Types of Boilers

Instruction Paper

By
Carl S. Dow, S.B. (Harvard University),
American Society Mechanical Engineers

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Contents

Definitions

The following definitions should be remembered in connection with the terms used in designating the various classes.

A fire-tube boiler is one having the heating surface composed largely of tubes which are surrounded with water, the hot gases passing through them.

A water-tube boiler is also composed of tubes, but in this case *water* flows through the tubes, while the hot gases pass around and among them.

In a sectional boiler the tubes and corresponding headers form comparatively small units. Each unit is complete in itself; that is, it is in communication with a steam and water drum but is independent of the other units.

A non-sectional boiler is one having all the tubes in communication with one another; in other words, all or nearly all the tubes are expanded into a common header or drum. The boiler is not made up of units.

A single-tube boiler is made up of plain tubes.

A double-tube boiler has a small tube inside of the regular tube and concentric with it.

A boiler is **externally-fired** when the furnace is separate from the shell; in such boilers the fire is usually placed in a brick furnace.

In the **internally-fired** boiler the grate is inside of a flue which is within the shell.

A fire-box boiler is one having the fire within a fire box which, although external to the shell, is rigidly connected to it. The fire box is usually made of steel plates instead of brick as in the case of the externally-fired boiler.

Chapter 2

Flue Boilers

In order to get the necessary heating surface in the cylindrical boiler without making it excessively long, it was made with an internal flue through which the hot gases passed to the chimney. This flue was quite large and extended from end to end. In the United States, Oliver Evans used this type in 1800. In England, it led to the internally-fired flue boilers which were so extensively used.

The Cornish Boiler

Horizontal—Single-Flue—Internally-Fired

When it was found that about 25 percent of the total heat of combustion was lost by radiation from the furnace, a Cornish engineer named Trevithick conceived the idea of placing the fire inside the large internal flue. He introduced this type which is known as the Cornish boiler.

The products of combustion pass from the fire on the grate bars C (Fig. 4) through the flue to the back end where they divide and return to the front end by means of the lateral flues L in the brickwork. See Fig. 4a. At the front the hot gases pass downward, and uniting pass through the flue F in contact with the bottom of the boiler. On leaving the boiler they go to the chimney. This arrangement of flues reduces the temperature of the gases before they come in contact with the bottom of the boiler where sediment collects. The grate bars rest on the dead plate D at one end

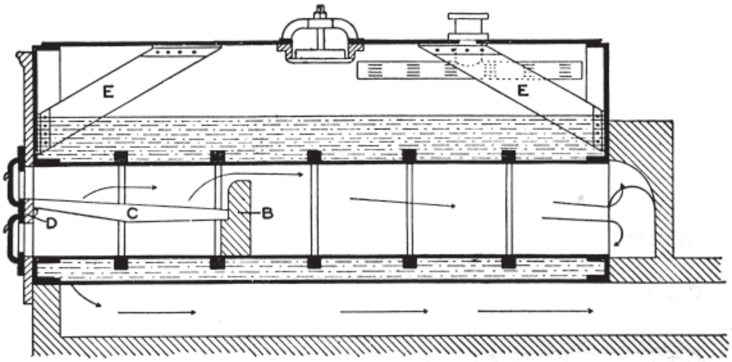


Fig. 4

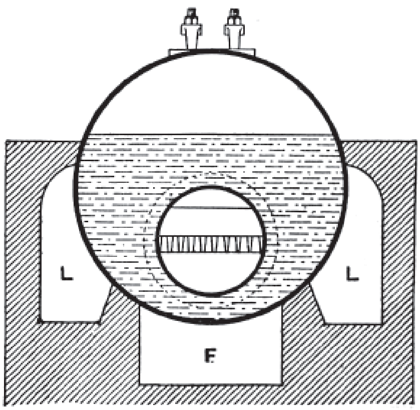


Fig. 4a

and on the bridge B at the other; if made in two lengths (as is often the case) they are supported at the center by a cross bearer. The bridge is built of fire brick and the external flues are lined with fire brick. The heads are stayed to the shell by gusset stays E E.

