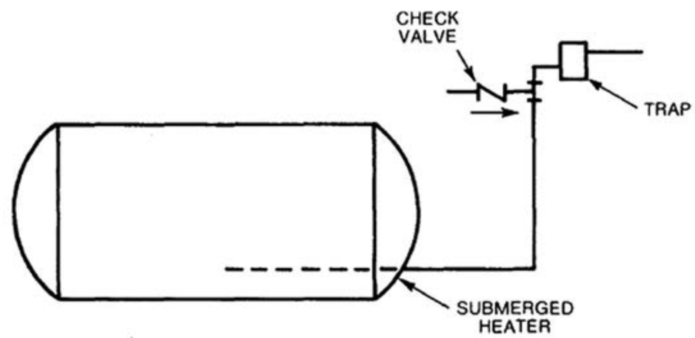
The discharge piping method shown is commonly used to elevate piping across walkways. A condition may occur where the boiler control valve closes tight and the pump discharge check valve leaks slightly. A leaking check valve at the pump discharge will drain condensate from the vertical leg which causes a negative pressure in the horizontal piping. This will cause flashing to occur and cause waterhammer in the discharge piping when the pump starts.

This condition can usually be corrected by repairing the check valves at the pump discharge. An alternate solution is to install a small check valve around the boiler valve to allow boiler pressure to remain on the pump discharge line. The flow of the bypass check valve would be from the boiler.

Another common occurrence of waterhammer in piping occurs when high temperature drips are piped into the boiler feed unit through a submerged inlet connection. This is often done to prevent flash steam from being wasted.

When traps are drained into a submerged inlet connection, there must be either a vacuum breaker or check valve to act as a vacuum breaker, installed to allow air to enter and permit condensate drainage. If a check valve or vacuum breaker is not installed, the return line will fill with condensate, as the condensate cools in the line, cooler water will be held at the trap discharge. The next time the trap opens and discharges condensate above saturation temperature, flashing and collapse of steam will occur causing water hammer. The addition of a vacuum breaker or check valve will allow drainage and correct the problem.

The following chart shows the temperature at which condensate will flash when subject to a negative pressure.



Piping of High Pressure Drip to Submerged Heater

Temperature	Ft. Water Negative Pressure	Temperature	Ft. Water Negative Pressure
212°F	0	190°F	12.5
211°F	.5	155°F	24.3
210°F	1.4	116°F	30.5
208°F	2.6	100°F	31.7
207°F	3.6	70°F	33.1
206°F	4.0		
205°F	4.7		
204°F	5.1		
200°F	7.5		

The following unit selection guide shows the Domestic products available to meet required conditions. For more information refer to the catalog section shown for various products.

HOW TO SIZE AND SELECT A BOILER FEED WATER SYSTEM

1. Determine the unit load requirements.
2. Determine the type of feed system to be used.
3. Select the type of control system required.
4. Calculate the pump capacity.
5. Calculate the pump discharge pressure.
6. Select the actual unit.
7. Select the accessory items desired.

STEP 1

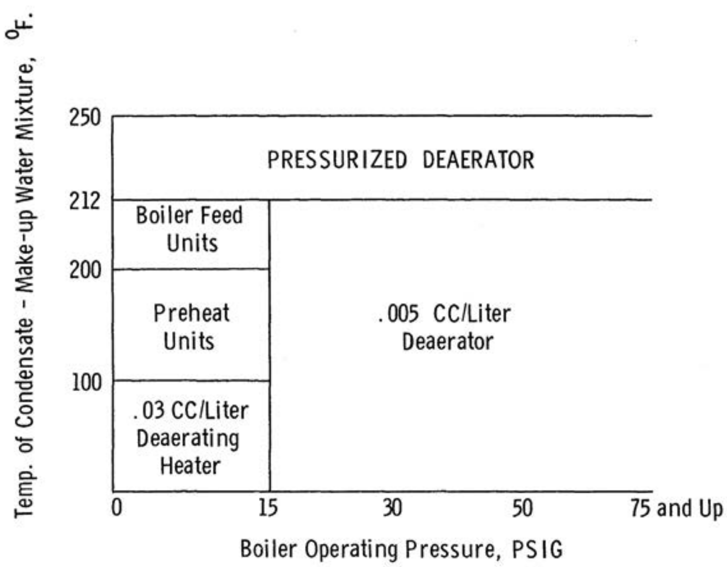
DETERMINE THE UNIT LOAD REQUIREMENT

The load requirement should be based on the boiler capacity, not the system capacity. The system capacity cannot exceed the boiler capacity and future expansion may add to the system load. The boiler is normally rated in boiler horsepower, however, some boilers may be rated in lbs. /hr., square ft. E.D.R., or BTU output. The conversion tables in the back of this manual may be used to determine the boiler steaming rate in gallons per minute. When multiple boilers are used, the rate for the total of all boilers should be used.

STEP 2

DETERMINE THE TYPE OF FEED SYSTEM TO BE USED

Small space heating systems up to 50 boiler horsepower or 8, 000 sq. ft. E.D.R. may use a condensate transfer unit to feed the boiler. A boiler feed type system is preferable for all steam boiler feed water control. The following chart shows the normal or recommended type of boiler feed system to be used in relation to the boiler pressure and blend temperature of return condensate and make-up water.



Boiler Feed Unit or Deaerator Which is Best for Your System?

STEP 3

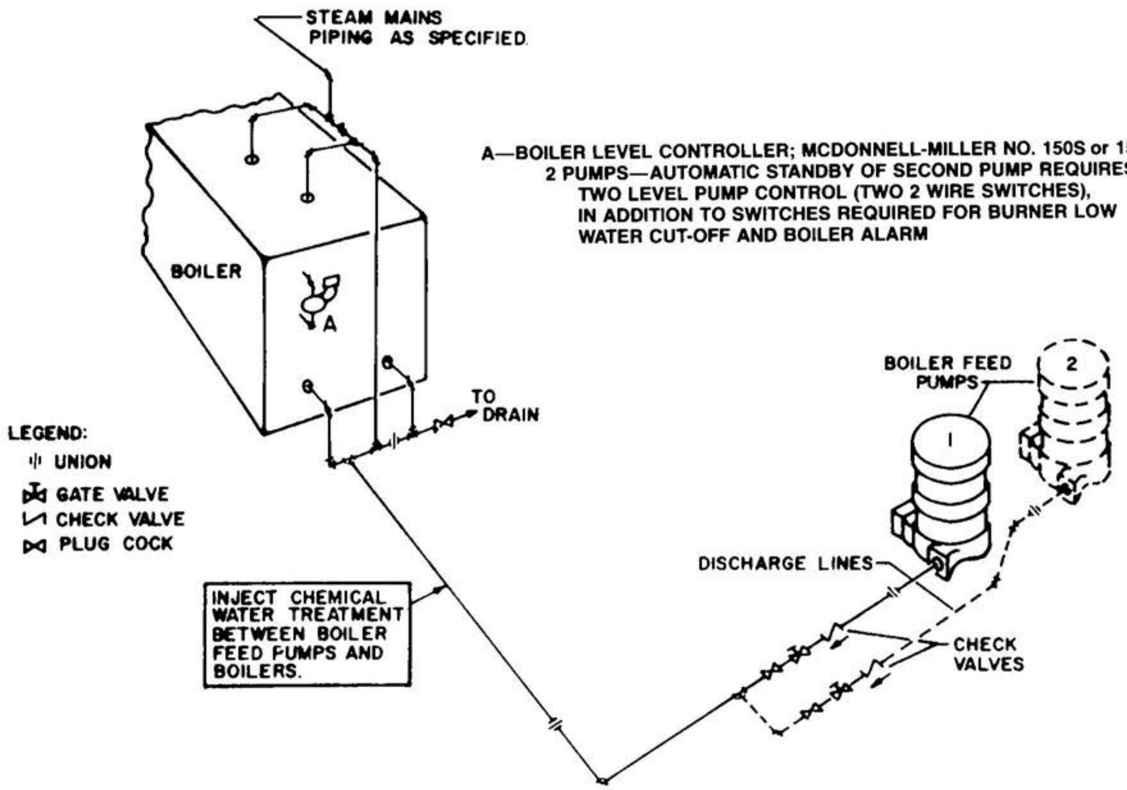
SELECT THE TYPE OF CONTROL SYSTEM REQUIRED

There are several choices in the type of piping arrangements to meet various requirements. The following are the most common used to meet most conditions. Careful consideration should be given in the selection to provide efficient operation and meet the various requirements.

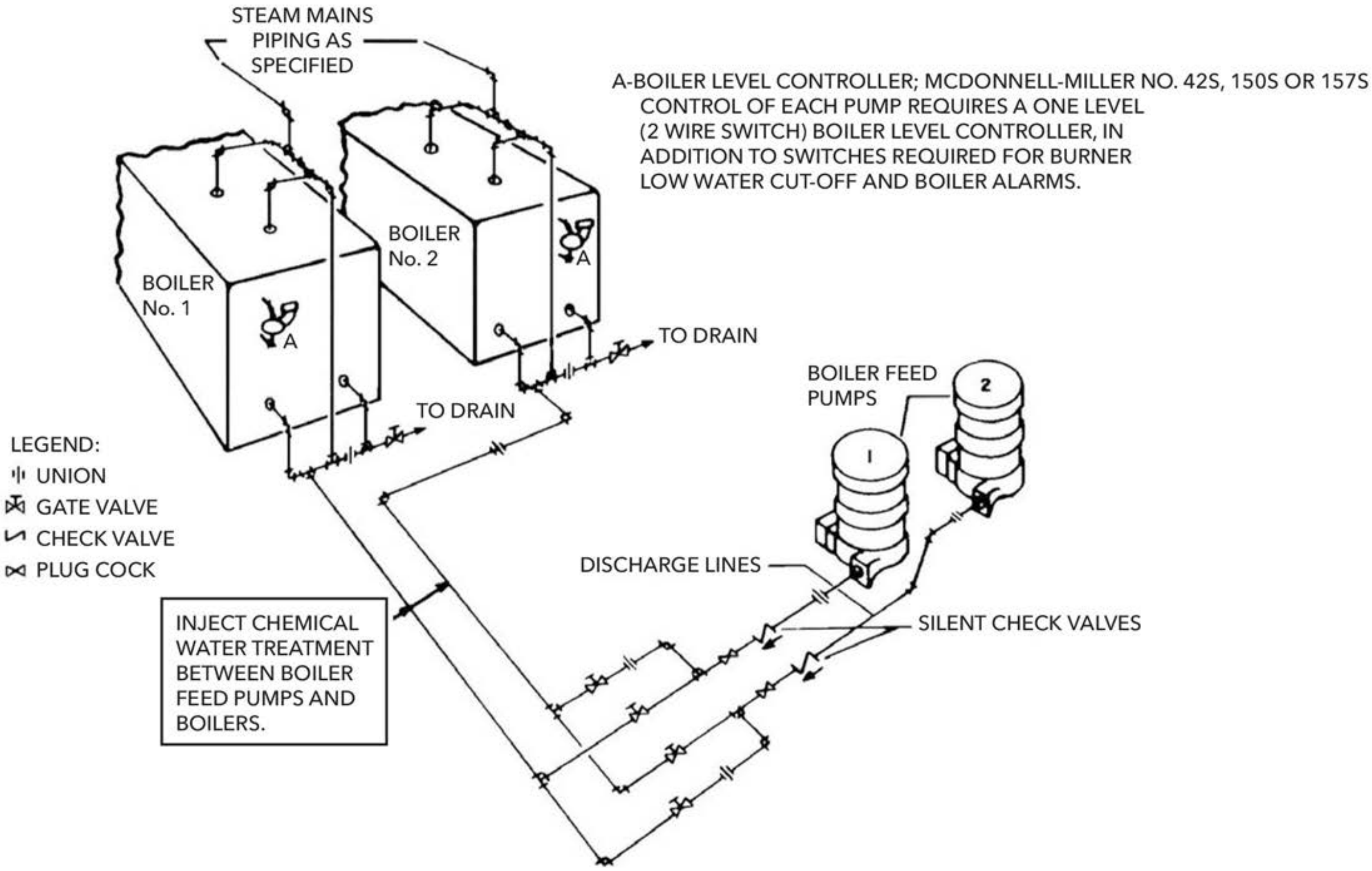
Control Systems

Piping Diagram 1 DPD21-D shows a single boiler installation. One or two pumps may be specified. Two pumps are preferred to provide standby protection. The boiler level control may be a single level switch to control one pump. With a single switch, the second pump would be a manual standby. The pump selector switches would provide automatic - off positions. An electric alternator may also be used to sequence the pump operation.

When a two level switch is provided, the second pump can be wired for automatic standby protection. With a two level boiler level control, the pump selector switches can be either "lead-off-lag" or "auto-off" with an electrical alternator used to sequence the pump operation. Manual standby is preferable where a pump failure can be monitored by a boiler room attendant. When there is no attendant during certain times, such as in a school, automatic standby should be provided to prevent a system freeze -up during a weekend or night period.

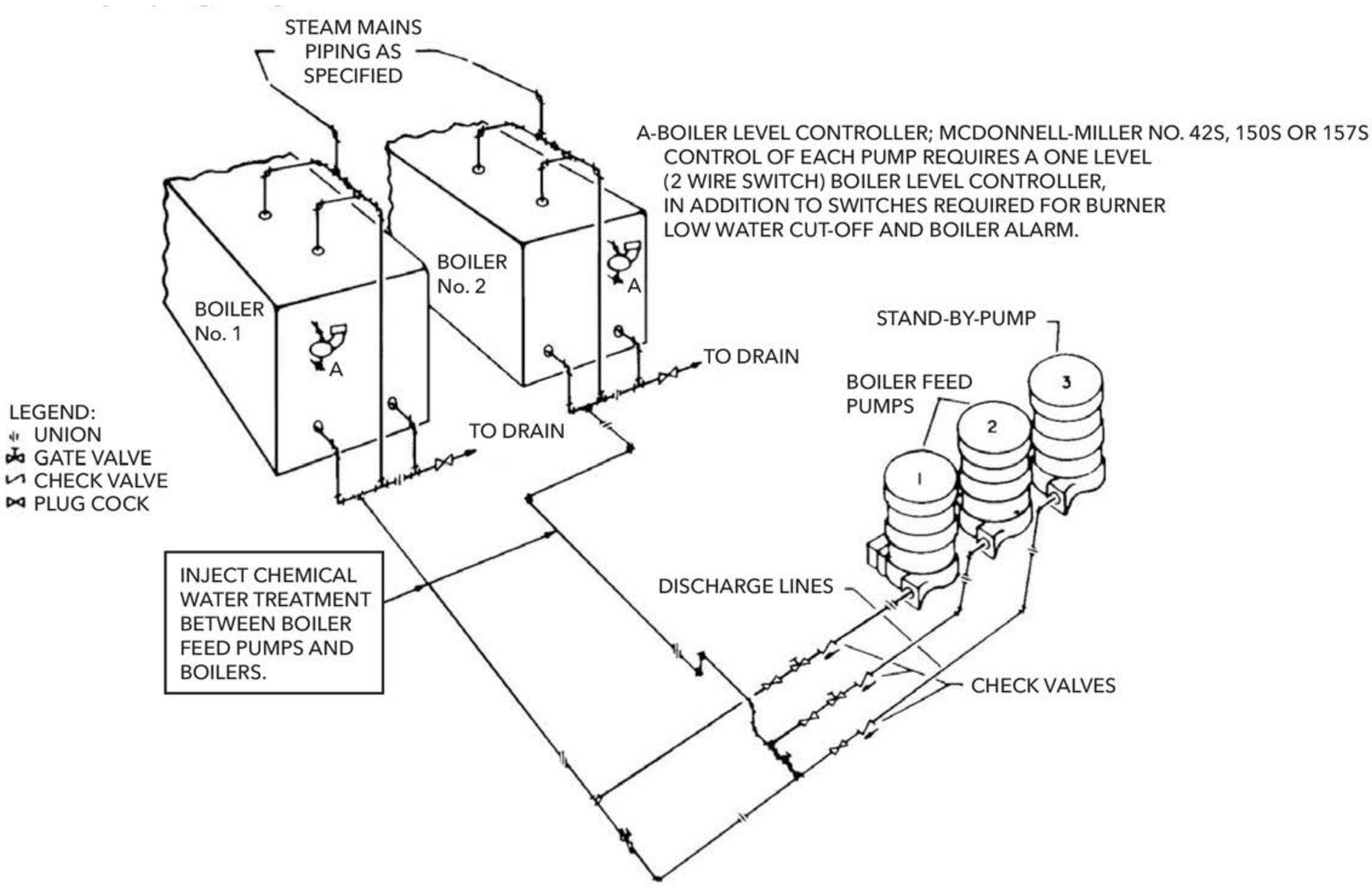


1 Boiler, 2 Pumps - Automatic Standby - Automatic Alternation
Elementary Piping Diagram – 1 DPD21-D



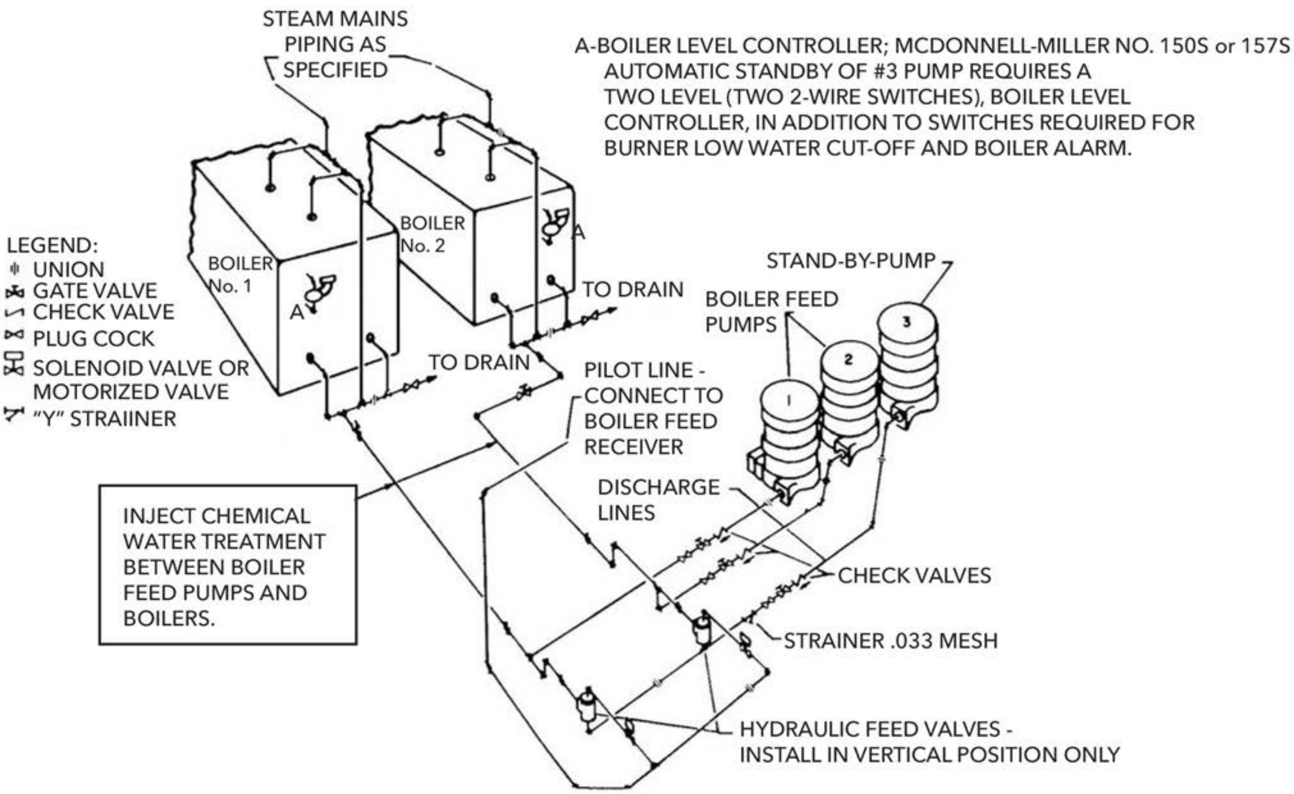
2 Boilers, 2 Pumps - Manual Standby
Each pump to feed its respective boiler with manual valves to permit operation of either pump with either boiler
Elementary Piping Diagram – 1 DPD17

Piping Diagram 1 DPD17 shows a two boiler system using two pumps. The No. 1 pump normally feeds No. 1 boiler and the No. 2 pump normally feeds the No. 2 boiler. The pump switches are marked Pump No. 1 "Feeding Boiler 1 - Off - Feeding Boiler 2" and Pump No. 2 "Feeding Boiler No. 1 - Off - Feeding Boiler No. 2". Therefore, manual standby is provided to permit operation of either boiler by changing the pump selector switch settings and manually opening the corresponding discharge line gate valves.