The large internal flue is the hottest portion of the boiler because it contains the fire. For this reason the flue has greater linear expansion than the shell and, if the flue is a plain cylinder, the increase in length causes the ends to bulge. When the boiler is cold, the flue returns to the normal length. This lengthening and shortening will soon loosen the flue at the ends. To overcome this, the flue is sometimes made up of several short rings flanged at the ends and joined by being riveted to a plain ring. This construction is shown in section in Fig. 4. Another method is shown in Fig. 5. The plain ring is riveted to the curved ring; this ring takes up the expansion, increases the heating surface, and strengthens

Chapter 3

Fire-Tube Boilers

Single-Flue Boiler

Horizontal—Single Fire Tube—Externally-Fired

In the Cornish, Lancashire, and Galloway boiler the large internal flue served as a fire box. There was, however, a flue boiler having the fire external to the shell. The boiler shown in Fig. 10 resembles the plain cylindrical boiler both in appearance and setting, but it has one or more large flues extending from end to end. This flue increases the heating surface to such an extent that the boiler can be considerably shorter than the plain cylindrical.

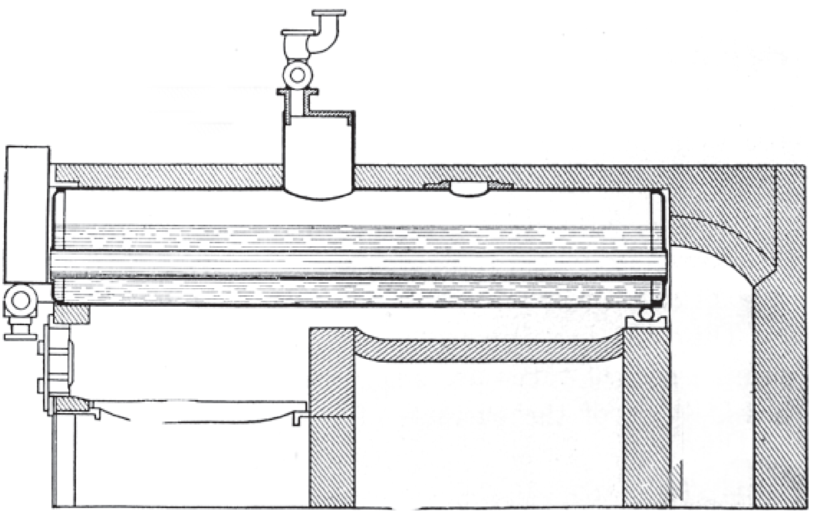


Fig. 10

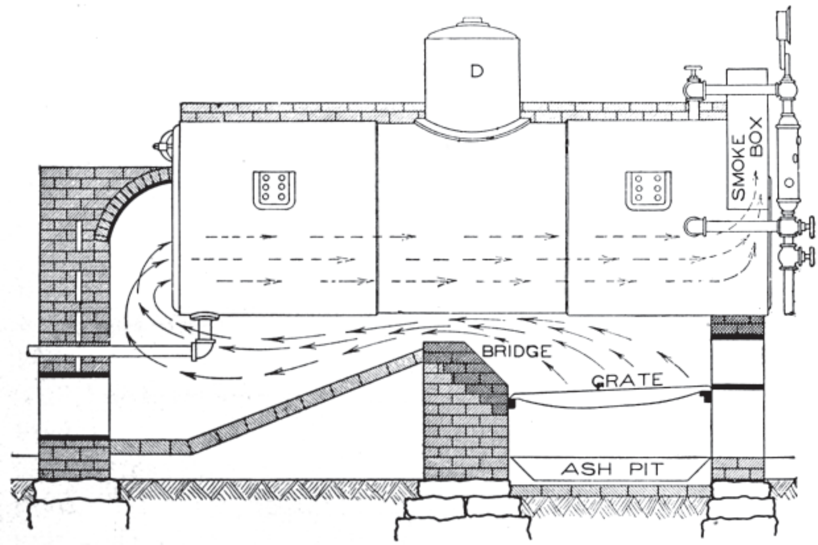


Fig. 13

elliptical; the former being about 11 inches by 15 inches in size; while the latter are about 4 inches by 6 inches.