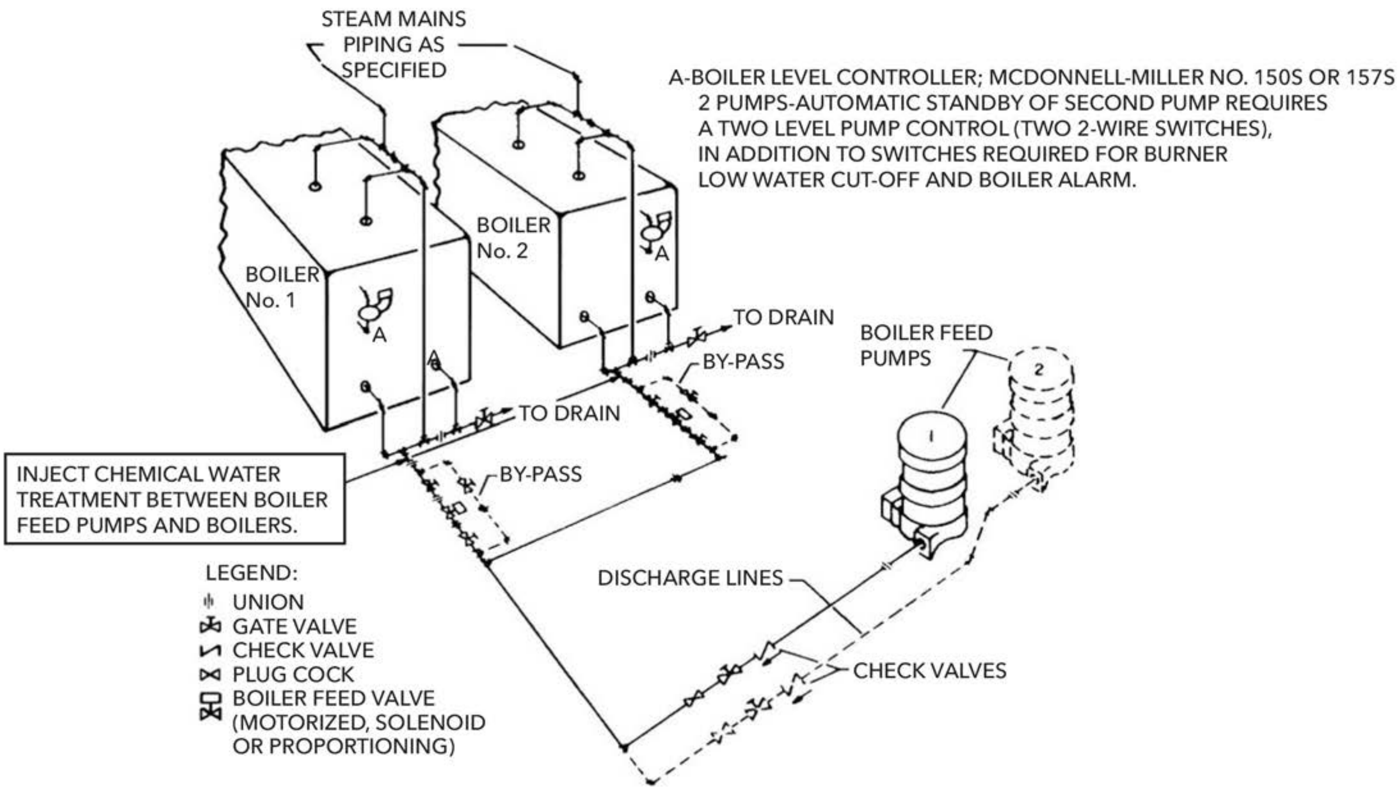
2 Boilers, 3 Pumps - Manual Standby
Elementary Piping Diagram – 1 DPD12

Piping Diagram 1 DPD12 provides three pumps to feed two boilers. Each boiler has a normal pump and Pump No. 3 may be selected to feed either boiler by setting the pump selector switch and opening the proper discharge gate valve. This system provides standby protection for operation of both boilers.



2 Boilers, 3 Pumps - Automatic Standby with Hydraulic Feed Valves
Elementary Piping Diagram – 1 DPD20

Piping Diagram 1 DPD20 is similar to 1 DPD12 except the No. 3 standby pump operation is automatic instead of manual. This arrangement requires that a two level boiler control switch be supplied to automatically start the second pump if the lead pump fails to maintain the boiler level.



2 Boilers, 2 Pumps - Automatic Standby
Electric valves with end switches in branch lines to each boiler
Elementary Piping Diagram – 1 DPD08-A

Piping Diagram 1 DPD08-A shows a multiple boiler installation being fed by a common manifold. The input rate to each boiler is controlled with an electric valve. As the water level in boiler recedes, a switch on the boiler level control closes to open the electric valve. Motorized valves are generally used, as solenoid valves may close too fast and cause water hammer in the piping. The motorized valve should have an opening and closing time between seven seconds and fifteen seconds. As the valve begins to open, an auxiliary switch (end switch) makes contact to start a pump. The boiler may be equipped with a second switch to automatically start the second pump at a lower water level. The pumps may have an "Automatic - Off" selector switch for manual selection, or an electric alternator may be added for automatic sequencing of the pumps. A lead-off-lag selector switch may be used to manually select the lead and lag pump. A two level boiler control switch is required with lead-lag control.

The arrangement shown in Diagram 1 DPD08-A is preferred when all the boilers are operated the majority of the time to provide the most efficient pump operation. When the load rate changes and at times all boilers are not firing, one of the arrangements using a separate pump is preferred. The pumps would then be sized for the individual boilers to provide the most efficient system.

STEP 4

CALCULATE THE PUMP CAPACITY

Depending on the type of control system selected, the pumps may be required to feed one boiler or multiple boilers. The individual pumps capacity should be based on the boiler(s) they are required to feed. The pumps are normally sized between 1-1/2 and 3 times the boiler load. Centrifugal pumps selected for continuous operation are normally sized at 1-1/2 times the boiler load. Centrifugal pumps for intermittent operation are normally sized at 2 times the boiler load. When there is a danger of pump cavitation or when turbine pumps which may lose their original capacity in a short time are used, the pump should be sized at 3 times the boiler load. The old standard was to size all pumps at 3 times the load for boiler feed applications. When modern 2' NPSH centrifugal pumps are used, this oversizing is not required particularly with modern boilers. See conversion Table 4 on page 42 to calculate the boiler steaming rate and multiply by 1½, 2, or 3 as required to determine the required pump capacity.

STEP 5

CALCULATE THE PUMP DISCHARGE PRESSURE

The required discharge pressure includes static head lift required, friction loss in the piping and fittings, friction loss through the check valve, gate valves, plug cocks, and automatic feed valves. The boiler pressure must be added plus a safety margin of 5 to 10 PSI. 5 PSI is usually added as a safety margin for pump pressures up to 50 PSI and 10 PSI added for higher pressure requirements.

Static Head - This is the elevation difference between the pump discharge and the highest point in the discharge piping or boiler water level whichever is highest.

For example, the pump is located in a pit in the boiler room and the discharge pipe runs 23 feet above the pit into the boiler which sits on the floor above the pit having a maximum water line 10' above the pump discharge. The static lift is 23 feet.

Friction Loss- The tables in the back of this manual, page 45 show the friction loss in feet for pipe and pipe fittings.

Example: 25 GPM are to be piped through a 1½" pipe 50' long having four (4) 90° elbows, a check valve, a gate valve, and through a proportioning motorized valve having a 10 PSI pressure drop at 25 GPM and pump into a boiler having a maximum firing pressure of 15 PSI.

Each 90° elbow has a pressure drop equal to 7.4 feet of pipe. The gate valve has a drop equal to 1.2 feet of pipe. A swing check valve has a drop equal to 15 feet of pipe. (If a spring loaded non-slam check valve were used, a higher pressure drop would occur usually between 1 to 5 PSI.) The total equivalent length of pipe would be as follows:
50 + (4 x 7.4) + 1. 2 + 15 = 95.8 equivalent length. The friction loss of 1½" pipe at 25 GPM is 4.4 feet per 100 feet or 95.8 x .044 = 4.2 feet loss.

The total pressure required for the system would be 23 divided by 2.31=10 PSI static pressure required+4.2 divided by 2.31=1.8 PSI friction loss in pipe+10 PSI pressure drop through the motorized valve+15 PSI boiler pressure or a total of 36.8 PSI required. We then add a safety margin of 5 PSI and select a pump for 42 PSI discharge at the required capacity.

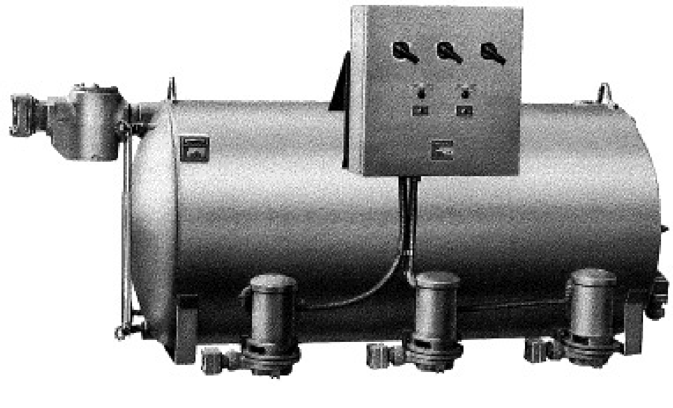
STEP 6

SELECT THE ACTUAL UNIT

We now should know the total boiler load and have determined the type of boiler feed, preheat or deaerator we wish to apply. The type of control system, the individual pump capacity and pump discharge pressure should have been selected.

We can now select the actual unit required to meet these requirements.
Example: In Step 1, we determined that the total load is two (2) 200 H.P. boilers operating at 15 PSI. A total load of 400 H.P. In Step 2, we determined that a boiler feed system is desired. In Step 3, due to only one boiler being used most of the time, we selected the feed arrangement per piping diagram 1 DPD12 to provide full system standby. In Step 4, the intermittent operating pumps are selected for 2 times the boiler steaming rate or 200 x .069 = 13.8 GPM x 2 = 27.6 GPM. In Step 5, the discharge pressure was calculated at 30 PSI. We can now select either the Domestic CHMD or CMED unit.

Style CMHD units offer flexible and economical solutions to feeding low pressure boilers. The conveniently low inlet of the floor mounted receiver frequently permits handling gravity returns without having to resort to expensive concrete pits.



Type CMHD Boiler Feed Unit

The receiver is fabricated of black steel, and is available galvanized or phenolic-epoxy lined. There is a wide range of receiver sizes, guaranteeing efficient matching of unit to system, and depending on receiver size, as many as eight boiler feed pumps can be mounted on the receiver.

"Domestic" type B35 pumps are standard equipment. These are 2 ft. NPSH centrifugal pumps, rugged and reliable, and they assure pumping even at temperatures within two degrees of boiling. A floor level receiver is practical only because of the low required NPSH of these pumps.

Features of the Style CMHD

- Lowest possible inlet -
  – Often eliminates double pumping and concrete pits
- Minimum headroom requirement -
  – Low profile units are easy to install and service.
- "Package" construction yields total unit responsibility
  – Complete factory assembly.
  – Thorough testing of complete unit.
  – Simplified installation.
- Type B35 2 ft. NPSH Centrifugal Boiler Feed Pumps
  – Vertical mounting puts motors above dirt and water, saves floor space.
  – LOW NPSH pumps -designed for condensate service- permit floor level receiver, yet retains full capacity.
- Butterfly shut-off valves between receiver and pumps
  – Permit convenient servicing without draining the receiver.

Type CMED Boiler Feed Unit

Style CMED boiler feed units are intended for low to medium pressure boilers and applications where the make-up requirements are relatively small and condensate approaches or reaches boiling temperatures. Receivers are fabricated of black steel and, as an option, can be galvanized or phenolic-epoxy lined. Elevating the receiver just thirty inches assures full capacity pumping at boiling temperatures, when using any of the pumps illustrated. Under these conditions, ordinary pumps can suffer vapor binding or cavitation, which can drastically reduce pump capacity and be quite destructive. Our family of Type B pumps - B35 and B17, are engineered for a maximum required NPSH of 2 ft. which means that any of them can pump boiling water with as little as 24 inches submergence. Their centrifugal designs retain nearly original capacities after years of operation. There is no need to oversize these pumps to compensate for capacity and pressure losses.

Features of the Style CMED

- 3 Types of centrifugal boiler feed pumps* -
  – All feature hand-finished enclosed bronze impellers.
  – All are designed for pumping boiling water at 2 ft. NPSH.
- Minimal receiver elevation -
  – "Packaged" construction.
  – Total unit responsibility.
  – Easy shipping and installation.
- Wide range of receiver sizes
  – For most efficient operation of your system.
- New standardized receivers for most popular sizes

For discussion purposes, we will assume the CMHD unit is selected due to the lower inlet connection to permit gravity return from the system return line. The following chart from the CMHD brochure permits us to select the actual unit.

The actual unit required would be a CMHD having a 36 x 72 receiver for 10 minute storage and three (3) pumps each rated 28 GPM at 30 PSI requiring 1 H.P. motors.

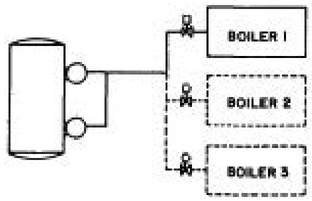
STEP 6A

UNIT SELECTION

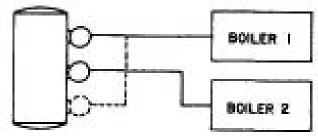
Choose the desired control arrangement.

Please note the pump sizing recommendation. For more detailed help in selecting controls please refer to Domestic Pump brochures on Boiler Feed Piping and Controls.

a. When pumps are discharging into a common header, each pump should be sized for total load. Use suggested PUMP GPM on same line as receiver to be chosen in Step 6B.



b. When each pump feeds its own boiler, size pump accordingly; that is, use suggesgted PUMP GPM on same line as each individual boiler's rating in Step 6B.



STEP 6B

UNIT SELECTION

Pick the receiver that fits your system rating, or is slightly larger; figures are based on 10 minutes storage in receiver.

Receiver Size** Inches (mm)	Net Storage Capacity, U.S. Gallons (L) & Receiver Number	Total Receiver Capacity U.S. Gallons (L)	System Rating			Suggested Pump GPM (L/M)	Approximate Overall Dimensions			
			Total Boiler HP	EDR X 1000	Lbs/Hr (Kg/Hr) Steam		Length Inches (mm)	Width*** Inches (mm)	Height Inches (mm)	Head & Shell Thickness
24 x 36 (610 x 914)	65 (246)	77 (291)	95	13	3200 (1452)	15 (57)	62 (1575)	39 (991)	44 3/4 (1137)	3/16 (5mm)
24 x 60 (610 x 1524)	104 (394)	124 (469)	150	21	5150 (2336)	22 (83)	86 (2184)	39 (991)	44 3/4 (1137)	
30 x 48 (762 x 1219)	141 (534)	161 (609)	205	28	6975 (3164)	30 (114)	73 (1854)	43 (1092)	50 1/2 (1283)	
30 x 72 (762 x 1829)	204 (772)	234 (886)	295	40	10100 (4581)	45 (170)	97 (2464)	45 (1143)	54 3/4 (1391)	
36 x 72 (914 x 1829)	302 (1143)	342 (1294)	440	60	14950 (6781)	60 (227)	102 (2591)	52 (1321)	54 3/4 (1391)	
42 x 84 (1067 x 2134)	492 (1862)	542 (2051)	715	98	24325 (11034)	90 (341)	116 (2946)	58 (1473)	58 5/8 (1489)	
48 x 96 (1219 x 2438)	712 (2695)	805 (3047)	1030	142	35225 (15978)	150 (568)	147 1/2 (3747)	63 (1600)	63 (1600)	
48 x 120 (1219 x 3048)	879 (3327)	995 (3766)	1275	176	43475 (19720)	180 (681)	171 1/2 (4356)	63 (1600)	63 (1600)	
60 x 108 (1524 x 2743)	1306 (4943)	1424 (5390)	1895	261	46400 (21047)	260 (984)	152 (3861)	74 1/2 (1892)	62 1/2 (1588)	1/4 (6mm)
60 x 120 (1524 x 3048)	1433 (5424)	1564 (5920)	2080	287	70875 (32149)	287 (1086)	164 (4166)	74 1/2 (1892)	62 1/2 (1588)	
60 x 144 (1524 x 3658)	1697 (6423)	1854 (7017)	2460	340	83925 (38068)	340 (1287)	188 (4775)	74 1/2 (1892)	62 1/2 (1588)	

*Pump GPM based upon 2 times system rate.
**For storage other than 10 minutes, adjust receiver size accordingly.
***Varies according to pump size; maximum dimension shown.

STEP 6C

UNIT SELECTION

Select the pumps: ratings are at 2' N.P.S.H.*

*Net positive suction head.

SELECTION DATA FOR B35

Pumps are designed for up to 35 PSI (241kPa) suction pressure and up to 250°F (121°C). CONSULT FACTORY for other suction pressure applications.

PUMP DELIVERY IN GMP AT MOTOR HP, 3500 RPM, 2 FT (0.6M) NPSH AND APPLICABLE DISCHARGE PRESSURE

HP	FT. TDH(M) PSIG (kPa)	34.6(10.5) 15(103)	46.2(14.1) 20(138)	57.7(17.6) 25(172)	69.3(21.1) 30(207)	92.4(28.2) 40(276)	115.5(35.2) 50(345)	139(42.4) 60(414)	173(52.7) 75(517)	196(59.7) 85(586)	231(70.4) 100(690)
1/2	gpm (I/S) Model	30(1.9) 616	15(0.9) 616								
3/4	gpm(I/S) Model	45(2.8) 616	45(2.8) 616	30(1.9) 616	22(1.4) 616						
1	gpm(I/S) Model	45(2.8) 616	45(2.8) 616	45(2.8) 616	37(2.3) 616						
1 1/2	gpm(I/S) Model	90(5.7) 626	60(3.8) 626	45(2.8) 616	45(2.8) 616	22(1.4) 617	9(0.6) 617				
2	gpm(I/S) Model		80(5.0) 626	75(4.7) 626	60(3.8) 626	35(2.2) 617	22(1.4) 617				
3	gpm(I/S) Model	125(7.9) 625	125(7.9) 625	90(5.7) 625	90(5.7) 626	65(4.1) 627	50(3.2) 627	25(1.6) 620	9(0.6) 620		
5	gpm(I/S) Model			150(9.5) 614	150(9.5) 614	110(6.9) 614	80(5.0) 613	75(4.7) 620	45(2.8) 620	37(2.3) 620	22(1.4) 620
7 1/2	gpm(I/S) Model					145(9.1) 614	136(8.6) 614	90(5.7) 618	75(4.7) 620	75(4.7) 620	37(2.3) 618
10	gpm(I/S) Model							140(8.8) 618	130(8.2) 618	110(6.9) 618	80(5.0) 618
15	gpm(I/S) Model								140(8.8) 618	140(8.8) 618	90(5.7) 618

Selection tables capacities are based on performance at 2 ft. (0.6M) NPSH. For other NPSH requirements refer to pump curves.
Impellers trimmed to nearest 1/16" (1.6mm) to meet capacity specified.

NOTE: TEFC and explosion proof motors available. The motor horsepower requirements is often greater using explosion proof as they have unity service factor.

STEP 7

SELECT THE ACCESSORY ITEMS

The basic boiler feed system requires a receiver, one or more pumps, a make-up water valve to add water on low level in the receiver, and a control panel. There are several optional items that should be considered. These include the following:

A. Gauge glass will permit visual indication of the water level in the receiver.

B. Thermometers are useful in monitoring the return temperature and provide indication when the steam traps are not operating properly.

C. Discharge pressure gauges permit visual indication of the pumps performance and are useful to set the discharge plug cock when balancing the system for maximum pump efficiency.

D. A low water cut-off float switch maybe added to prevent pump operation on low water level. This will prevent pumps running dry which will damage pump seals. A low water cut-off is recommended on all but the smallest sizes of boiler feed units, on receivers smaller than 100 gallon. On small receivers, the cut-off float switch will reduce the receiver net capacity considerably.

E. Alarm float switches and bells may be added to indicate abnormal conditions in the system.

F. Pump suction shut-off valves are recommended to permit pump service without shutting down the entire system and draining the receiver. Domestic offers a Butterfly Valve in the pump suction on heightless units up to 75 GPM pump capacity and suction gate valves in all capacity ranges.

G. Control Panels - Control panels are required on all boiler feed units and deaerators. The boiler level control switches are normally single pole switches rated 10 amps or less can cannot be used to start even a 1/3 H.P., single phase motor.

Factory mounted and wired control panels are available which permits factory testing of the complete unit prior to field start-up.

Control panels are available with magnetic starters or combination starters containing disconnect switches or circuit breakers in the same enclosure.

Domestic Pump sales brochures contain control panel specifications for the control arrangements shown in Step 3. These specifications include the necessary selector switches and control components required.

VACUUM RETURN CONDENSATE UNITS AND BOILER FEED UNITS

Older steam system designs incorporated the use of vacuum condensate transfer units and vacuum boiler feed units. The system functions were basically similar to standard condensate transfer and boiler feed systems.

The vacuum units provided the advantages of (1) faster system heating, (2) more even heating in remote sections of the system, (3) faster condensate return to reduce system lag and prevent boiler cut-off on low level, and (4) lifting of low returns using accumulator tanks and/or vacuum lift fittings.

1. FASTER SYSTEM HEATING

   A steam system when not in operation is filled with air. When steam is required, the air must be vented from the mains and radiation through air vent valves. When vacuum pumps are used, a 3" to 8" Hg vacuum is maintained on the return line and when the radiator thermostat traps are open as on a cold system, a vacuum is pulled on the radiation. The steam then can flow faster as it does not have to push the volume of air out through the vent valves.

2. MORE EVEN HEATING

   As the steam can flow faster through the system, there is less time lag until the steam reaches the radiation near the end of the zone. Thus, faster steam distribution permits more even heating.

3. FASTER CONDENSATE RETURN

   By maintaining a vacuum on the return line, the pressure differential across the traps is increased which permits faster drainage. The pressure differential in the return line is also increased, thus the condensate is returned faster than with a gravity return system. By getting the condensate back faster, the boiler surge is reduced and often can be fed using a condensate unit in lieu of requiring a boiler feed unit on some installations.

4. LIFTING OF LOW RETURNS

   The vacuum units were often used in conjunction with an accumulator tank or lift fitting to lift condensate from low return lines. The following illustrations show methods of using vacuum pumps for lifting condensate from low return lines. The need for vacuum pumps in new construction was eliminated by the use of separate zone control valves and boiler feed systems. The existing vacuum pump installation usually should be retained as a vacuum system to provide the balance and lift required.

Sizing Vacuum Pumps

Vacuum condensate pump water capacities are normally sized at 2 or 3 times the system condensing rate. This is the same as the sizing of standard condensate pumps. Air capacities are normally sized according to the following table:

	Vacuum Range in Hg	cfm /1000 EDR
Tight systems thur 10,000 EDR	0-10*	.5
Tight systems in excess of 10,000 EDR	0-10*	.3
All systems, some air in-leakage	0-10*	1.0
All systems	10-15	1.5
All systems	15-20	2
Replacing steam pumps, all systems	0-8*	1
Replacing steam pumps, all systems	above 8	2

*Air pumps are usually adjusted to operate between 3" and 8" Hg.

Suggested Guide for Air Removal Requirements

TYPICAL PIPING — LOW RETURNS
(IF LIFT EXCEEDS 5 FEET, A MECHANICAL LIFT IS RECOMMENDED)

CONNECTIONS TO VACUUM PUMP WHERE HEATING UNITS ARE ABOVE THE WATER LINE OF BOILER AND A SECTION OF THE RETURN IS BELOW THE PUMP INLET

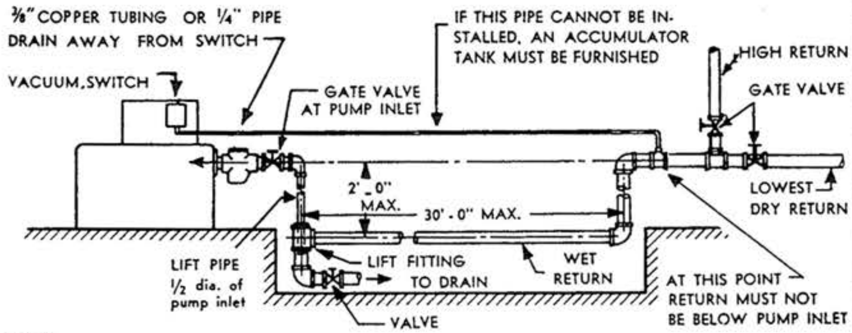


FIG. 5

RETURNS BELOW PUMP INLET (NO ACCUMULATOR TANK) VACUUM PUMP TO RUN CONTINUOUSLY.

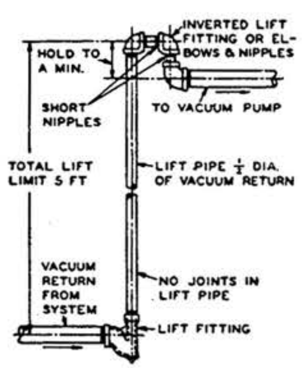
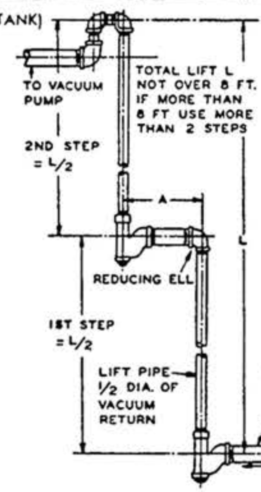


Fig. 6. Method of Constructing a Lift in a Return Line



VACUUM RETURN PIPE SIZE INCHES	A IN.
1	7
1¼	8
1½	9
2	10
2½	14
3	15
4	18
5	21
6	24

* MAXIMUM LENGTH A

Fig. 7. Construction of a Step Lift

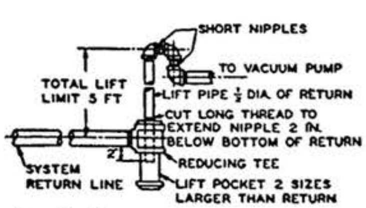


Fig. 8. How to Build a Lift Fitting

LIFT PIPE DETAIL
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FROM HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1957.

Note—A valve or cock is recommended to drain lift fitting.

PIPING TO VACUUM PUMP WHERE RETURN MAIN IS BELOW PUMP FLOOR LEVEL WITH CONNECTIONS TO PITTED AND VERTICAL UNDERGROUND ACCUMULATOR TANKS.

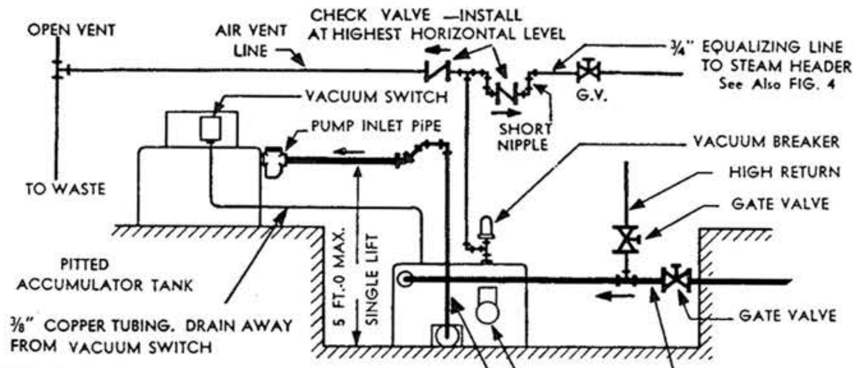


FIG. 9

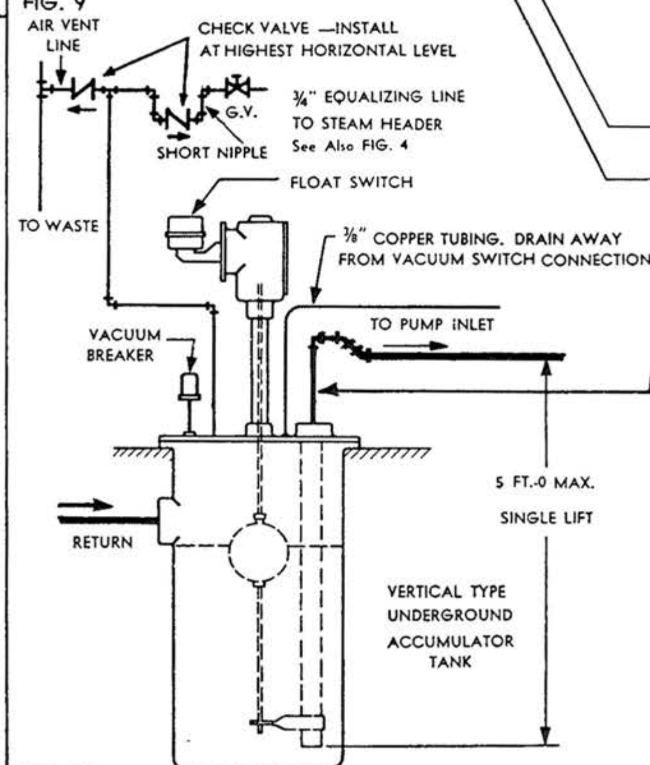
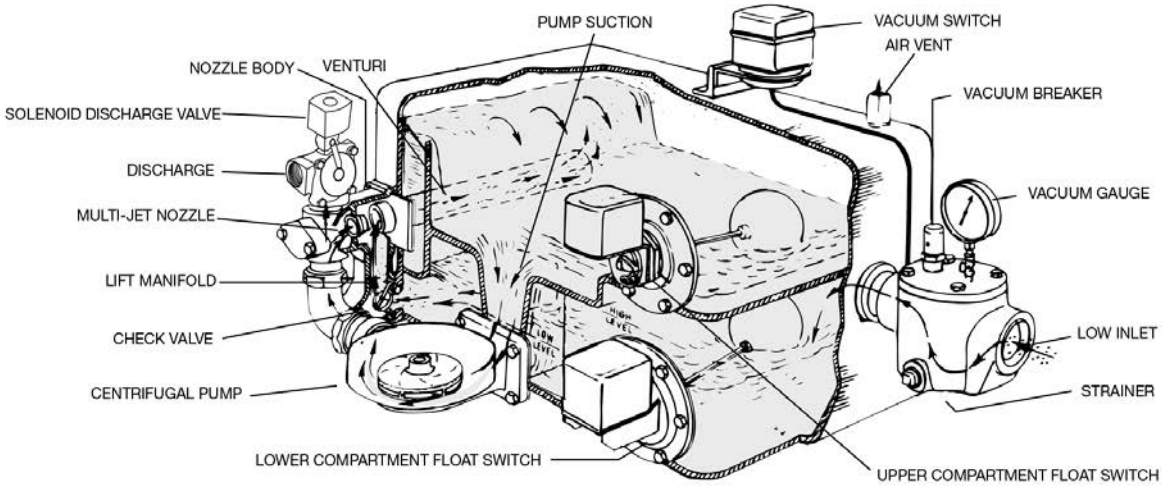


FIG. 10



Simplex Unit Sectional View Illustrates Condensate and Air Flow thru VLR Units

Systems up to 20, 000 sq. ft. E.D.R. use the Domestic Type VLR Unit having one pump to perform both the air removal and condensate pumping functions.

Domestic VLR units have a two compartment receiver which is divided horizontally. The lower compartment acts as an accumulator and is under the same vacuum as that maintained in the return piping. The upper compartment is used to separate the air from the condensate and must always be open to atmosphere. For initial starting the upper compartment must be half-filled with water as indicated in the gage glass. With the line disconnect switch closed, the pump motor then operates in response to the float and vacuum switches, while the upper compartment float switch and the solenoid operated discharge valve controls the discharge of condensate.

Condensate and air entering the lower compartment thru the strainer actuates either the lower float switch or vacuum switch or both to start the pump motor. When the pump is operating, “hurling water” enters the pump suction from the upper compartment and is discharged thru an elbow into the forward part of the nozzle body, then thru the multi-jet nozzle and venturi and returned to the upper compartment. The water driving at high velocity across the gap between nozzle and venturi creates a smooth, steady vacuum which draws condensate, air and gases from the lower compartment and heating system thru the lift manifold and rear section of the nozzle body. This mixture is entrained in the jet streams and discharged thru the venturi into the upper compartment of the receiver where the air and gases separate from the condensate and are vented.

As the condensate level rises in the upper compartment, it causes the upper compartment float switch to close. This energizes and opens the solenoid operated discharge valve allowing condensate to flow out of the discharge. The centrifugal pump then pumps condensate thru the discharge valve as well as thru the multi-jet nozzles. Thus the unit continues to remove air at the normal rate while discharging condensate. When the water level drops to a predetermined level, the float switch breaks contact deenergizing and closing the solenoid operated discharge valve. This configuration retains a volume of “hurling water” in the upper compartment even though the pump may continue operation as an air pump.

When the vacuum and float switches have been satisfied and the pump stops, the check valve in the lift manifold closes, preventing the return of air and water to the lower compartment. The purpose of the float switch in the upper compartment is to continue the operation of the pump or pumps to return the maximum amount of condensate each cycle, and to operate the solenoid discharge valve.

The following selection tables from the VLR brochure are used for selection of VLR Units.

Selection Data Domestic VLR Vacuum Units – Simplex and Duplex

STANDARD CAPACITY — Recommended for normal heating systems and especially for finned tube radiation.

CAPACITY SQ. FT. EDR (LB./HR)	RATING 5 1/2" HG. VACUUM AT 160°F			DISCH. PRESS PSI (kPa) AT PUMP	MOTOR HORSEPOWER		SIMPLEX UNIT MODEL NO.	DOUBLE CAPACITY DUPLEX UNIT MODEL NO.
	WATER ONLY GPM[1] (L/M)	SIMULTANEOUS WATER GPM[2] (L/M)	SIMULTANEOUS AIR CFM		RPM 3500	RPM 1750		
1,000 thru 5,000 (250 thru 1,250)	7.5 (28)	2.5 (9)	2.5	20 (138)	3/4		5VLR1-20-35	5VLR2-20-35
				20 (138)		3/4	-20-17	-20-17
				30 (207)	1		-30-35	-30-35
				30 (207)		1 1/2	-30-17	-30-17
				40 (276)	1 1/2		-40-35	-40-35
10,000 (2,500)	15 (57)	5 (19)	4	20 (138)	1		10VLR1-20-35	10VLR2-20-35
				20 (138)		1	-20-17	-20-17
				30 (207)	1 1/2		-30-35	-30-35
				30 (207)		1 1/2	-30-17	-30-17
				40 (276)	2		-40-35	-40-35
15,000 (3,750)	22.5 (85)	7.5 (28)	5.4	20 (138)	1		15VLR1-20-35	15VLR2-20-35
				20 (138)		1 1/2	-20-17	-20-17
				30 (207)	1 1/2		-30-35	-30-35
				30 (207)		2	-30-17	-30-17
				40 (276)	2		-40-35	-40-35
20,000 (5,000)	30 (114)	10 (38)	6.8	20 (138)	1 1/2		20VLR1-20-35	20VLR2-20-35
				20 (138)		2	-20-17	-20-17
				30 (207)	2		-30-35	-30-35
				30 (207)		3	-30-17	-30-17
				40 (276)	3		-40-35	-40-35

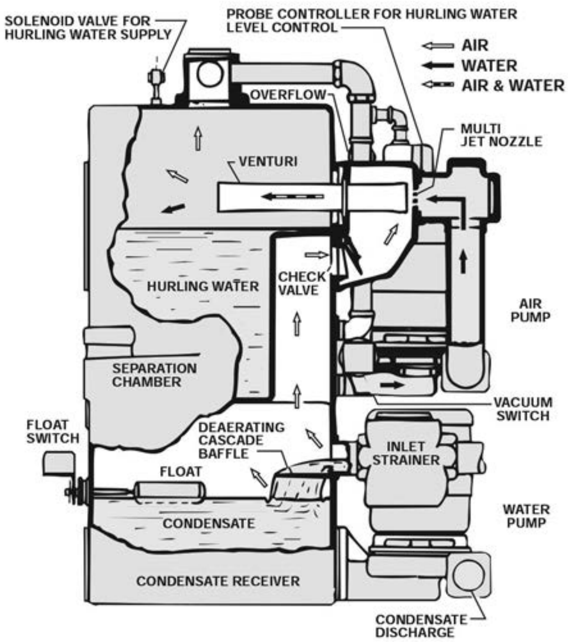
[1] Pump discharge – three times system condensing rate for ample safety factor. [2] System condensing rate entering receiver corresponding to EDR listed.

SPECIAL CAPACITY — Recommended when greater air capacities and higher vacuums are necessary.

CAPACITY SQ. FT. EDR (LB./HR)	RATING 5 1/2" HG. VACUUM AT 160°F			DISCH. PRESS PSI (kPa) AT PUMP	MOTOR HORSEPOWER		SIMPLEX UNIT MODEL NO.	DOUBLE CAPACITY DUPLEX UNIT MODEL NO.
	WATER ONLY GPM[1] (L/M)	SIMULTANEOUS WATER GPM[2] (L/M)	SIMULTANEOUS AIR CFM		RPM 3500	RPM 1750		
1,000 thru 5,000 (250 thru 1,250)	7.5 (28)	7 (26)	3	20 (138)	3/4		5VLRS1-20-35	5VLRS2-20-35
				20 (138)		3/4	-20-17	-20-17
				30 (207)	1		-30-35	-30-35
				30 (207)		1 1/2	-30-17	-30-17
				40 (276)	1 1/2		-40-35	-40-35
10,000 (2,500)	15 (57)	14 (53)	6	20 (138)	1		10VLRS1-20-35	10VLRS2-20-35
				20 (138)		1 1/2	-20-17	-20-17
				30 (207)	1 1/2		-30-35	-30-35
				30 (207)		2	-30-17	-30-17
				40 (276)	2		-40-35	-40-35
15,000 (3,750)	22.5 (85)	21 (79)	9	20 (138)	1 1/2		15VLRS1-20-35	15VLRS2-20-35
				20 (138)		2	-20-17	-20-17
				30 (207)	2		-30-35	-30-35
				30 (207)		3	-30-17	-30-17
				40 (276)	3		-40-35	-40-35
20,000 (5,000)	30 (114)	28 (106)	11	20 (138)	2		20VLRS1-20-35	20VLRS2-20-35
				20 (138)		2	-20-17	-20-17
				30 (207)	3		-30-35	-30-35
				30 (207)		3	-30-17	-30-17
				40 (276)	3		-40-35	-40-35

[1] Pump discharge – three times system condensing rate for ample safety factor.

For systems larger than 20,000 sq. ft. E.D.R., separate air pumps and water pumps are recommended for more efficient operation.



Cut-away View of VCD Pump
with No. 50 Receiver No. 25 VCD Receivers are Similar

Operation is Simple, Effective and Reliable

There are two separate and independent cycles of operation in the VCD design - one of air evacuation and the other for condensate return. This is accomplished by completely separating the air pumps from the condensate storage receiver and water pumps. The figure above illustrates a single two compartment receiver, divided horizontally, where the two pumps operate from the upper compartment or separation chamber while the water pumps operate from the lower compartment or condensate receiver.

Air Evacuation Cycle

The independent air evacuation cycle begins when the vacuum switch, responding to system requirements, starts the centrifugal "air" pump. This pump circulates "hurling" water from the separation chamber through the multi-jet nozzle, venturi and returns it to the separate chamber. The water, forced at high velocity across the gap between nozzle and venturi, entrains air and gases in multiple jet streams, creating a smooth, steady vacuum in the condensate receiver and system. The mixture is discharging through the venturi into the separation chamber where the air and gases separate from the "hurling" water and are vented. When the desired vacuum has been produced in the system, the vacuum switch stops the pump, and the check valve at air suction inlet to separate chamber closes, preventing the return of air to the system.

Replacement of the hurling water evaporated from the separation chamber is controlled by a solenoid valve, connected to the water supply and actuated by a float switch.