The heating surface is the surface in contact with the hot gases. In this type, the heating surface is made up of about half the shell, the tubes, and about two-thirds of the rear tube sheet. In general, all the heating surface is below the water line.

The complete multitubular boiler is shown in its brick setting in Fig. 14, and a longitudinal section of the setting in Fig. 13. The brick setting consists of brick laid in cement or mortar. The bridge and the portions of the furnace exposed to the fire are lined with fire brick. The bridge is built at the rear of the grate and forms a support for the grate bars; it also directs the flames upward. The arrows show the direction of the flow of hot gases. The furnace is formed by the bridge, the side walls, and the lower part of the boiler front. The boiler front is usually of cast iron with the lower part lined with fire brick. The front has doors which lead to the furnace, ashpit, and smoke box. The space below the grate

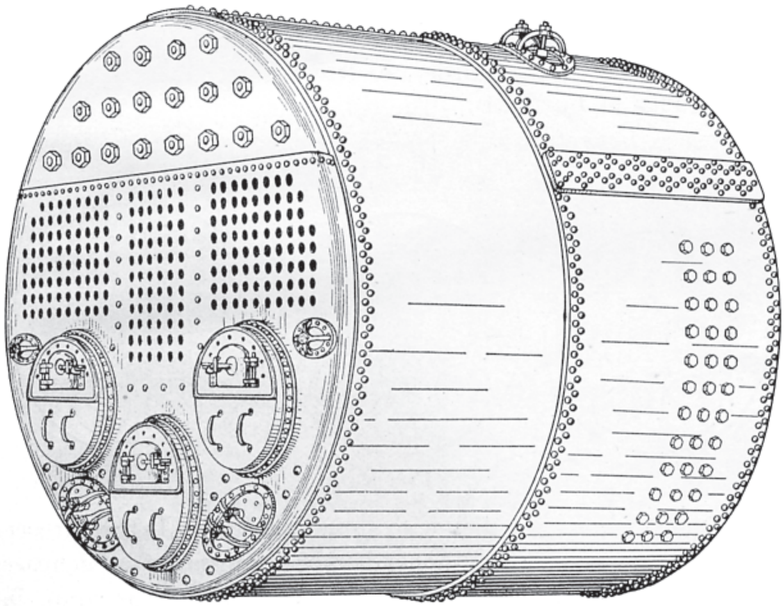


Fig. 22

boiler, for a large boiler must have a large grate area which can be obtained only by using several furnaces. The various arrangements are shown diagrammatically in Fig. 23.

A single-furnace boiler has but one combustion chamber. A two-furnace boiler may have a combustion chamber for each furnace or it may have a common combustion chamber. If there is but one boiler on board, it is better to have two combustion chambers, so that in case a tube bursts, the boiler will not be disabled. If, however, there are several

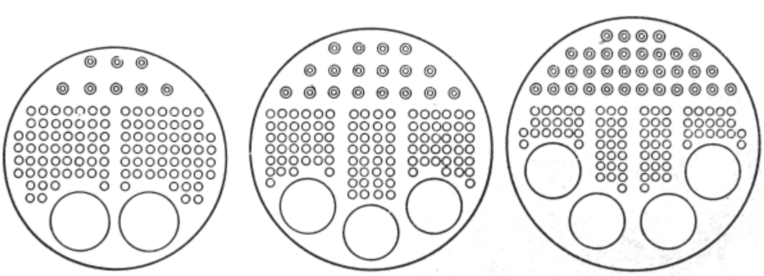


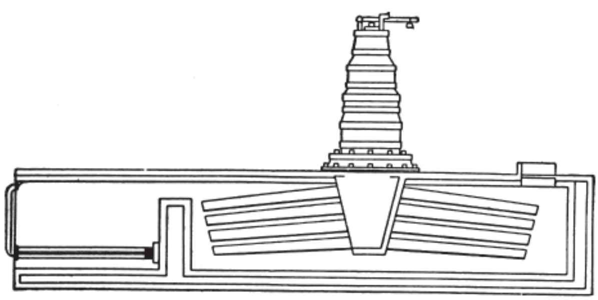
Fig. 23

Chapter 4

Water-Tube Boilers

The water-tube boiler differs essentially from the fire-tube. The names indicate the chief point of difference. In the fire-tube boiler, the tubes, which are surrounded with water, conduct the hot gases to the smoke box. In the water-tube, the tubes are filled with water, and the hot gases pass over and among them on their way to the chimney.