Condensate Return Cycle

The condensate return cycle begins when a float switch starts a water pump on condensate rise. The condensate is pumped to the boiler until the preset low float switch setting has been reached.

Duplex Pumps

The second or lag pump of duplex water and/or air pumps functions if the first or lead pump fails and automatically operates to double the capacity in the event of abnormal demand.

Temperature Limit Switch

Some units may be equipped with temperature limit switches. When located on the separation chamber, it is used to admit cooling water if the hurling temperature exceeds a predetermined limit.

A condition may be encountered where the temperature of the condensate fluctuates intermittently to critically high levels, where operation under vacuum could cause the condensate to vaporize. A temperature limit switch can be installed on the condensate receiver to prevent the air pump(s) from operating where such a condition exists. Upon temperature drop the vacuum switch(es) will again control operation of the air pump(s).

The following quick selection chart shows standard selection of VCD units based on square feet E.D.R.

Series VCD Quick Selection Table for Usual System Conditions - Based on EDR

SYSTEM CAPACITY SQ. FT. EDR	PUMP PERFORMANCE RE-CEIVER NO.	RATING AT 5 1/2" Hg AT 160°F CFM	GPM*	AIR PUMP HORSEPOWER RPM 3500	1750	WATER PUMP – HP AT PRESSURE INDICATED FROM 10" Hg PUMP CAPACITY SAME AS SHOWN IN COL. 4 15 PSI 3500	20 PSI 3500	25 PSI 3500	30 PSI 3500	35 PSI 3500	40 PSI 3500	45 PSI 3500	INLET SIZE INCHES	MAX. DISCH. SIZE INCHES
6,000	25	5.8	6	3/4		1/3	1/2	1/2	3/4	1	1	1 1/2	2 1/2	1 1/2
9,000	25	8	9	1		1/3	1/2	3/4	3/4	1	1	1 1/2	2 1/2	1 1/2
12,000	25	8	12	1		1/3	1/2	3/4	1	1	1 1/2	1 1/2	2 1/2	1 1/2
15,000	25	12	15	1 1/2		1/3	1/2	3/4	1	1	1 1/2	1 1/2	2 1/2	1 1/2
22,000	25	12	22	1 1/2		1/2	3/4	3/4	1	1 1/2	1 1/2	2	2 1/2	1 1/2
22,000	25	17	22	2		1/2	3/4	3/4	1	1 1/2	1 1/2	2	2 1/2	1 1/2
30,000	50	17	30	2		3/4	3/4	1	1 1/2	1 1/2	2	2	2 1/2	1 1/2
37,000	50	18	37	2		3/4	1	1 1/2	1 1/2	2	2	3	3	1 1/2
45,000	50	18	45	2		1	1	1 1/2	2	2	3	3	3	1 1/2
60,000	50	26	60	3		1 1/2	1 1/2	2	2	3	3	3	3	2
75,000	100	29	75		3	1 1/2	2	2	3	3	5	5	4	2
90,000	100	52	90		5	2	2	3	5	5	5	5	4	2
112,000	100	52	112		5	2	3	3	5	5	5	5	4	3
150,000	150	52	150		5	3	5	5	5	7 1/2	7 1/2	7 1/2	4/6	3
150,000	150	74	150		7 1/2	3	5	5	5	7 1/2	7 1/2	7 1/2	4/6	3

*Water pump capacities are based on semi-duplex or duplex applications. For single units, increase the capacity by one third, making the selections from Table 2.

Type VCMD Vacuum Boiler Feed Units

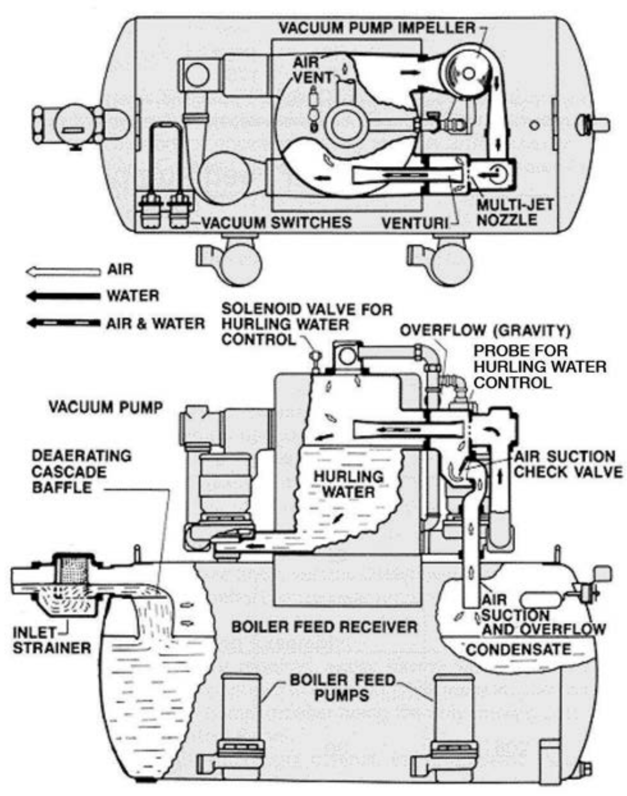
The vacuum heating pumps discussed previously combined the two functions of condensate return and vacuum production. The VCMD combines boiler feed vacuum production. The vacuum part is the usual multi-jet nozzle and venturi producer. It is mounted either on top of or close to the boiler feed unit. The boiler feed unit itself can be of any configuration steel tank or cast iron.

The advantage of combining the boiler feed unit with the vacuum pump is that the vacuum is produced centrally rather than by various vacuum heating pumps throughout the system. This means that even the boiler feed receiver itself is kept under vacuum, thus keeping the condensate partially deaerated.

Operation of Type VCMD Units

Highest boiler efficiency is achieved when the boiler water level is held within the limits designated by the boiler manufacturer. "Domestic" II type VCMD units are designed to accomplish this through pump controls installed on each boiler, operating the boiler feed pumps in response to changes in the boiler water level. In addition, The VCMD design incorporates water make-up equipment, a simple overflow control and an efficient air pump.

The boiler feed cycle begins when the pump control in the boiler closes on low level and starts a boiler feed pump. When the boiler is restored to normal, the pump control opens and the pump starts.



Series VCMD Style CMHD-A Cutaway Drawing

Automatic Water Make-up Control

A water make -up valve maintains a minimum level in the condensate receiver to compensate for condensate or steam losses from the system.

Simple Automatic Overflow Control

If excess condensate, entering the condensate receiver, causes the water level to rise above a preselected height, a float switch actuates the air pump. The resulting vacuum draws excess water through the air suction line into the separation chamber of the air pump from where it simply overflows to a drain.

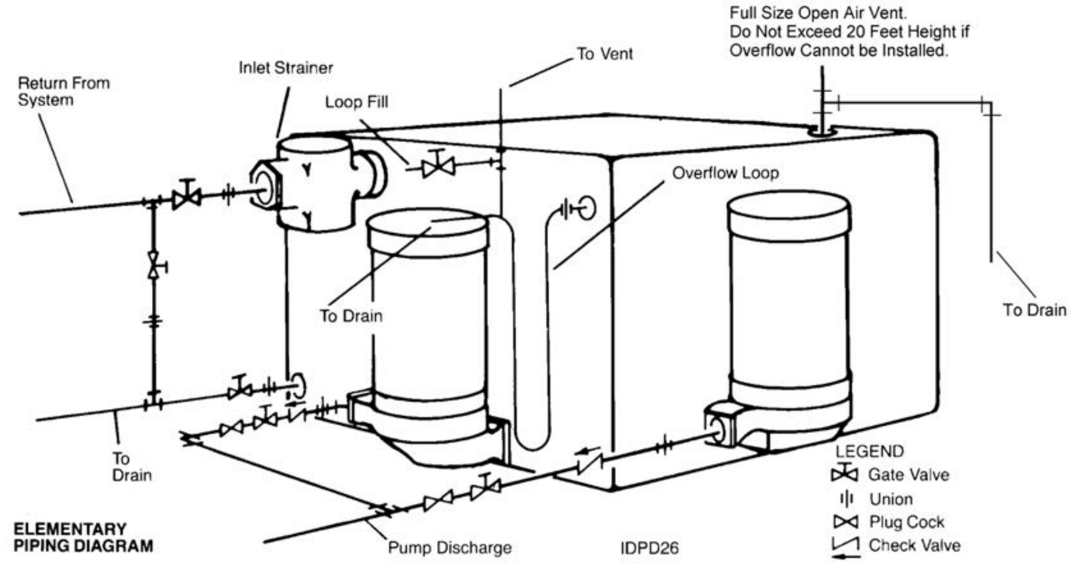
Air Evacuation Cycle

The independent air evacuation cycle begins when the vacuum switch, responding to system requirements, starts the centrifugal pump. This pump circulates "hurling" water from the separation chamber through the multi-jet nozzle, venturi and returns it to the separation chamber. The water at high velocity across the gap between nozzle and venturi entrains air and gases in multiple jet streams, creating a smooth, steady vacuum in the condensate receiver and system. The mixture is discharged through the venturi into the separation chamber where the air and gases separate from the "hurling" water and are vented. When the desired vacuum has been produced in the system, the vacuum switch stops the pump, and the check valve at air suction inlet to separation chamber closes, preventing the return of air to the system.

The combination vacuum boiler feed pumps are often required to replace condensate transfer vacuum type units when old boilers having large storage volumes are replaced with modern boilers having smaller storage volume. For more information on vacuum pumps, refer to the Domestic Pump brochures.

SYSTEM PIPING FOR CONDENSATE BOILER FEED AND VACUUM UNITS

The following diagram shows the piping connections of a standard condensate transfer unit with a vented receiver.

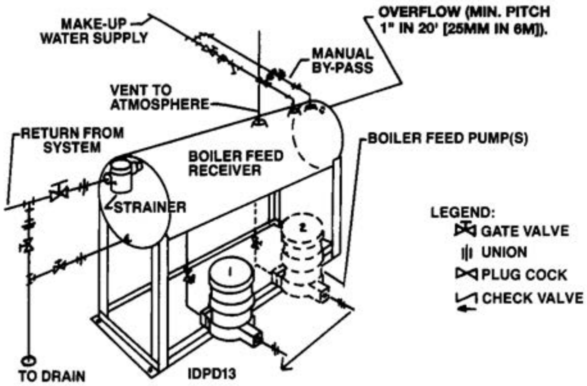


Condensate Pumps with Cast Iron Receivers

The returns from the system are piped into the receiver inlet connection. A valved bypass is recommended as shown to permit drainage of the condensate during maintenance of the unit. An inlet strainer should be installed to remove dirt from the system return.

The air vent connection should be piped outdoors to prevent steam vapors from escaping into the boiler room if high temperatures are encountered. The vent pipe should be the full size equal to the receiver connection to prevent pressurization of the receiver. An overflow connection should be provided to serve as a secondary vent and permit drainage of the condensate in the event of pump failure.

The pump discharges should include a check valve, gate valve, and plug cock. The check valve is required to prevent a backflow of condensate from the discharge piping and also to prevent the pump from discharging into the second pump on a duplex unit. The gate valve is required to allow service to the pump. The plug cock is required to balance the pump flow rate with the nameplate rating for the most efficient operation.

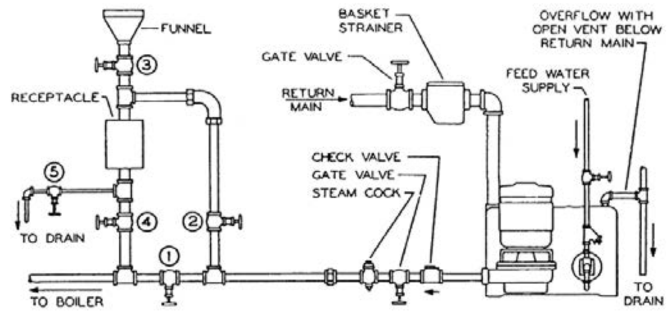


Type CMD - Style CMED Boiler Feed Unit

Piping Diagram above shows the piping of a boiler feed unit. The returns from the system enter the receiver inlet. The return pipe should have a shut-off gate valve and bypass to permit service to the unit. An inlet strainer should be provided to remove dirt from the system. The receiver drain should provide a valved connect to a drain to permit draining the receiver. The air vent should be piped outdoors to prevent the escape of steam into the boiler room. The vent pipe should be the full size equal to the receiver connection. The overflow should be piped to a drain. The overflow provides a secondary vent and permits the overflow of condensate in the event of pump failure, make-up valve failure, or system flooding in the event of a too small boiler feed receiver.

Make -up water should be connected to the mechanical or electrical make-up water valve to replace condensate lost in the system. A three-valve bypass around the make-up is recommended for manual fill of the system.

Boiler treatment should never be added to the pump receiver. The following illustration shows a chemical feeder for adding chemical treatment.



Suggested Method for
Feeding Boiler Compound into System

Chemical treatment added ahead of the pump suction will increase the friction and cause short life of mechanical pump seals.

UNIT SELECTION GUIDE

CONDENSATE UNITS

Type	Receiver	Capacity (lb/hr)	Pump Type	Maximum Condensate Temperature
WC / WCS	Cast Iron or Steel	1,500 - 3000	Centriflo	200° F
CC	Cast Iron	250 - 37,500	Centriflo	200° F
CS	Steel	250 - 37,500	Centriflo	200° F
CB	Cast Iron Floor Mounted	2,250 - 33,750	B-Style	210° F
CBE	Cast Iron Elevated	2,250 - 33,750	B-Style	212° F
CU	Cast Iron Underground	2,500 - 22,500	Centriflo	200° F
CHD	Cylindrical Steel Floor	7,500 - 137,500	Centriflo / B-Style	200° / 210° F
CED	Cylindrical Steel Elevated	7,500 - 137,500	Centriflo / B-Style	205° / 212° F

BOILER FEED UNITS

Type	Receiver	System Size (BHP)	Pump Type	Maximum Condensate Temperature
CM	C.I.	to 650	Centriflo	200° F
CBM	C.I.	to 600	B-Style	210° F
CBEM	Centriflo	to 600	B-Style	212° F
CMHD	Centriflo	to 1895	Centriflo / B-Style	200° / 210° F
CMED	STEEL	to 1895	Centriflo / B-Style	205° / 212° F

VACUUM UNITS

Type	Receiver	Capacity	Pump Type	Maximum Condensate Temperature
VLR	Cast Iron	5,000 to 20,000 Sq. Ft. EDR	Centriflo	160º F
VL	Cast Iron	25,000-65,000 Sq. Ft. EDR	Centriflo	160º F
VCD	Cast Iron and Steel	6,000 to 150,000 Sq. Ft. EDR	Centriflo	160º F*
VCMD	Cast Iron and Steel	to 975 BHP	Centriflo	160º F*
MJ	Cast Iron and Steel	172 CFM @ 5" of HG vacuum @ 70º	Centriflo	160º F

* Consult factory for higher condensate temperatures.

ENGINEERING DATA AND TECHNICAL INFORMATION

This section contains necessary Engineering technical information used in the design, installation, maintenance or revamping of low pressure steam heating systems. The Tables, Charts, and Examples, including properties of saturated steam, steam capacities of ASTM Schedule 40(S) Pipe and return pipe capacities used in One-Pipe and Two-Pipe Steam Heating Systems. Also included is data for determining pipe friction allowance, steam velocity, system pressure drops and similar information.

PROPERTIES OF SATURATED STEAM (APPROX.)

Absolute Pressure	Gage Reading at Sea Level	Temp. °F.	Heat in Water B.T.U. per Lb.	Latent Heat in Steam (Vaporization) B.T.U. per Lb.	Volume of 1 Lb. Steam Cu. Ft.	Wgt. of Water Lbs. per Cu. Ft.
INCHES OF MERCURY	VACUUM—INCHES OF MERCURY					
0.18	29.7	32	0.0	1076	3306	62.4
0.50	29.4	59	27.0	1061	1248	62.3
1.0	28.9	79	47.0	1049	653	62.2
2.0	28	101	69	1037	341	62.0
4.0	26	125	93	1023	179	61.7
6.0	24	141	109	1014	120	61.4
8.0	22	152	120	1007	93	61.1
10.0	20	161	129	1002	75	60.9
12.0	18	169	137	997	63	60.8
14.0	16	176	144	993	55	60.6
16.0	14	182	150	989	48	60.5
18.0	12	187	155	986	43	60.4
20.0	10	192	160	983	39	60.3
22.0	8	197	165	980	36	60.2
24.0	6	201	169	977	33	60.1
26.0	4	205	173	975	31	60.0
28.0	2	209	177	972	29	59.9
29.0	1	210	178	971	28	59.9
30.0	0	212	180	970	27	59.8
POUNDS PER SQ. INCH	PRESSURE—POUNDS PER SQ. INCH					
14.7	0	212	180	970	27	59.8
15.7	1	216	184	968	25	59.8
16.7	2	219	187	966	24	59.7
17.7	3	222	190	964	22	59.6
18.7	4	225	193	962	21	59.5
19.7	5	227	195	960	20	59.4
20.7	6	230	198	958	19	59.4
21.7	7	232	200	957	19	59.3
22.7	8	235	203	955	18	59.2
23.7	9	237	205	954	17	59.2
25	10	240	208	952	16	59.2
30	15	250	219	945	14	58.8
35	20	259	228	939	12	58.5
40	25	267	236	934	10	58.3
45	30	274	243	929	9	58.1
50	35	281	250	924	8	57.9
55	40	287	256	920	8	57.7
60	45	293	262	915	7	57.5
65	50	298	268	912	7	57.4
70	55	303	273	908	6	57.2
75	60	308	277	905	6	57.0
85	70	316	286	898	5	56.8
95	80	324	294	892	5	56.5
105	90	332	302	886	4	56.3
115	100	338	309	881	4	56.0
140	125	353	325	868	3	55.5

Table 1

RELATIONS OF ALTITUDE, PRESSURE & BOILING POINT

Altitude Feet	ATMOSPHERIC PRESSURE ABSOLUTE		BOILING POINT OF WATER °F. (GAGE 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
10000	20.70	10.17	194.0	198.4	213.5	228.3	240.4
11000	19.95	9.80	192.2	196.8	212.3	227.3	239.6
12000	19.23	9.45	190.6	195.2	211.1	226.3	238.7
13000	18.53	9.10	188.7	193.6	209.9	225.4	237.9
14000	17.86	8.77	187.2	192.3	208.8	224.5	237.2
15000	17.22	8.46	185.4	190.6	207.6	223.6	236.4

Table 2

Temp. °F	Static Suction Head in Feet										
	0	1	2	3	4	5	6	7	8	9	10
	Net Positive Suction Head Available (NPSHA)										
212°	0	1	2	3	4	5	6	7	8	9	10
211°	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
210°	1.4	2.4	3.4	4.4	5.4	6.4	7.4	8.4	9.4	10.4	11.4
208°	2.6	3.6	4.6	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6
207°	3.6	4.6	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6	13.6
206°	4.0	5.0	6.0	7.0	8.0	9.0	10	11.0	12.0	13.0	14.0
205°	4.7	5.7	6.7	7.7	8.7	9.7	10.7	11.7	12.7	13.7	14.7
204°	5.1	6.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1
200°	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5
190°	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5
155°	24.3	25.3	26.3	27.3	28.3	29.3	30.3	31.3	32.3	33.3	34.3
116°	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5
100°	31.7	32.7	33.7	34.7	35.7	36.7	37.7	38.7	39.7	40.7	41.7
70°	33.1	34.1	35.1	36.1	37.1	38.1	39.1	40.1	41.1	42.1	43.1

Table 3
Net Positive Suction Head Available (NPSHA) Table For Water at Sea Level* and Atmospheric Vented Supply Tank

*Boiling point decreases 1°F for every 500 feet of elevation above sea level.
(@ 500' above sea level, boiling point is 211°F)

CONVERSION FACTORS

	MULTIPLY	BY	TO GET
1.	Boiler Horsepower (BHP)	34.5	Lb. of Steam (Water per hour (lb/hr)
2.	Boiler Horsepower (BHP)	0.069	Gallons of Water Per Minute (GPM)
3.	Boiler Horsepower (BHP)	33,479	B.T.U.
4.	Boiler Horsepower (BHP)	139	Sq. Feet of Equivalent Direct Radiation (EDR)
5.	Sq. Feet of Equivalent Direct Radiation (EDR)	0.000496	Gallons of Water Per Minute (GPM)
6.	Lbs. of Steam (Water per hour (lb/hr)	0.002	Gallons of Water Per Minute (GPM)
7.	Lbs. per square inch	2.307	Feet of Water
8.	Feet of Water (head)	0.4335	Lbs. per square inch
9.	Gallons of Water	8.345	Lbs. of Water
10.	Cubic Feet of Water	7.48	Gallons of Water
11.	Cubic Feet per minute	62.43	Lbs. of Water per minute
12.	Cubic Feet per minute	448.8	Gallons per hour
13.	Cubic Centimeters per ltr. of Oxygen	1400	Parts per billion of Oxygen

Table 4

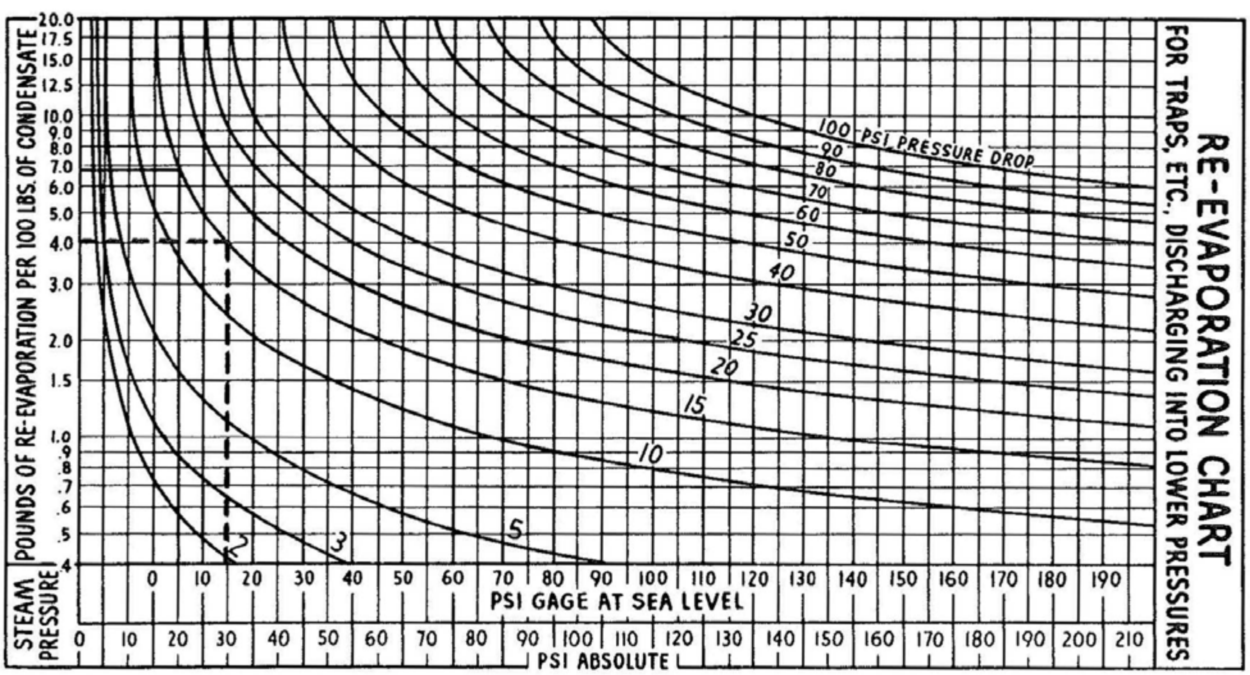


Chart 1

HEAT LOSSES FROM COVERED PIPE 85 PERCENT MAGNESIA TYPE BTU PER LINEAR FOOT PER HOUR PER °F TEMPERATURE DIFFERENCE (SURROUNDING AIR ASSUMED 75°F)						
Pipe Size	Insulation Thickness, Inches	MAX. TEMP. OF PIPE SURFACE °F.				
		125	175	225	275	325
½	1	.145	.150	.157	.160	.162
¾	1	.165	.172	.177	.180	.182
1	1	.190	.195	.200	.203	.207
	1½	.160	.165	.167	.170	.175
1¼	1	.220	.225	.232	.237	.245
	1½	.182	.187	.193	.197	.200
1½	1	.240	.247	.255	.260	.265
	1½	.200	.205	.210	.215	.219
2	1	.282	.290	.297	.303	.307
	1½	.230	.235	.240	.243	.247
	2	.197	.200	.205	.210	.217
2½	1	.322	.330	.340	.345	.355
	1½	.260	.265	.270	.275	.280
	2	.220	.225	.230	.237	.242
3	1	.375	.385	.395	.405	.415
	1½	.300	.305	.312	.320	.325
	2	.253	.257	.263	.270	.277
3½	1	.419	.430	.440	.450	.460
	1½	.332	.339	.345	.352	.360
	2	.280	.285	.290	.295	.303
4	1	.460	.470	.480	.492	.503
	1½	.362	.370	.379	.385	.392
	2	.303	.308	.315	.320	.327
5	1	.545	.560	.572	.585	.600
	1½	.423	.435	.442	.450	.460
	2	.355	.360	.367	.375	.382
6	1	.630	.645	.662	.680	.693
	1½	.487	.500	.510	.520	.530
	2	.405	.415	.420	.430	.437
8	1	.790	.812	.835	.850	.870
	1½	.603	.620	.635	.645	.660
	2	.495	.507	.517	.527	.540

Table 5

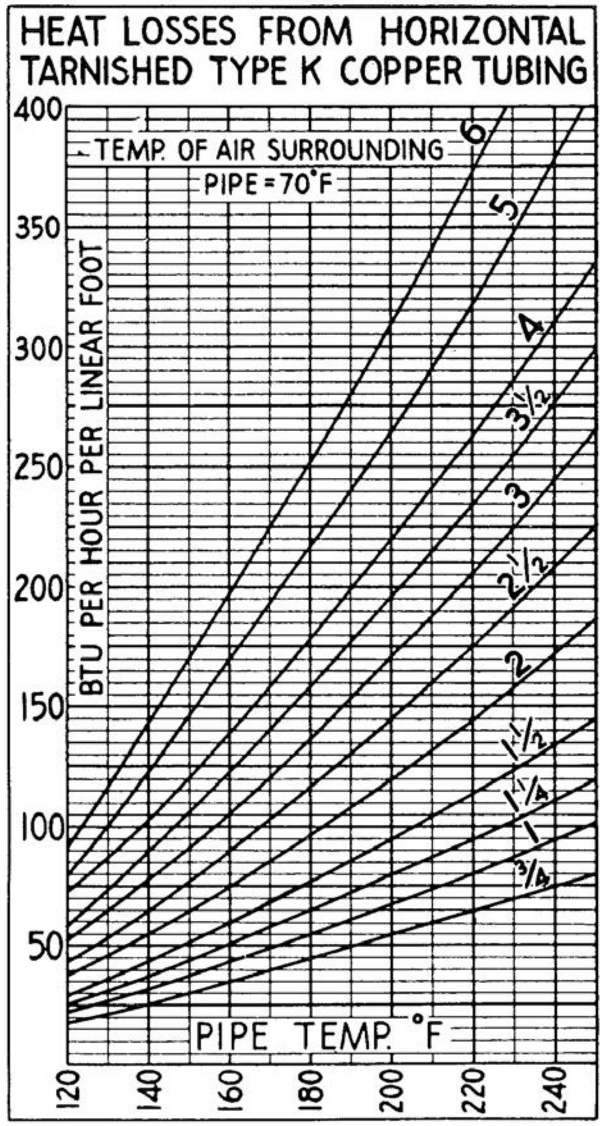


Chart 2

EQUIVALENT CAPACITIES OF PIPES OF SAME LENGTH—STEAM

Size	NO. OF SMALL PIPES EQUIVALENT TO ONE LARGE PIPE											
	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″	4″	5″	6″
½″	1.00	2.27	4.88	10.0	15.8	31.7	52.9	96.9	140	205	377	620
¾″		1.00	2.05	4.30	6.97	14.0	23.3	42.5	65	90	166	273
1″			1.00	2.25	3.45	6.82	11.4	20.9	30	44	81	133
1¼″				1.00	1.50	3.10	5.25	9.10	12	19	37	68
1½″					1.00	2.00	3.34	6.13	9	13	23	39
2″						1.00	1.67	3.06	4.5	6.5	11.9	19.6
2½″							1.00	1.82	2.70	3.87	7.12	11.7
3″								1.00	1.50	2.12	3.89	6.39
3½″									1.00	1.25	2.50	4.25
4″										1.00	1.84	3.02
5″											1.00	1.65
6″												1.00

This table may be used to find the number of smaller pipes equivalent in steam carrying capacity to one larger pipe. It may also be used to find the size of a larger pipe equivalent to several smaller ones. The pipes in either case must be of the same lengths.

EXAMPLE 1—Find the number of 1″ pipes each 50 ft. long equivalent to one 4″ pipe 50 ft. long.

SOLUTION 1—Follow down column headed 4″ to the point opposite 1″ in vertical column, and it is found that it will take 44 of the 1″ pipes in parallel to equal one 4″ pipe in steam carrying capacity.

EXAMPLE 2—Find the size of one pipe equivalent to four 2″ pipes in steam carrying capacity.

SOLUTION 2—Find 2″ in vertical column headed "Size" and follow across horizontally until closest number to 4 is found. The nearest to 4 is 4.5. Following this column up it is found that the size is 3½″. One 3½″ pipe is, therefore, equivalent in steam carrying capacity to approximately four 2″ pipes.

Table 6

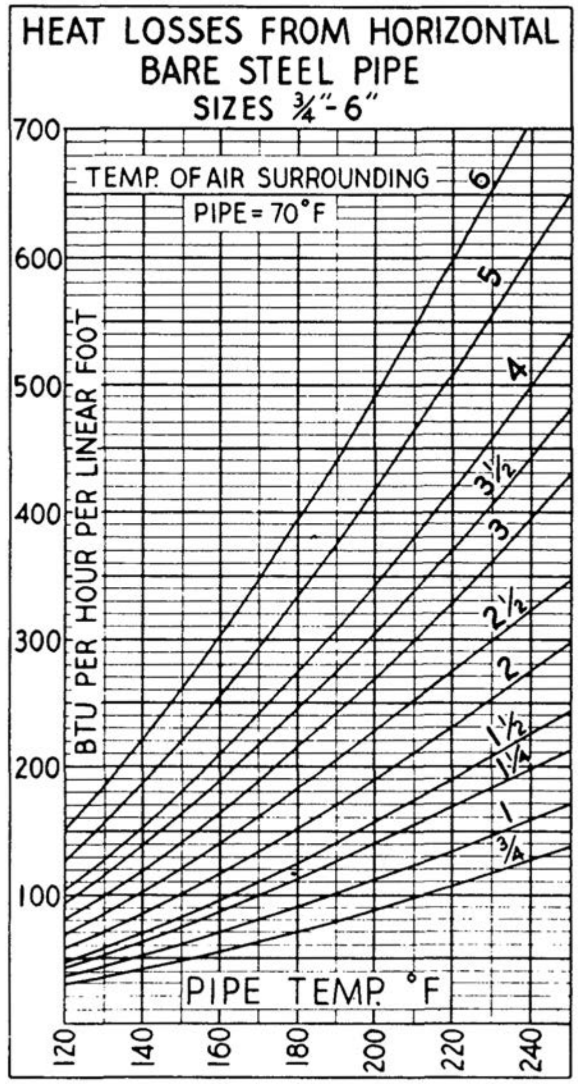


Chart 3

FRICTION OF WATER IN PIPES

Gal. Per Min.	¾-Inch Pipe Fric.[1]	¾-Inch Pipe Vel.[2]
2	1.4	1.2
3	2.6	1.8
4	4.2	2.4
5	6.3	3.0
6	8.9	3.6
9	18.8	5.4
12	32.6	7.2
15	49.5	9.0
1-INCH PIPE		
5	1.9	1.9
6	2.7	2.2
9	5.6	3.3
12	9.6	4.5
15	14.6	5.6
18	20.6	6.7
20	25.1	7.4
22	30.2	8.2
25	45.0	9.3
1¼-INCH PIPE		
9	1.5	1.9
12	2.5	2.6
15	3.8	3.2
18	5.2	3.9
20	6.3	4.3
22	7.6	4.7
25	9.6	5.4
30	13.6	6.4
35	18.2	7.5
37	20.5	8.0
40	23.5	8.6
45	29.4	9.7
1½-INCH PIPE		
12	1.2	1.9
15	1.8	2.4
18	2.4	2.8
20	2.9	3.2
22	3.5	3.5
25	4.4	3.9
30	6.3	4.7
35	8.4	5.5
37	9.4	5.8
40	10.8	6.3
45	13.4	7.0
50	16.4	7.9
60	23.2	9.5
70	31.3	11.0
2-INCH PIPE		
18	.7	1.7
22	1.0	2.1
25	1.3	2.4
30	1.8	2.9
35	2.4	3.3
37	2.7	3.5
40	3.1	3.8
45	3.8	4.3
50	4.7	4.8
60	6.6	5.7
75	10.1	7.2
80	11.4	7.7
90	14.2	8.6
97	16.5	9.3
100	17.4	9.6
112	21.7	10.7
120	24.7	11.5
125	26.9	12.0

Gal. Per Min.	2½-Inch Pipe Fric.[1]	2½-Inch Pipe Vel.[2]
25	0.6	1.7
30	0.8	2.0
37	1.1	2.5
45	1.6	3.0
50	1.9	3.3
60	2.7	4.0
75	4.1	5.0
80	4.7	5.4
90	5.8	6.0
97	6.7	6.5
100	7.1	6.7
112	8.8	7.5
120	10.0	8.0
125	10.9	8.4
150	15.4	10.0
175	20.8	11.7
3-INCH PIPE		
45	.5	2.0
60	.9	2.6
75	1.4	3.3
80	1.6	3.5
90	2.0	3.9
100	2.4	4.3
112	3.0	4.9
125	3.6	5.4
150	5.1	6.5
175	6.9	7.6
200	8.9	8.7
225	11.2	10.2
250	13.7	11.9
275	16.3	12.0
4-INCH PIPE		
75	.4	1.9
80	.4	2.0
90	.5	2.3
100	.6	2.5
112	.8	2.8
125	1.0	3.2
150	1.3	3.8
175	1.8	4.4
200	2.3	5.0
225	2.9	5.7
250	3.5	6.3
275	4.2	6.9
300	4.9	7.6
350	6.6	8.8
400	8.5	10.1
450	10.7	11.3
500	13.0	12.6
5-INCH PIPE		
125	.3	2.0
150	.4	2.4
175	.6	2.8
200	.7	3.2
225	.9	3.6
250	1.1	4.0
275	1.3	4.4
300	1.6	4.8
350	2.1	5.6
400	2.7	6.4
450	3.4	7.2
500	4.2	8.0
550	5.0	8.8
600	5.9	9.6
650	6.9	10.4
700	7.9	11.2

[1] Fric. = friction. Loss of head in ft. per 100 ft. of new schedule 40 wrought steel or galvanized pipe.
[2] Vel. = velocity of liquid in ft. per second.
The above table shows average values of pipe friction for new pipe. No allowance for aging of pipe is included. Interpolated from Hydraulic Institute data.

Table 7

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
British Thermal Units 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

Table 8

* REASONABLE VELOCITIES FOR FLOW OF WATER THRU PIPE

Pump suction and drains (should be short and direct)	3 to 7 fps
Pump discharge, general and boiler feed longer than 100 ft.	5 to 10 fps
Pump discharge, boiler feed less than 100 ft. long	7 to 12 fps

For low noise level, low pumping cost, long lines and for hot water, use lowest velocities.
Use velocities up to 12 fps for double capacity duplex boiler feed pumps.

EQUIVALENT LENGTH IN FEET OF PIPE FOR FITTINGS

PIPE SIZE	¾	1	1¼	1½	2	2½	3	4	5
Regular 90° ell	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0	7.3*
Long radius 90° ell	2.3	2.7	3.2	3.4	3.6	3.6	4.0	4.6	5.0*
Regular 45° ell	.9	1.3	1.7	2.1	2.7	3.2	4.0	5.5	4.5*
Tee, line flow	2.4	3.2	4.6	5.6	7.7	9.3	12.0	17.0	3.3*
Tee, branch flow	5.3	6.6	8.7	9.9	12.0	13.0	17.0	21.0	15.0*
Globe valve	24.0	29.0	37.0	42.0	54.0	62.0	79.0	110.0	150.0*
Gate valve	.7	.3	1.1	1.2	1.5	1.7	1.9	2.5	3.1*
Swing check valve	8.8	11.0	13.0	15.0	19.0	22.0	27.0	38.0	50.0*
Bell mouth inlet	.1	.2	.3	.3	.4	.5	.7	1.0	1.3
Square mouth inlet	1.3	1.8	2.6	3.1	4.3	5.2	6.7	9.5	13.0
Inward projecting pipe	2.6	3.6	5.1	6.2	8.5	10.0	13.0	19.0	25.0

* Flanged

Table 9

OXYGEN SOLUBILITY IN WATER
AT VARIOUS TEMPERATURES AND PRESSURES

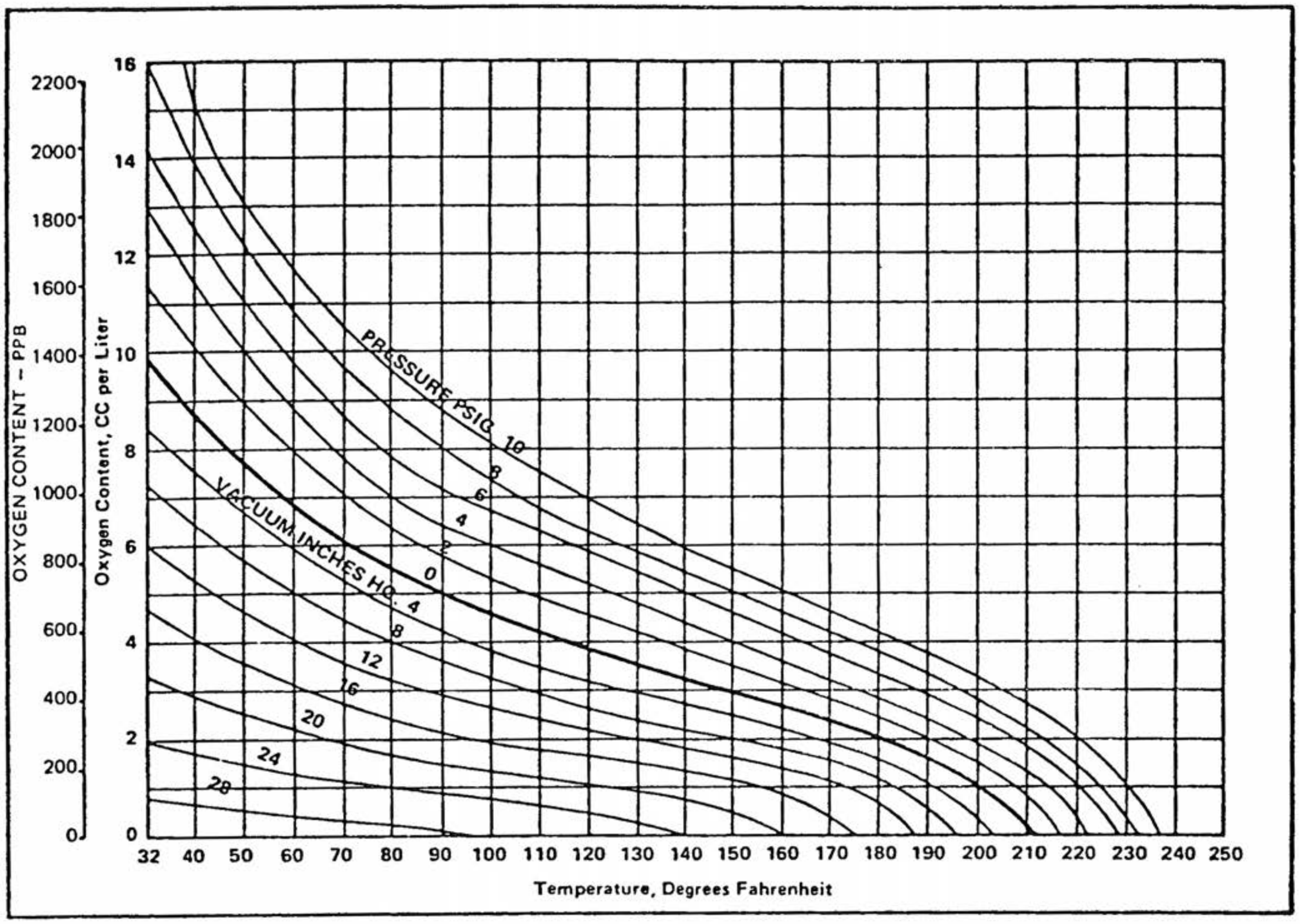


Chart 4

CAPACITY OF ROUND STORAGE TANKS

Depth or Length	NUMBER OF GALLONS — INSIDE DIAMETER IN INCHES									
	18	24	30	36	42	48	54	60	66	72
1 In.	1.10	1.96	3.06	4.41	5.99	7.83	9.91	12.24	14.81	17.62
2 Ft.	26	47	73	105	144	188	238	294	356	423
2½	33	59	91	131	180	235	298	367	445	530
3	40	71	100	158	216	282	357	440	534	635
3½	46	83	129	184	252	329	416	513	623	740
4	53	95	147	210	288	376	475	586	712	846
4½	59	107	165	238	324	423	534	660	800	952
5	66	119	181	264	360	470	596	734	899	1057
5½	73	130	201	290	396	517	655	808	978	1163
6	79	141	219	315	432	564	714	880	1066	1268
6½	88	155	236	340	468	611	770	954	1156	1374
7	92	165	255	368	504	658	832	1028	1244	1480
7½	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 × 32″ wide × 20″ deep
Then 56″ × 32″ × 20″ = 35840 cu. in.
35840 ÷ 231 = 155 gallons capacity