Although flue boilers and the tubular types were introduced at an earlier period than the water-tube, the last-named type is not a new form of steam generator. About a century ago, John Stevens invented a water-tube boiler and fitted it to a steamboat. This boiler (Fig. 39) was a combination of small tubes connected, at one end, to a reservoir. Thus the "porcupine" was one of the earliest forms. At various times since then, many ideas have been worked out both for marine and stationary boiler. During the last



Stevens Boiler

Fig. 39

fifteen years, however, the water-tube boiler has been steadily growing in favor, the chief reasons being—the necessity of higher steam pressures, greater reliability of materials, greater skill in design and workmanship, and more intelligent management.

It is not within the province of this instruction paper to discuss the relative merits of fire-tube and water-tube boilers, but a careful, impartial consideration seems to show that as far as economy of running is concerned there is but little difference. The fire-tube boiler is reliable and can be handled by those possessing comparatively little knowledge of engineering. Its chief defect seems to be the disastrous results following an explosion. The water-tube boiler, on the other hand, is safe, and suited to higher pressures, but requires greater care in management.

Before discussing these boilers in detail, let us consider briefly the salient points.

Safety. Probably the greatest advantage claimed for the water-tube boiler is its safety. The boiler contains much less water than does the flue or tubular boiler and the water is divided into small masses, thus minimizing serious results in case of rupture. On account of the shape and arrangement of parts, the circulation is usually good, and no part exposed to the fire can be uncovered while there is any water in the boiler. The tubes cannot become overheated until the boiler is empty and with an empty boiler there cannot be a serious explosion.

Rapidity in Raising Steam. The many small streams into which the water is divided as it passes through the furnace greatly facilitate the absorption of heat. Because of the small streams and the rapid circulation, the water is converted into steam in a very short time. Several hours (usually five to seven) are required to raise steam to working pressure in a tubular boiler, while in many water-tube

The steam drum and also the mud drum are equipped with swinging manheads. The steam drum also has several handholes for use in removing and replacing tubes.

Stirling

Water Tubes Nearly Vertical—Steam and Water Drums Horizontal—Curved-Tubes—Single-Tube—Non-Sectional

The Stirling boiler, shown in Fig. 64, consists of three cylindrical steam and water drums at the top, and a mud drum at the bottom. The lower drum is connected to the upper drums by three sets of tubes which are curved slightly at the ends. The curved tubes allow for expansion and make it possible to have the tubes enter the drums radially.

The feed water enters the rear steam and water drum and coming in contact with the hot gases just before they enter the uptake, becomes gradually warmed. This heating causes most of the sediment to fall to the mud drum from