Table 10

USEFUL DATA

Diameter	×	3.1416	= Circumference
Circumference	×	.3183	= Diameter
Diameter^2	×	.7854	= Area of Circle
Area of Circle	×	1.2732	= Area of Circumscribed Square
Area of Circle	×	.63662	= Area of Inscribed Square
Diameter of Circle	×	.88623	= Side of Equal Square
Diameter of Circle	×	.7071	= Side of Inscribed Square
Circumference of Circle	×	1.1284	= Perimeter of Equal Square
Side of Square	×	1.4142	= Diameter of Circumscribed Circle
Side of Square	×	1.1284	= Diameter of Equal Circle
Perimeter of Square	×	.88623	= Circumference of Equal Circle
Diameter^2	×	3.1416	= Surface of Sphere
Diameter^3	×	.5236	= Volume of Sphere
Diameter of Sphere	×	.806	= Dimensions of Equal Cube
Diameter of Sphere	×	.667	= Length of Equal Cylinder
Area of Base	×	⅓ Height	= Volume of Pyramid or Cone
Base	×	½ Height	= Area of Triangle
Radius	×	1.1547	= Side of Inscribed Cube
Square Inches	×	1.2732	= Circular Inches
Square Inches	×	.00695	= Square Feet
Square Feet	×	.111	= Square Yard
Square Yards	×	.0002066	= Acres
Cubic Inches	×	.00058	= Cubic Feet
Cubic Feet	×	.03704	= Cubic Yards
Cubic Inches	×	.004329	= U.S. Gallons
Cubic Feet	×	7.4805	= U.S. Gallons
Cubic Inches	×	.000466	= U.S. Bushels
Cubic Feet	×	.8036	= U.S. Bushels
U.S. Bushels	×	2150.42	= Cubic Inches
U.S. Bushels	×	1.242	= Cubic Feet
U.S. Bushels	×	.046	= Cubic Yards
U.S. Gallons	×	231.0	= Cubic Inches
U.S. Gallons	×	.13368	= Cubic Feet
Cubic Inches Water	×	.036127	= Pounds (Avoirdupois)
Cubic Feet Water	×	62.4283	= Pounds (Avoirdupois)
U.S. Gallons Water	÷	268.8	= Tons
Column of Water 1″ Diameter x 12″ High			= .34 Pounds (Avoirdupois)
Cubic Inch	×	.263	= Pound Average Cast Iron
Cubic Inch	×	.281	= Pound Average Wrought Iron
Cubic Inch	×	.283	= Pound Average Cast Steel
Cubic Inch	×	.3225	= Pound Average Copper
Cubic Inch	×	.3037	= Pound Average Brass
Cubic Inch	×	.26	= Pound Average Zinc
Cubic Inch	×	.4103	= Pound Average Lead
Cubic Inch	×	.2636	= Pound Average Tin
Cubic Inch	×	.4908	= Pound Average Mercury
12 × Weight of Pine Pattern			= Iron Casting
13 × Weight of Pine Pattern			= Brass Casting
14 × Weight of Pine Pattern			= Lead Casting
1—Calorie			= 3.968 B.T.U.
1—B.T.U.			= 0.252 Calorie
1—Pound per Square Inch			= 703.08 Kilogrammes per M^2
1—Kilogramme per M^2			= 0.00142 Pounds per Square Inch
1—Calorie per M^2			= 0.3687 B.T.U. per Square Foot
1—B.T.U. per Square Foot			= 2.712 Calories per M^2
1—Calorie per M^2 per Degree Difference Centigrade			= 0.2048 B.T.U. per Square Foot per Degree Difference, Fahrenheit
1—B.T.U. per Square Foot per Degree Difference Fahrenheit			= 4.882 Calories per M^2 per Degree Difference Fahrenheit
1—B.T.U. per Pound			= 0.556 Calories per Kilogramme
1—Calorie per Kilogram			= 1.8 B.T.U. per Pound
1—Litre of Coke at 26.3 Lb. per Cu. Ft.			= 0.93 Pounds
1—Lb. of Coke at 26.3 Lb. per Cu. Ft.			= 1.076 Liter
Water Expands in Bulk from 40° to 212°			= One Twenty-Third

Table 11

INCHES (in.) to CENTIMETERS (cm) to MILLIMETERS (mm)

in.	cm.	mm.
1.00	2.54	25.40
2.00	5.08	50.80
3.00	7.62	76.20
4.00	10.16	101.60
5.00	12.70	127.00
6.00	15.24	152.40
7.00	17.78	177.80
8.00	20.32	203.20
9.00	22.86	228.60
10.00	25.40	254.00
20.00	50.80	508.00
30.00	76.20	762.00
36.00	91.40	914.00
40.00	101.60	1016.00
50.00	127.00	1270.00
60.00	152.40	1524.00
70.00	177.80	1778.00
80.00	203.20	2032.00
90.00	228.60	2286.00
100.00	254.00	2540.00

Table 12

ELECTRICAL UNITS

VOLT—The unit of electrical motive force, force required to send one ampere of current through one ohm of resistance.

OHM—Unit of resistance. The resistance offered to the passage of one ampere, when impelled by 1-volt.

AMPERE—Unit of current, the current which one volt can send through a resistance of one ohm.

COULOMB—Unit of quantity. Quantity of current which impelled by one volt, would pass through one ohm in one second.

JOULE—Unit of work. The work done by one watt in one second.

WATT—The unit of electrical energy, and is the product of ampere and volt. That is, one ampere of current flowing under a pressure of one volt gives one watt of energy.

One electrical horsepower is equal to 746 watts.

ONE KILOWATT—Is equal to 1000 watts, or 3415 B.T.U. when used for heating or the equivalent output of 14.2 sq. ft. of steam radiation.

ONE KILOWATT HOUR—(KW. HR.) equals the consumption of 1000 watts in one hour.

To find the watts consumed in a given electrical circuit, multiply the volts by the amperes.

To find the volts—divide the watts by the amperes.

To find the amperes—divide the watts by the volts.

To find the electrical horsepower required by a motor, divide the watts of the motor by 746. With A.C. current multiply the wattage by the power factor, then divide by 74.6.

To find the amperes of a given circuit, of which the volts and ohms resistance are known, divide the volts by the ohms.

To find the volts, when the amperes and ohms are known, multiply the amperes by the ohms.

To find the resistance in ohms, when the volts and amperes are known, divide the volts by the amperes.

Table 13

FAHRENHEIT - CENTIGRADE CONVERSION TABLE

F.	C.	F.	C.	F.	C.	F.	C.
−20	−28.9	62	16.7	144	62.2	226	107.8
−18	−27.8	64	17.8	146	63.3	228	108.9
−16	−26.7	66	18.9	148	64.4	230	110.
−14	−25.6	68	20.	150	65.6	232	111.1
−12	−24.4	70	21.1	152	66.7	234	112.2
−10	−23.3	72	22.2	154	67.8	236	113.3
− 8	−22.2	74	23.3	156	68.9	238	114.4
− 6	−21.1	76	24.4	158	70.	240	115.6
− 4	−20.	78	25.6	160	71.1	242	116.7
− 2	−18.9	80	26.7	162	72.2	244	117.8
0	−17.8	82	27.8	164	73.3	246	118.9
2	−16.7	84	28.9	166	74.4	248	120.
4	−15.6	86	30.	168	75.6	250	121.1
6	−14.4	88	31.1	170	76.7	252	122.2
8	−13.3	90	32.2	172	77.8	254	123.3
10	−12.2	92	33.3	174	78.9	256	124.4
12	−11.1	94	34.4	176	80.	258	125.6
14	−10.	96	35.6	178	81.1	260	126.7
16	− 8.9	98	36.7	180	82.2	262	127.8
18	− 7.8	100	37.8	182	83.3	264	128.9
20	− 6.7	102	38.9	184	84.4	266	130.
22	− 5.6	104	40.	186	85.6	268	131.1
24	− 4.4	106	41.1	188	86.7	270	132.2
26	− 3.3	108	42.2	190	87.8	272	133.3
28	− 2.2	110	43.3	192	88.9	274	134.4
30	− 1.1	112	44.4	194	90.	276	135.6
32	0.	114	45.6	196	91.1	278	136.7
34	1.1	116	46.7	198	92.2	280	137.8
36	2.2	118	47.8	200	93.3	282	138.9
38	3.3	120	48.9	202	94.4	284	140.
40	4.4	122	50.	204	95.6	286	141.1
42	5.6	124	51.1	206	96.7	288	142.2
44	6.7	126	52.2	208	97.8	290	143.3
46	7.8	128	53.3	210	98.9	292	144.4
48	8.9	130	54.4	212	100.	294	145.6
50	10.	132	55.6	214	101.1	296	146.7
52	11.1	134	56.7	216	102.2	298	147.8
54	12.2	136	57.8	218	103.3	300	148.9
56	13.3	138	58.9	220	104.4		
58	14.4	140	60.	222	105.6		
60	15.6	142	61.1	224	106.7		

Table 14

CONVERSION TABLE
METRIC TO ENGLISH MEASURE

METRIC	ENGLISH
MEASURES OF LENGTH	
1 Kilometer 1000 Meters	0.621 Mile 3281. Feet
1 Meter 100 Centimeters 1000 Millimeters	1.094 Yards 3.28 Feet 39.37 Inches
1 Centimeter 10 Millimeters	0.0328 Feet 0.394 Inches
1 Millimeter	0.0394 Inches
MEASURES OF SURFACE	
1 Sq. Kilometer 1,000,000 Sq. Meters	0.386 Sq. Mile 247.1 Acres 1,195,985 Sq. Yards
1 Sq. Meter 10,000 Sq. Centimeters	1.196 Sq. Yards 10.76 Sq. Feet 1550. Sq. Inches
1 Sq. Centimeter 100 Sq. Millimeters 1 Sq. Millimeter	0.155 Sq. Inch 0.0011 Sq. Feet 0.00155 Sq. Inch

CONVERSION TABLE
METRIC TO ENGLISH MEASURE

METRIC	ENGLISH
MEASURES OF VOLUME AND CAPACITY	
1 Cu. Meter 1000 Liters 1,000,000 Cu. Centimeters	1.308 Cu. Yards 35.31 Cu. Feet 61023.4 Cu. Inches
1 Liter 1,000 Cu. Centimeters	0.264 Gallons (U.S.) 0.220 Gallons (Imperial) 1.057 Quarts (U.S.) 0.880 Quarts (Imperial)
1 Cu. Centimeter 1000 Cu. Millimeters	0.061 Cu. Inches
MEASURES OF WEIGHT	
1 Kilogram 1000 Gram	0.0011 Ton (2000 Lbs.) 2.205 Pounds (Av.)
1 Gram	0.0022 Pounds (Av.) 0.035 Ounces (Av.) 15.43 Grains

NOTE—For conversion of pressures from metric to English units see "Conversion Table—Pressures."

Table 15

CONVERSION TABLE
PRESSURES

INCHES		FEET Water	MILLIMETER Mercury (Hg.)	METER Water	POUNDS		GRAMS Sq. Centimeter	KILOGRAMS		Atmos-phere
Water	Mercury				Per Sq. Inch	Per Sq. Foot		Per Sq. Meter	Per Sq. Cm.	
1.0	0.074	0.083	1.88	0.0254	0.036	5.20	2.53	25.37	0.003	0.0024
13.6	**1.0**	1.13	25.4	0.344	0.490	70.5	34.4	344.4	0.0344	0.0333
12.0	0.884	**1.0**	22.4	0.305	0.433	62.4	30.4	304.5	0.0304	0.0295
0.54	0.039	0.045	**1.0**	0.014	0.019	2.78	1.36	13.6	0.00136	0.00131
39.4	2.89	3.28	73.5	**1.0**	1.422	204.6	100.0	1000.0	0.10	0.0967
27.7	2.04	2.390	51.8	0.703	**1.0**	144.0	70.3	703.1	0.070	0.0680
0.19	0.014	0.016	0.36	0.005	0.0069	**1.0**	0.49	4.88	0.00049	0.00047
0.40	0.03	0.033	0.74	0.01	0.014	2.05	**1.0**	10.0	0.001	0.00097
0.04	0.003	0.0033	0.074	0.001	0.0014	0.205	0.10	**1.0**	0.0001	0.0001
393.8	28.96	32.8	735.5	10.0	14.2	2048.	1000.0	10000.	**1.0**	0.9678
407.	29.92	33.9	760.0	10.3	14.7	2116.	1033.2	10332.	1.03	**1.0**

To use table go to column headed by unit to be converted. Follow this column down to the "1.0" in heavy print and read horizontally across. Example: Convert five kilograms per sq. meter to lbs. per sq. inch. Select column headed kilograms per sq. meter and follow down to "1.0", then to left to column headed lbs. per sq. inch. The number 0.0014 found in this space is the conversion factor by which the number of kilograms per sq. meter must be multiplied to change this quantity to lbs. per sq. inch. Therefore, five kilograms per meter is equal to five times 0.0014, or 0.007 lbs. per sq. inch.

Table 16

LINEAR EXPANSION OF SOLIDS AT ORDINARY TEMPERATURES

MATERIAL	For 1°F. Length = 1"
Aluminum (Cast)	0.00001234
Brass Cast	0.00000957
Brass Plate	0.00001052
Brick (Fire)	0.00000300
Bronze (Copper, 96½; Tin, 2½; Zinc, 1)	0.00000986
Copper	0.00000887
Glass, Hard	0.00000397
Gold, Pure	0.00000786
Iron, Wrought	0.00000648
Iron, Cast	0.00000556
Lead	0.00001571
Mercury (Cubic Expansion)	0.00009984
Nickel	0.00000695
Porcelain	0.00000200
Silver, Pure	0.00001079
Slate	0.00000577
Steel, Cast	0.00000636
Steel, Tempered	0.00000689
Stone (Sandstone), Dry	0.00000652
Tin	0.00001163
Wood, Pine	0.00000276
Zinc	0.00001407

Table 17

WEIGHTS OF MATERIALS

MATERIAL	Pounds per Cubic Ft.	MATERIAL	Pounds per Cubic Ft.
Aluminum	166.5	Lead	709.7
Ashes	45-50	Lignite	31-47
Barley	37-40	Lime	50-80
Brass—Copper, Zinc		Limestone	156-162
80 20	536.3	Manganese	450
70 30	523.8	Mercury 32°	849.3
60 40	521.3	Mercury 60°	846.8
50 50	511.4	Mercury 212°	834.4
Bronze—Cop. 95 to 80	552.	Nickel	548.7
Tin 5 to 20		Oats	25-30
Cement	90-118	Ore (Iron)	105-215
Charcoal	17-27	Platinum	1333
Clay	95-169	Rye	44-50
Coal (Lump)	50-54	Sand	75-120
Nut Coal & Screenings	53-60	Silver	655.1
Coke	26-30	Slag (Blast Furnace)	37-63
Earth	75-115	Steel	489.6
Gold, Pure	1200.9	Stone	90-120
Copper	552	Tin	458.3
Gravel	90-135	Wheat	44-50
Iron, Cast	450	Zinc	448
Iron, Wrought	480		

Table 18

MELTING POINTS OF METALS

	Deg. F.		Deg. 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) 350-570			

Table 19

BOILING POINTS OF VARIOUS FLUIDS

	Deg. F.		Deg. F.
Water (Atmospheric Pressure)	212	Turpentine	320
Alcohol	173	Sulphur	832
Sulphuric Acid	620	Linseed Oil	549

Table 20

DECIMAL EQUIVALENTS OF PARTS OF AN INCH

1/64	.01563	33/64	.51563
1/32	.03125	17/32	.53125
3/64	.04688	35/64	.54688
1/16	.0625	9/16	.5625
5/64	.07813	37/64	.57813
3/32	.09375	19/32	.59375
7/64	.10938	39/64	.60938
1/8	.125	5/8	.625
9/64	.14063	41/64	.64063
5/32	.15625	21/32	.65625
11/64	.17188	43/64	.67188
3/16	.1875	11/16	.6875
13/64	.20313	45/64	.70313
7/32	.21875	23/32	.71875
15/64	.23438	47/64	.73438
1/4	.25	3/4	.75
17/64	.26563	49/64	.76563
9/32	.28125	25/32	.78125
19/64	.29688	51/64	.79688
5/16	.3125	13/16	.8125
21/64	.32813	53/64	.82813
11/32	.34375	27/32	.84375
23/64	.35938	55/64	.85938
3/8	.375	7/8	.875
25/64	.39063	57/64	.89063
13/32	.40625	29/32	.90625
27/64	.42188	59/64	.92188
7/16	.4375	15/16	.9375
29/64	.45313	61/64	.95313
15/32	.46875	31/32	.96875
31/64	.48438	63/64	.98438
1/2	.5	1	1.0000

Table 21

AREAS OF CIRCLES

Diameter	Area	Diameter	Area	Diameter	Area	Diameter	Area
1/64	.00019	5½	23.758	25	490.87	64	3216.9
1/32	.00077	6	28.274	26	530.93	65	3318.3
1/16	.00307	6½	33.183	27	572.55	66	3421.2
3/32	.00690	7	38.484	28	615.75	67	3525.6
⅛	.01227	7½	44.178	29	660.52	68	3631.6
5/32	.01917	8	50.265	30	706.86	69	3739.2
3/16	.02761	8½	56.745	31	754.76	70	3848.4
7/32	.03758	9	63.617	32	804.24	71	3959.2
¼	.04909	9½	70.882	33	855.30	72	4071.5
5/16	.07670	10	78.54	34	907.92	73	4185.3
⅜	.11045	10½	86.59	35	962.11	74	4300.8
7/16	.15033	11	95.03	36	1017.8	75	4417.8
½	.19635	11½	103.86	37	1075.2	76	4536.4
9/16	.24850	12	113.09	38	1134.1	77	4656.0
⅝	.30680	12½	122.71	39	1194.5	78	4778.3
11/16	.37122	13	132.73	40	1256.6	79	4901.6
¾	.44179	13½	143.13	41	1320.2	80	5026.5
13/16	.51849	14	153.93	42	1385.4	81	5153.0
⅞	.60132	14½	165.13	43	1452.2	82	5281.0
15/16	.69029	15	176.71	44	1520.5	83	5410.6
1	.7854	15½	188.69	45	1590.4	84	5541.7
1⅛	.9940	16	201.06	46	1661.9	85	5674.5
1¼	1.227	16½	216.82	47	1734.9	86	5808.8
1⅜	1.484	17	226.98	48	1809.5	87	5944.6
1½	1.767	17½	240.52	49	1885.7	88	6082.1
1⅝	2.073	18	254.46	50	1963.5	89	6221.1
1¾	2.405	18½	268.80	51	2042.8	90	6361.7
1⅞	2.761	19	283.52	52	2123.7	91	6503.8
2	3.141	19½	298.64	53	2206.1	92	6647.6
2¼	3.976	20	314.16	54	2290.2	93	6792.9
2½	4.908	20½	330.06	55	2375.8	94	6939.7
2¾	5.939	21	346.36	56	2463.0	95	7088.2
3	7.068	21½	363.05	57	2551.7	96	7238.2
3¼	8.295	22	380.13	58	2642.0	97	7389.8
3½	9.621	22½	397.60	59	2733.9	98	7542.9
3¾	11.044	23	415.47	60	2827.4	99	7697.7
4	12.566	23½	433.73	61	2922.4	100	7854.0
4½	15.904	24	452.39	62	3019.0		
5	19.635	24½	471.43	63	3117.2		

To find the circumference of a circle when diameter is given, multiply the given diameter by 3.1416. To find the diameter of a circle when circumference is given, multiply the given circumference by .31831.

Table 22

ASTM SCHEDULE 40(S) PIPE DIMENSIONS

DIAMETER			Nominal Thickness In.	CIRCUMFERENCE		TRANSVERSE AREAS		Length of Pipe Per Sq. Ft. of External Surface Ft.	Length of Pipe Containing 1 Cu. Ft.	Nominal Weight Per Ft. in Lbs.	Number of Threads Per Inch of Screw
Nominal Internal In.	Actual External In.	Approx. Internal In.		External In.	Internal In.	External Sq. In.	Internal Sq. In.				
1/8	0.405	0.27	0.068	1.27	0.85	0.13	0.06	9.44	2513.00	0.24	27
1/4	0.540	0.36	0.088	1.70	1.14	0.23	0.10	7.08	1383.30	0.42	18
3/8	0.675	0.49	0.091	2.12	1.55	0.36	0.19	5.66	751.20	0.57	18
1/2	0.840	0.62	0.109	2.63	1.95	0.55	0.30	4.55	472.40	0.85	14
3/4	1.050	0.82	0.113	3.30	2.59	0.87	0.53	3.64	270.00	1.13	14
1	1.315	1.05	0.134	4.13	3.29	1.36	0.86	2.90	166.90	1.68	11½
1¼	1.660	1.38	0.140	5.22	4.34	2.16	1.50	2.30	96.25	2.27	11½
1½	1.900	1.61	0.145	5.97	5.06	2.84	2.04	2.01	70.66	2.72	11½
2	2.375	2.07	0.154	7.46	6.49	4.43	3.36	1.61	42.91	3.65	11½
2½	2.875	2.47	0.204	9.03	7.75	6.49	4.78	1.33	30.10	5.79	8
3	3.500	3.07	0.217	11.00	9.63	9.62	7.39	1.09	19.50	7.57	8
3½	4.000	3.55	0.226	12.57	11.15	12.57	9.89	0.96	14.57	9.11	8
4	4.500	4.03	0.237	14.14	12.65	15.90	12.73	0.85	11.31	10.79	8
5	5.563	5.05	0.259	17.48	15.85	24.31	19.99	0.69	7.20	14.62	8
6	6.625	6.07	0.280	20.81	19.05	34.47	28.89	0.58	4.98	18.97	8
8	8.625	8.07	0.276	27.10	25.35	58.43	51.15	0.44	2.82	24.69	8
8	8.625	7.98	0.322	27.10	25.07	58.43	50.02	0.44	2.88	28.55	8
9	9.625	8.94	0.344	30.24	28.08	72.76	62.72	0.40	2.29	33.91	8
10	10.750	10.19	0.278	33.77	32.01	90.76	81.55	0.36	1.76	31.20	8
10	10.750	10.14	0.306	33.77	31.86	90.76	80.75	0.36	1.78	34.24	8
10	10.750	10.02	0.366	33.77	31.47	90.76	78.82	0.36	1.82	40.48	8
12	12.750	12.09	0.328	40.06	37.98	127.68	114.80	0.30	1.25	43.77	8
12	12.750	12.00	0.375	40.06	37.70	127.68	113.10	0.30	1.27	49.56	8

Table 23

SURFACE AREAS AND VOLUMES OF SPHERES

Diameter	Surface Area	Volume	Diameter	Surface Area	Volume
1/8	.04908	.00102	4¼	56.745	40.195
1/4	.19636	.00818	4½	63.617	47.712
3/8	.44180	.02761	4¾	70.882	56.115
1/2	.78540	.06545	5	78.540	65.450
5/8	1.2272	.12783	5¼	86.590	75.766
3/4	1.7672	.22090	5½	95.033	87.113
7/8	2.4053	.35077	5¾	103.87	99.542
1	3.1416	.52360	6	113.10	113.10
1⅛	3.9760	.74550	6¼	122.72	127.83
1¼	4.9088	1.0227	6½	132.73	143.79
1⅜	5.9396	1.3611	6¾	143.14	161.03
1½	7.0684	1.7671	7	153.94	179.60
1⅝	8.2956	2.2467	7¼	165.13	199.53
1¾	9.6212	2.8062	7½	176.71	220.88
1⅞	11.045	3.4516	7¾	188.69	243.72
2	12.566	4.1887	8	201.06	268.08
2¼	15.904	5.9640	8¼	213.82	294.00
2½	19.635	8.1812	8½	226.98	321.55

SURFACE AREAS AND VOLUMES OF SPHERES

Diameter	Surface Area	Volume	Diameter	Surface Area	Volume
2¾	23.758	10.889	8¾	240.53	350.77
3	28.274	14.137	9	254.47	381.70
3¼	33.183	17.974	9¼	268.80	414.40
3½	38.484	22.449	9½	283.53	448.92
3¾	44.179	27.612	9¾	298.65	485.30
4	50.266	35.511	10	314.16	523.60

SPHERE FORMULAE

This table can be used for feet, inches or any metric unit. For example, the volume of a 2" diameter sphere is 4.1887 cu. in., and for a 2 ft. diameter, 4.1887 cu. ft. The figures apply to either the exterior or to the interior of a hollow sphere, provided the diamter is measured at the proper place. For example: the capacity of a spherical tank measuring 10 ft. on the inside is 523.60 cu. ft. A float ball having an outside diameter of 6 in. has a volume of 113.10 cu. in.

The area or the volume of a sphere of a diameter not given in the table may be figured from the following simple formulae:

$$S = 4A$$
$$V = 0.524D^3$$

in which:
D = Diameter of the Sphere
A = Area of a Circle of Diameter D
S = Surface Area of Sphere
V = Volume of Sphere

Table 24

VELOCITY OF STEAM

To find the approximate velocity of low pressure steam (ft. per second) through a pipe, multiply the condensation in pounds per hour by the volume of steam in cubic feet per pound corresponding to the steam pressure. Divide this result by 25 times the internal area of the pipe.

The pipe area is found in the Table "Standard Pipe Dimensions" and the volume per cu. ft. is found in the Table "Properties of Saturated Steam."

Example. What is the velocity of steam at 5 lbs. per sq. inch flowing through a 2" pipe at a rate to produce 175 lbs. of condensate per hour?

1 pound of steam at 5 lbs. pressure = 20 cu. ft.
Internal area of 2" pipe = 3.36

The velocity of steam is:

$$\frac{175 \times 20}{25 \times 3.36} = \frac{3500}{84} = 41.7 \text{ ft. per sec.}$$

Table 3 gives the capacity of ASTM Schedule 40(S) pipe expressed in square feet EDR. The values are obtained from charts published by the American Society of Heating, Refrigerating and Air Conditioning Engineers' 1967 GUIDE.

STEAM CAPACITY[a] OF ASTM[b] SCHEDULE 40(S) PIPE AT INTERNAL PRESSURES OF 3.5 and 12 PSIG[c]

FLOW EXPRESSED IN SQ. FT. EDR

NOMINAL PIPE SIZE INCHES	PRESSURE DROP—PSI PER 100 FT. IN LENGTH													
	1/16 PSI (1 oz.)		1/8 PSI (2 oz.)		1/4 PSI (4 oz.)		1/2 PSI (8 oz.)		3/4 PSI (12 oz.)		1 PSI		2 PSI	
	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12	SAT. PR. 3.5	PSIG 12
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
¾″	36	44	56	64	80	96	116	140	144	172	168	200	240	292
1″	68	84	104	124	148	184	216	264	272	328	324	380	456	548
1¼″	144	180	212	264	312	384	444	552	560	680	648	800	928	1120
1½″	224	280	326	400	480	588	696	840	872	1040	984	1216	1440	1720
2″	432	536	648	776	936	1140	1344	1640	1680	2040	1920	2360	2840	3400
2½″	696	860	1032	1240	1512	1840	2160	2640	2720	3280	3120	3800	4600	5480
3″	1272	1520	1860	2200	2640	3240	3840	4640	4760	5720	5520	6680	7800	9600
3½″	1848	2200	2680	3200	3960	4872	5640	6800	6960	8400	8000	9680	11800	13800
4″	2560	3200	3800	4640	5640	6760	7920	9600	9800	12000	11520	13840	16800	19600
5″	4800	5720	6720	8400	9760	12000	14280	17000	17520	21000	20400	24400	30000	34400
6″	7680	9200	11280	13200	15840	19400	22800	28000	28800	34400	33600	40000	47600	56800
8″	15600	19200	22280	28000	32400	40000	45600	57200	58000	70800	66000	82000	96000	118000
10″	28800	35200	40800	50400	60000	72800	84000	104000	104800	128000	120000	148000	170800	208000
12″	45600	54800	66000	78000	93600	113600	132000	160000	164000	198000	192000	230000	271200	324000

a—Based on Moody Friction Factor where flow of condensate does not inhibit the flow of steam.
b—American Society for Testing Materials Schedule. The number 40 refers to the ASTM Schedule. The letter (S) refers to the former designation of standard weight pipe.
c—The flow rates at 3.5 psig can be used to cover saturated pressures from 1 to 6 psig, and the rates at 12 psig can be used to cover saturated pressures from 8 to 16 psig with an error not exceeding 8%.

Table 25

HEATING VALUES OF FUELS

All of the values given here are very approximate but sufficiently close for ordinary calculations. If greater accuracy is required the exact value should be obtained from the producer of the fuel in question. The heating value is also referred to as the "calorific value".

COAL

TYPE	BTU PER POUND
ANTHRACITE	13000
SEMI ANTHRACITE	13700
BITUMINOUS	12500
LIGNITE	7000

OIL

GRADE	BTU PER GALLON
No. 1	135000
No. 2	140000
No. 4	155000
No. 5	150000
No. 6	153000

GAS

KIND	BTU PER CUBIC FOOT
NATURAL	1000
MANUFACTURED	550
PROPANE	2250
BUTANE	3000

Table 26

SPECIFIC GRAVITY OF METALS

METAL	SPECIFIC GRAVITY
Water (Basis for Comparison)	1.00
Aluminum	2.55-2.80
Tin (Cast)	7.2-7.5
Steel	7.84
Cast Iron	7.03-7.13
Wrought Iron	7.6-7.9
Brass	8.4-8.7
Copper	8.8-8.95
Lead (Cast)	11.35
Mercury	13.60
Platinum	21.50

Table 28

SPECIFIC HEAT

AVERAGE VALUES 32° TO 212°F.

Air*	.237	Ice	.505
Air†	.169	Iron, Cast	.113
Alcohol	.615	Kerosene	.500
Aluminum	.212	Lead	.030
Ammonia	1.098	Limestone	.217
Ammonia*	.520	Marble	.206
Ammonia†	.391	Mercury	.033
Antimony	.052	Mica	.208
Asbestos	.195	Nickel	.109
Benzole	.340	Nitrogen*	.244
Bismuth	.030	Nitrogen†	.173
Brass	.092	Oak	.570
Brick	.220	Olive Oil	.471
Bronze	.104	Oxygen*	.224
Carbon, Graphite	.126	Oxygen†	.155
Carbon, Dioxide*	.215	Osmium	.031
Carbon, Dioxide†	.168	Paraffin	.589
Carbon, Monoxide*	.243	Petroleum	.504
Carbon, Monoxide†	.173	Platinum	.032
Cement, Portland	.271	Rubber, Hard	.339
Chalk	.220	Sand	.195
Chloroform (Liquid)	.235	Selenium	.068
Chloroform (Gas)	.147	Silicon	.175
Coal	.201	Silver	.056
Cobalt	.103	Steam*	.480
Coke	.0203	Steam†	.350
Concrete	.156	Stones	.200
Copper	.092	Steel	.118
Cork	.485	Sulphuric Acid	.336
Cotton	.362	Tantalum	.033
Ether	.540	Tin	.054
Fuel Oil	.500	Turpentine	.420
Gasoline	.500	Tungsten	.034
Glass	.180	Water	1.000
Gold	.032	Wool	.393
Gypsum	.259	Wood	.327
Hydrogen*	3.41	Zinc	.093
Hydrogen†	2.81		

* = Constant Pressure. † = Constant Volume.

Table 27

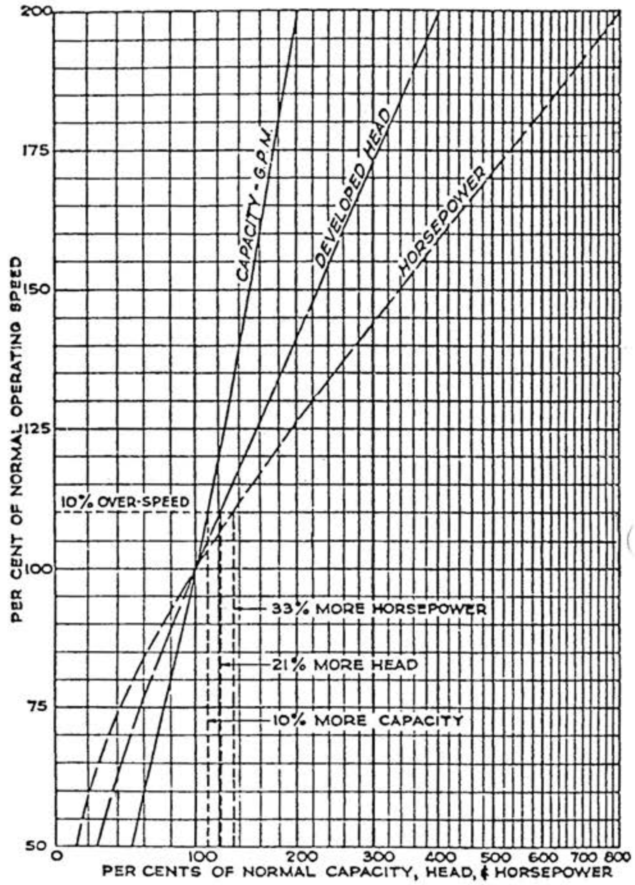
WEIGHTS OF STEEL & IRON PLATES & SHEETS

U.S. STANDARD GAGE

No. of Gage	Thickness Inches (Approx.)	WEIGHT PER SQUARE FOOT	
		Iron	Steel
0000000	.500	20.00	20.40
000000	.469	18.75	19.12
00000	.437	17.50	17.85
0000	.406	16.25	16.57
000	.375	15.00	15.30
00	.344	13.75	14.02
0	.312	12.50	12.75
1	.281	11.25	11.47
2	.266	10.62	10.84
3	.250	10.00	10.20
4	.234	9.37	9.56
5	.219	8.75	8.92
6	.203	8.12	8.29
7	.187	7.50	7.65
8	.172	6.87	7.01
9	.156	6.25	6.37
10	.141	5.62	5.74
11	.125	5.00	5.10
12	.109	4.37	4.46
13	.094	3.75	3.82
14	.078	3.12	3.19
15	.070	2.81	2.87
16	.062	2.50	2.55
17	.056	2.25	2.29
18	.050	2.00	2.04
19	.044	1.75	1.78
20	.037	1.50	1.53
21	.034	1.37	1.40
22	.031	1.25	1.27
23	.028	1.13	1.15
24	.025	1.00	1.02
25	.022	0.87	0.89
26	.019	0.75	0.76
27	.017	0.69	0.70
28	.016	0.63	0.64
29	.014	0.56	0.57
30	.012	0.50	0.51
31	.011	0.44	0.45
32	.010	0.40	0.41
33	.009	0.37	0.38
34	.009	0.34	0.35
35	.008	0.31	0.32
36	.007	0.28	0.29
37	.007	0.27	0.27
38	.006	0.25	0.25

Table 29

THEORETICAL EFFECT OF CHANGING SPEED OF A CENTRIFUGAL PUMP



Example:

If the prime mover overspeeds 10%, i.e. 110% of the rated speed, the effect on the head, capacity, and horse-power is as shown by the dotted line. The capacity increases in direct proportion or 10%; the head increases as the square of the ratio or 21%; and the horse-power varies as the cube or in this case 33% increase.

Chart 5

RULES OF THUMB FOR SIZING UNITS

- Condensate and Boiler Feed Pumps sized for two times the evaporation rate of the boiler. (i.e. 1 gpm per 1000 sq ft EDR).

- Condensate Storage Receivers are sized for 1 minute net storage. Boiler Feed Receivers sized for 5 minute net storage to allow you to keep feeding boiler and steaming till steam can condense and be returned from the system. Large systems may require sizing for 10 minute net storage.

- Pump Discharge pressure for Boilers **UP TO 50 psi:** boiler pressure plus the required pressure to overcome the losses and an additional 5 psi. When using vacuum in systems you must make an additional allowance to overcome the vacuum in the condensate receiver. Add 5 psi for the first 5-1/2 inches of HG vacuum. Then for every inch of vacuum deeper after that add ½ of a psi per inch.

- Pump Discharge pressure for Boilers **OVER 50 psi:** boiler pressure plus the required pressure to overcome the losses, plus an additional 10 psi (plus an additional allowance to overcome the vacuum in the condensate receiver as noted above).

Table 30

QUICK SELECT CONVERSION TABLE

BTU	LB/HR	Sq Ft of Equivalent Direct Radiation (EDR)	BHP	Boiler Evaporation Rate (GPM)	Sizing at 1 GPM per 1000 Sq Ft EDR	Sizing at 1.5 GPM per 1000 Sq Ft EDR	Receiver Gallons @ 5 Minute Storage	Receiver Gallons @ 10 Minute Storage
1,339,160	1,380	5,560	**40**	2.8	5.5	8.3	14	28
1,841,345	1,898	7,645	**55**	3.8	7.6	11.4	19	38
2,678,320	2,760	11,120	**80**	5.5	11.0	16.6	28	55
3,347,900	3,450	13,900	**100**	6.9	13.8	20.7	35	69
4,184,875	4,313	17,375	**125**	8.6	17.3	25.9	43	86
5,021,850	5,175	20,850	**150**	10.4	20.7	31.1	52	104
5,858,825	6,038	24,325	**175**	12.1	24.2	36.2	60	121
6,695,800	6,900	27,800	**200**	13.8	27.6	41.4	69	138
7,532,775	7,763	31,275	**225**	15.5	31.1	46.6	78	155
8,369,750	8,625	34,750	**250**	17.3	34.5	51.8	86	173
9,206,725	9,488	38,225	**275**	19.0	38.0	56.9	95	190
10,043,700	10,350	41,700	**300**	20.7	41.4	62.1	104	207
10,880,675	11,213	45,175	**325**	22.4	44.9	67.3	112	224
11,717,650	12,075	48,650	**350**	24.2	48.3	72.5	121	242
12,554,625	12,938	52,125	**375**	25.9	51.8	77.6	129	259
13,391,600	13,800	55,600	**400**	27.6	55.2	82.8	138	276
14,228,575	14,663	59,075	**425**	29.3	58.7	88.0	147	293
15,065,550	15,525	62,550	**450**	31.1	62.1	93.2	155	311
15,902,525	16,388	66,025	**475**	32.8	65.6	98.3	164	328
16,739,500	17,250	69,500	**500**	34.5	69.0	103.5	173	345
17,576,475	18,113	72,975	**525**	36.2	72.5	108.7	181	362
20,087,400	20,700	83,400	**600**	41.4	82.8	124.2	207	414
20,924,375	21,563	86,875	**625**	43.1	86.3	129.4	216	431
21,761,350	22,425	90,350	**650**	44.9	89.7	134.6	224	449
22,598,325	23,288	93,825	**675**	46.6	93.2	139.7	233	466
23,435,300	24,150	97,300	**700**	48.3	96.6	144.9	242	483
25,109,250	25,875	104,250	**750**	51.8	103.5	155.3	259	518
26,783,200	27,600	111,200	**800**	55.2	110.4	165.6	276	552
28,457,150	29,325	118,150	**850**	58.7	117.3	176.0	293	587
30,131,100	31,050	125,100	**900**	62.1	124.2	186.3	311	621
31,805,050	32,775	132,050	**950**	65.6	131.1	196.7	328	656
33,479,000	34,500	139,000	**1000**	69.0	138.0	207.0	345	690
36,826,900	37,950	152,900	**1100**	75.9	151.8	227.7	380	759
40,174,800	41,400	166,800	**1200**	82.8	165.6	248.4	414	828
45,196,650	46,575	187,650	**1350**	93.2	186.3	279.5	466	932
50,218,500	51,750	208,500	**1500**	103.5	207.0	310.5	518	1,035
55,240,350	56,925	229,350	**1650**	113.9	227.7	341.6	569	1,139
60,262,200	62,100	250,200	**1800**	124.2	248.4	372.6	621	1,242
63,610,100	65,550	264,100	**1900**	131.1	262.2	393.3	656	1,311
66,958,000	69,000	278,000	**2000**	138.0	276.0	414.0	690	1,380

Table 31

DEFINITIONS OF HEATING TERMS

The definitions given in this section are only those applying to heating and particularly as used in this Book. It is realized that some do not define the terms for all usages, but in the interest of clearance and space this sacrifice was made.