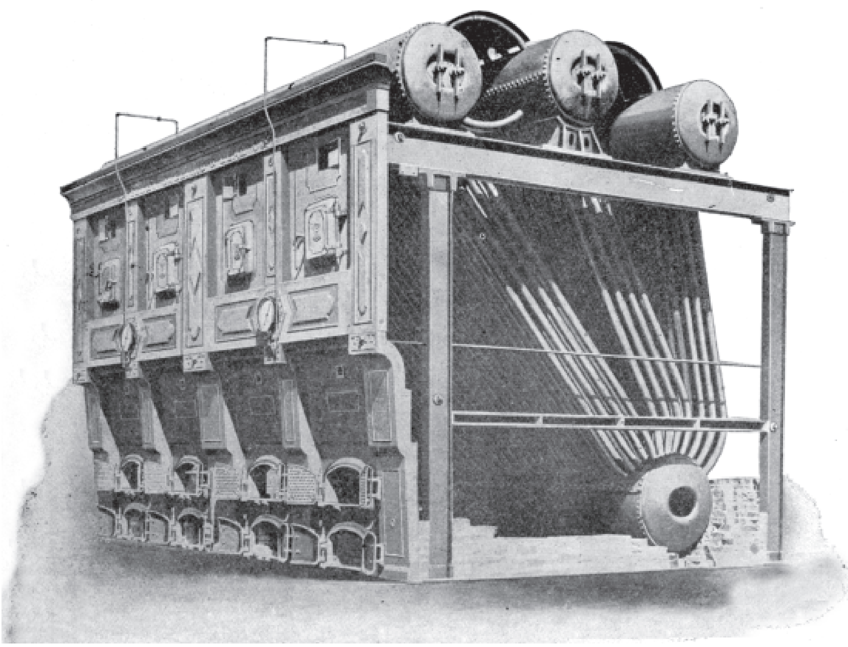


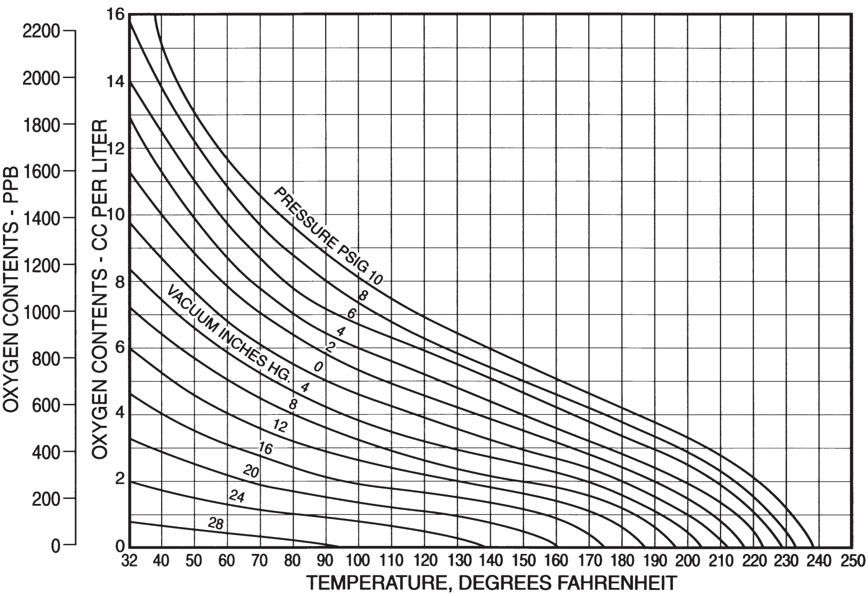
Fig. 64

Atmospheric Advantages:

- No ASME Code tank expense
- No float drainer for overflow
- No safety valve
- Less steam loss at partial load
- No orifice in vent
- Shell & tube vent condenser/preheater advantage for larger temperature rise heating requirements

Pressurized Advantage:

- Faster response of pressure pilot



A steam manifold is boiling the water hard near the bottom of the tank with volumes of steam rising. The incoming water is sprayed into the top of the tank just below the vent, condensing the steam and heating the incoming water. It then cascades through the baffles further heating the water, condensing more steam, and releasing oxygen which travels up toward the vent with the steam. The water, then mostly deaerated, drops to the surface where the bubbling steam purges the last of the oxygen. The deaerated water is stored until the boiler calls for water and it is pumped from the bottom of the tank to the boiler.

Important Features:

1) A path in one direction for the steam to carry the oxygen toward the vent, effectively isolating it from the deaerated water.