Absolute Humidity: The weight of water vapor in grains actually contained in one cubic foot of the mixture of air and moisture.

Absolute Pressure: The actual pressure above zero. It is the atmospheric pressure added to the gage pressure. It is expressed as a unit pressure such as lbs. per sq. in. absolute.

Absolute Temperature: The temperature of a substance measured above absolute zero. To express a temperature as absolute temperature add 460°F to the reading of a Fahrenheit thermometer or 273°F to the reading of a Centigrade one.

Absolute Zero: The temperature (-460°F approx.) at which all molecular motion of a substance ceases, and at which the substance contains no heat.

Air: An elastic gas. It is a mechanical mixture of oxygen and nitrogen and slight traces of other gases. It may also contain moisture known as humidity. Dry air weighs 0.075 lbs. per cu. ft.

One Btu will raise the temperature of 55 cu. ft. of air one degree F.

Air expands or contracts approximately 1/490 of its volume for each degree rise or fall in temperature from 32°F.

Air Change: The number of times in an hour the air in a room is changed either by mechanical means or by the infiltration of outside air leaking into the room through cracks around doors and windows, etc.

Air Cleaner: A device designed for the purpose of removing air-borne impurities, such as dust, fumes, and smokes. (Air cleaners include air washers and air filters.)

Air Conditioning: The simultaneous control of the temperature, humidity, air motion, and air distribution within an enclosure. Where human comfort and health are involved, a reasonable air purity with regard to dust, bacteria, and odors is also included. The primary requirement of a good air conditioning system is a good heating system.

Air Infiltration: The leakage of air into a house through cracks and crevices, and through doors, windows, and other openings, caused by wind pressure and/or temperature difference.

Air Valve: See Vent Valve.

Atmospheric Pressure: The weight of a column of air, one square inch in cross section and extending from the earth to the upper level of the blanket of air surrounding the earth. This air exerts a pressure of 14.7 pounds per square inch at sea level, where water will boil at 212°F. High altitudes have lower atmospheric pressure with correspondingly lower boiling point temperatures.

Boiler: A closed vessel in which steam is generated or in which water is heated by fire.

Boiler Heating Surface: The area of the heat transmitting surfaces in contact with the water (or steam) in the boiler on one side and the fire or hot gases on the other.

Boiler Horse Power: The equivalent evaporation of 34.5 lbs. of water per hour at 212°F to steam at 212°F. This is equal to a heat output of 33,475 Btu per hour, which is equal to approximately 140 sq. ft. of steam radiation (EDR).

British Thermal Unit (Btu): The quantity of heat required to raise the temperature of 1 lb. of water 1°F. This is somewhat approximate but sufficiently accurate for any work discussed in this Book.

Bucket Trap (Inverted): A float trap with an open float. The float or bucket is open at the bottom. When the air or steam in the bucket has been replaced by condensate the bucket loses its buoyancy and when it sinks it opens a valve to permit condensate to be pushed into the return.

Bucket Trap (Open): The bucket (float) is open at the top. Water surrounding the bucket keeps it floating and the pin is pressed against its seat. Condensate from the system drains into the bucket. When enough has drained into it so that the bucket loses its buoyancy it *sinks* and pulls the pin off its seat and steam pressure forces the condensate out of the trap.

Calorie (Small): The quantity of heat required to raise 1 gram of water 1°C (approx.).

Calorie (Large): The quantity of heat required to raise 1 kilogram of water 1°C (approx.).

Centigrade: A thermometer scale at which the freezing point of water is 0°F and its boiling is 100°F. In this country it is only used in scientific and laboratory work.

Central Fan System: A mechanical indirect system of heating, ventilating, or air conditioning consisting of a central plant where the air is heated and/or conditioned and then circulated by fans or blowers through a system of distributing ducts.

Chimney Effect: The tendency in a duct or other vertical air passage for air to rise when heated due to its decrease in density.

Circulating Pipe (Hot Water System): The pipe and orifice in a Hoffman Specialty Panelmatic Hot Water Control System through which the return water by-passes the boiler until the temperature of the circulating stream is too low at which time part of it is replaced by the correct quantity of hot boiler water to restore its temperature.

Coefficient of Heat Transmission (Over-all)-U-: The amount of heat (Btu) transmitted *from air to air* in one hour per square foot of the wall, floor, roof, or ceiling for a difference in temperature of one degree Fahrenheit *between the air on the inside and outside of the wall, floor, roof, or ceiling*.

Column Radiator: A type of direct radiator. (This radiator has not been listed by manufacturers since 1926.)

Comfort Line: The effective temperature at which the largest percentage of adults feel comfortable.

Comfort Zone (Average): The range of effective temperatures over which the majority of adults feel comfortable.

Concealed Radiator: See Convector.

Condensate: In steam heating, the water formed by cooling steam as in a radiator. The capacity of traps, pumps, etc., is sometimes expressed in lbs. of condensate they will handle per hour. One pound of condensate per hour is equal to approximately 4 sq. ft. of steam heating surface (240 Btu per hour per sq. ft.).

Conductance (Thermal)-C-: The amount of heat (Btu) transmitted *from surface to surface*, in one hour through one square foot of a material or construction *for the thickness or type under consideration* for a difference in temperature of one degree Fahrenheit between the two surfaces.

Conduction (Thermal): The transmission of heat through and by means of matter.

Conductivity (Thermal)-k-: The amount of heat (Btu) transmitted in one hour through one square foot of a homogenous material one inch thick for a difference in temperature of one degree Fahrenheit between the two surfaces of the material.

Conductor (Thermal): A material capable of readily transmitting heat by means of conduction.

Convection: The transmission of heat by the circulation (either natural or forced) of a liquid or a gas such as air. If natural, it is caused ,by the difference in weight of hotter and colder fluid.

Convector: A concealed *radiator*. An enclosed heating unit located (with enclosure) either within, adjacent to, or exterior to the room or space to be heated, but transferring heat to the room or space mainly by the process of convection. A shielded heating unit is also termed a convector. If the heating unit is located exterior to the room or space to be heated, the heat is transferred through one or more ducts or pipes.

Convertor: A piece of equipment for heating water with steam without mixing the two. It may be used for supplying hot water for domestic purposes or for a hot water heating system.

Cooling Leg: A length of uninsulated pipe through which the condensate flows to a trap and which has sufficient cooling surface to permit the condensate to dissipate enough heat to prevent flashing when the trap opens. In the case of a thermostatic trap a cooling leg may be necessary to permit the condensate to drop a sufficient amount in temperature to permit the trap to open.

Degree-Day: (Standard) A unit which is the difference between 65°F and the daily average temperature when the latter is below 65°F. The "degree days" in anyone day is equal to the number of degrees F that the average temperature for that day is below 65°F.

Dew-Point Temperature: The air temperature corresponding to saturation (100 per cent relative humidity) for a given moisture content. It is the lowest temperature at which air can retain the water vapor it contains.

Direct-Indirect Heating Unit: A heating unit located in the room or space to be heated and partially enclosed, the enclosed portion being used to heat air which enters from outside the room.

Direct Radiator: Same as *radiator:*

Direct-Return System (Hot Water): A two-pipe hot water system in which the water after it has passed through a heating unit, is returned to the boiler along a direct path so that the total distance traveled by the water from each radiator is the shortest feasible. There is, therefore, a considerable difference in the lengths of the several circuits composing the system.

Domestic Hot Water: Hot water used for purposes other than for house heating such as for laundering, dish washing, bathing, etc .

Down-Feed One-Pipe Riser (Steam): A pipe which carries steam downward to the heating units and into which the condensation from the heating units drains.

Down-Feed System (Steam): A steam heating system in which the supply mains are above the level of the heating units which they serve.

Dry-Bulb Temperature: The temperature of the air as determined by an ordinary thermometer.

Dry Return (Steam): A return pipe in a steam heating system which carries both water of condensation and air.

Dry Saturated Steam: Saturated steam containing no water in suspension.

Equivalent Direct Radiation (E.D.R.): See Square Foot of Heating Surface.

Extended Heating Surface: Heating surface consisting of ribs, fins, or ribs which receive heat by conduction from the prime surface.

Extended Surface Heating Unit: A heating unit having a relatively large amount of extended surface which may be integral with the core containing the heating medium or assembled over such a core, making good thermal contact by pressure, or by being soldered to the core or by both pressure and soldering. (An extended surface heating unit is usually placed within an enclosure and therefore functions as a convector.)

Fahrenheit: A thermometer scale at which the freezing point of water is 32°F and its boiling point is 212°F above zero. It is generally used in this country for expressing temperature.

Flash (Steam): The rapid passing into steam of water at a high temperature when the pressure it is under is reduced so that its temperature is above that of its boiling point for the reduced pressure. For example: If hot condensate is discharged by a trap into a low pressure return or into the atmosphere, a certain percentage of the water will be immediately transformed into steam. It is also called re-evaporation.

Float & Thermostatic Trap: A float trap with a thermostatic element for permitting the escape of air into the return line.

Float Trap: A steam trap which is operated by a float. When enough condensate has drained (by gravity) into the trap body the float is lifted which in turn lifts the pin off its seat and permits the condensate to flow into the return until the float has been sufficiently lowered to close the port. Temperature does not effect the operation of a float trap.

Furnace: That part of a boiler or warm air heating plant in which combustion takes place. Sometimes also the complete heating unit of a warm air heating system.

Gage Pressure: The pressure above that of the atmosphere. It is the pressure indicated on an ordinary pressure gage. It is expressed as a unit pressure such as lbs. per sq. in. gage.

Grille: A perforated covering for an air inlet or outlet usually made of wire screen, pressed steel, cast-iron or other material.

Head: Unit pressure usually expressed in ft. of water or mil-inches of water.

Heat: That form of energy into which all other forms may be changed. Heat always flows from a body of higher temperature to a body of lower temperature. See also: Latent Heat, Sensible Heat, Specific Heat, Total Heat, Heat of the Liquid.

Heat of the Liquid: The heat (Btu) contained in a liquid due to its temperature. The heat of the liquid for water is zero at 32°F and increases 1 Btu approximately for every degree rise in temperature.

Heat Unit: In the foot-pound-second system, the British Thermal Unit (Btu) in the centimeter-gram-second system, the calorie (cal).

Heating Medium: A substance such as water, steam, or air used to convey heat from the boiler, furnace, or other source of heat to the heating units from which the heat is dissipated.

Heating Surface: The exterior surface of a heating unit. See also Extended Heating Surface.

Heating Unit: Radiators, convectors, base boards, finned tubing, coils embedded in floor, wall, or ceiling, or any device which transmits the heat from the heating system to the room and its occupants.

Horsepower: A unit to indicate the time rate of doing work equal to 550 ft.-lb. per second, or 33,000 ft.-lb. per minute. One horsepower equals 2545 Btu per hour or 746 watts.

Hot Water Heating System: A heating system in which water is used as the medium by which heat is carried through pipes from the boiler to the heating units.

Humidstat: An instrument which controls the relative humidity of the air in a room.

Humidity: The water vapor mixed with air.

Insulation (Thermal): A material having a high resistance to heat flow.

Latent Heat of Evaporation: The heat (Btu per pound) necessary to change 1 pound of liquid into vapor without raising its temperature. In round numbers this is equal to 960 Btu per pound of water.

Latent Heat of Fusion: The heat necessary to melt one pound of a solid without raising the temperature of the resulting liquid. The latent heat of fusion of water (melting 1 pound of ice) is 144 Btu.

Mechanical Equivalent of Heat: The mechanical energy equivalent to 1 Btu which is equal to 778 ft.-lb.

Mil-Inch: One one-thousandth of an inch (0.001/1).

One- Pipe Supply Riser (Steam): A pipe which carries steam to a heating unit and which also carries the condensation from the heating unit. In an up feed riser steam travels upwards and the condensate downward while in a down feed both steam and condensate travel down.

One-Pipe System (Hot Water): A hot water heating system in which one-pipe serves both as a supply main and also as a return main. The heating units have separate supply and return pipes but both are connected to the same main.

One-Pipe System (Steam): A steam heating system consisting of a main circuit in which the steam and condensate flow in the same pipe. There is but one connection to each heating unit which must serve as both the supply and the return.

Overhead system: Any steam or hot water system in which the supply main is above the heating units. With a steam system the return must be below the heating units; with a water system, the return may be above the heating units.

Panel Heating: A method of heating involving the installation of the heating units (pipe coils) within the wall, floor or ceiling of the room.

Panel Radiator: A heating unit placed on, or flush with, a flat wall surface and intended to function essentially as a radiator. Do not confuse with panel heating system.

Plenum Chamber: An air compartment maintained under pressure and connected to one or more distributing ducts.

Pressure: Force per unit area such as lb. per sq. inch. See Static, Velocity, and Total Gage and Absolute Pressures. Unless otherwise qualified, it refers to unit static gage pressure.

Pressure Reducing Valve: A piece of equipment for changing the pressure of a gas or liquid from a higher to a lower one.

Prime Surface: A heating surface having the heating medium on one side and air (or extended surface) on the other.

Radiant Heating: A heating system in which the heating is by radiation only. Sometimes applied to Panel Heating System.

Radiation: The transmission of heat in a straight line through space.

Radiator: A heating unit located within the room to be heated and exposed to view. A radiator transfers heat by radiation to objects "it can see" and by conduction to the surrounding air which in turn is circulated by natural convection.

Recessed Radiator: A heating unit set back into a wall recess but not enclosed.

Reducing Valve: See Pressure Reducing Valve.

Re-Evaporation: See Flash.

Refrigeration, Ton of: See Ton of Refrigeration.

Register: A grille with a built-in damper or shutter.

Relative Humidity: The amount of moisture in a given quantity of air compared with the maximum amount of moisture the same quantity of air could hold at the same temperature. It is expressed as a percentage.

Return Mains: The pipes which return the heating medium from the heating units to the source of heat supply.

Reverse-Return System (Hot Water): A two-pipe hot water heating system in which the water from the several heating units is returned along paths arranged so that all radiator circuits of the system are practically of equal length.

Roof Ventilator: A device placed on the roof of a building to permit egress of air.

Sensible Heat: Heat which only increases the temperature of objects as opposed to latent heat.

Specific Heat: In the foot-pound-second system, the amount of heat (Btu) required to raise one pound of a substance one degree Fahrenheit. In the centimeter- gram-second system, the amount of heat (cal.) required to raise one gram of a substance one degree centigrade. The specific heat of water is 1.

Split System: A system in which the heating is accomplished by radiators or convectors and ventilation by separate apparatus.

Square Foot of Heating Surface: Equivalent direct radiation (EDR). By definition, that amount of heating surface which will give off 240 Btu per hour when filled with a heating medium at 215°F and surrounded by air at 70°F. The equivalent square foot of heating surface may have no direct relation to the actual surface area.

Static Pressure: The pressure which tends to burst a pipe. It is used to overcome the frictional resistance to flow through the pipe. It is expressed as a unit pressure and may be either in absolute or gage pressure. It is frequently expressed in feet of water column or (in the case of pipe friction) in mil-inches of water column per ft. of pipe.

Steam: Water in the vapor phase. The vapor formed when water has been heated to its boiling point, corresponding to the pressure it is under. See also Dry Saturated Steam, Wet Saturated Steam, Super Heated Steam.

Steam Heating System: A heating system in which the heating units give up their heat to the room by condensing the steam furnished to them by a boiler or other source.

Steam Trap: A device for allowing the passage of condensate and air but preventing the passage of steam. See Thermostatic, Float, Bucket Trap.

Superheated Steam: Steam heated above the temperature corresponding to its pressure.

Supply Mains: The pipes through which the heating medium flows from the boiler or source of supply to the run-outs and risers leading to the heating units.

Tank Regulator: See Temperature Regulator.

Temperature Regulator: A piece of equipment for controlling the admission of steam to a hot water (or other liquid) heating device in the correct quantities so that the temperature of the liquid will remain constant.

Thermostat: An instrument which responds to changes in temperature and which directly or indirectly controls the room temperature.

Thermostatic Trap: A steam trap which opens by a drop in temperature such as when cold condensate or air reaches it and closes it when steam reaches it. The temperature sensitive element is usually a sealed bellows or series of diaphragm chambers containing a small quantity of volatile liquid.

Ton of Refrigeration: The heat which must be extracted from one ton (2,000 lbs.) of water at 32°F to change it into ice at 32°F in 24 hours. It is equal to 288,000 Btu/24 hours, 12,000 Btu/hour, or 200 Btu/minute.

Total Heat: The latent heat of vaporization added to the heat of the liquid with which it is in contact.

Total Pressure: The sum of the static and velocity pressures. It is also used as the total static pressure over an entire area, that is, the unit pressure multiplied by the area on which it acts.

Trap: See Steam Trap, Thermostatic Trap, Float Trap, and Bucket Trap.

Two-Pipe System (Steam or Water): A heating system in which one pipe is used for the supply main and another for the return main. The essential feature of a two-pipe hot water system is that each heating unit receives a direct supply of the heating medium which cannot have served a preceding heating unit.

Unit Heater: A heating unit consisting of a heat transfer element, a housing, a fan with driving motor, and outlet deflectors or diffusers. It is usually suspended from the ceiling and its heat output is controlled by starting and stopping the fan by a room thermostat. The circulation of the heating medium (steam or hot water) is usually continuous. It is used mostly for industrial heating.

Unit Pressure: Pressure per unit area as lbs. per sq. in.

Up-Feed System (Hot Water or Steam): A heating system in which the supply mains are below the level of the heating units which they serve.

Vacuum Heating System (Steam): A one- or two-pipe heating system equipped with the necessary accessory apparatus to permit the pressure in the system to go below atmospheric.

Vapor: Any substance in the gaseous state.

Vapor Heating System (Steam): A two-pipe heating system which operates under pressure at or near atmospheric and which returns the condensation to the boiler or receiver by gravity.

Velocity Pressure: The pressure used to create the velocity of flow in a pipe. It is expressed as a unit pressure.

Ventilation: Air circulated through a room for ventilating purposes. It may be mechanically circulated with a blower system or it may be natural circulation through an open window, etc.

Vent Valve (Steam): A device for permitting air to be forced out of a heating unit or pipe and which closes against water and steam.

Vent Valve (Water): A device permitting air to be pushed out of a pipe or heating unit but which closes against water.

Warm Air Heating System: A warm air heating plant consists of a heating unit (fuel-burning furnace) enclosed in a casing, from which the heated air is distributed to the various rooms of the building through ducts. If the motive head producing flow depends on the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing, it is termed a gravity system.
A booster fan may however, be used in conjunction with a gravity-designed system. If a fan is used to produce circulation and the system is designed especially for fan circulation, it is termed a fan furnace system or a central fan furnace system.
A fan furnace system may include air washer, filters, etc.

Wet Bulb Temperature: The lowest temperature which a water-wetted body will attain when exposed to an air current.

Wet Return (Steam): That part of a return main of a steam heating system which is completely filled with water of condensation.

Wet Saturated Steam: Saturated steam containing some water particles in suspension.

TABLES AND CHARTS

STEAM SELECTION AND SIZING TOOLS

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Heat Exchanger Product Selection

- ESP – Thermal Plate Heat Exchanger Selection Program

Steam and Water Pressure Reducing Valves

- Steam – 2000 Pressure and Temperature Regulator
- Steam – 1140 Temperature Regulator
- Water – 1140 Temperature Regulator
- Steam – Traps

Sizing Tools

- Steam – Pipe
- Steam – Loss
- Flash – Steam
- Condensate – Pipe

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

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