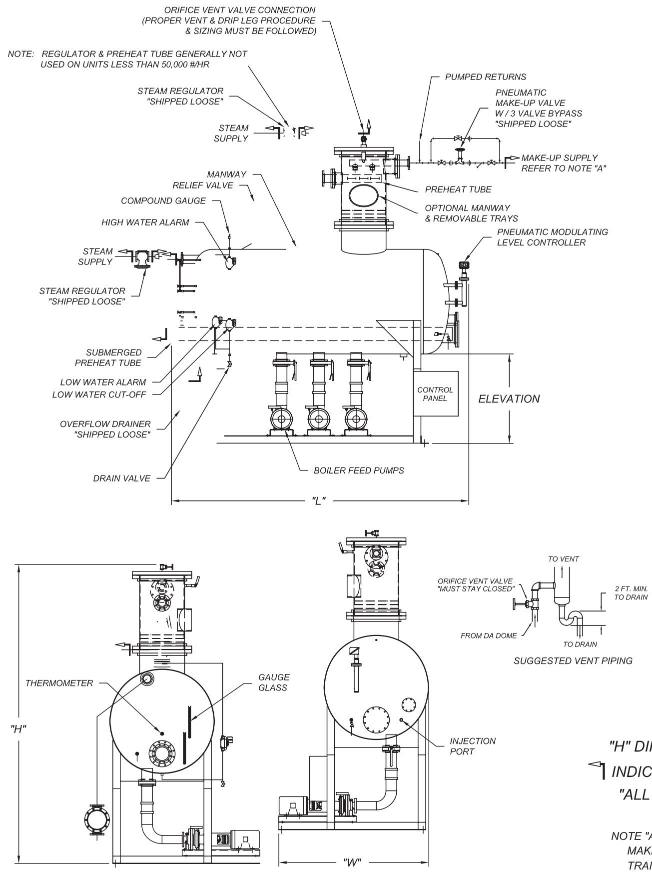
2) Spring-loaded spray nozzles that provide a fine spray at varying flow rates for rapid heating and oxygen removal.

3) A series of baffles further providing for heating of water, condensing of steam, and release of oxygen, as well as providing the one-direction pathway.

4) A steam manifold with narrow slits to provide good distribution of fine steam bubbles to scrub the last of the oxygen from the stored water. It will operate relatively quietly above 160°F.

5) This scrubbing heater (a little above the bottom) assures the pumps are getting the most thoroughly deaerated water in the unit. Since heat rises, steam added at the bottom is more effective in heating the bottom as opposed to adding heat at a higher level. Furthermore, the rising steam bubbles are very effective in carrying any remaining tiny air bubbles to the surface.

6) Noticeably better deaeration can be obtained when flows increase or decrease gradually. Sudden increases and decreases, such as a large on and off flow from a condensate pump, will hinder performance unless a surge tank is used with modulated flows from the surge tank to the deaerator tank. A system with 80% to 100% make-up water



SELECTED CAPACITIES AND OVERALL DIMENSIONS

STANDARD RECEIVER SIZE	NET RECEIVER GALLONS	SYSTEM SIZE based on 10 min. Storage Capacity		APPROXIMATE OVERALL DIMENSIONS		
		Boiler Horsepower	lb/hr Steam	Length	Width	Height
36 x 60	230	350	12,000	110	80	156
36 x 72	257	375	13,000	122	80	156
36 x 84	293	435	15,000	134	80	156
42 x 72	380	580	20,000	126	83	170
42 x 84	438	640	22,000	138	83	170
42 x 96	482	695	24,000	150	83	170
48 x 84	538	810	28,000	142	86	176
48 x 96	594	870	30,000	154	86	176
48 x 120	715	1,045	36,000	178	86	176
54 x 120	987	1,450	50,000	180	90	190
60 x 120	1,273	1,855	64,000	184	92	196
60 x 144	1,479	2,145	74,000	208	92	196
66 x 120	1,641	2,375	82,000	186	95	204
66 x 144	1,907	2,755	95,000	210	95	204
72 x 120	2,036	2,955	102,000	190	108	235
72 x 144	2,375	3,480	120,000	214	108	235
72 x 168	2,675	3,885	134,000	238	108	235
72 x 192	3,000	4,350	150,000	262	108	235
72 x 204	3,250	4,785	165,000	274	108	235
84 x 132	3,134	4,540	157,000	204	114	260
84 x 144	3,365	4,875	168,000	216	114	260
84 x 168	3,828	5,550	190,000	240	114	260
84 x 192	4,285	6,200	215,000	264	114	260
96 x 204	5,686	8,260	285,000	280	120	270
108 x 168	6,446	9,420	325,000	254	126	285
108 x 180	6,830	9,855	340,000	266	126	285
108 x 198	7,396	10,725	370,000	284	126	285
108 x 216	7,986	11,595	400,000	302	126	285
108 x 264	9,430	14,495	500,000	350	126	285

Width dimension may vary based on pump model selection

Height dimension based on 48" elevation

Base footprint is approximate, if smaller footprint desired, consult factory for customization.

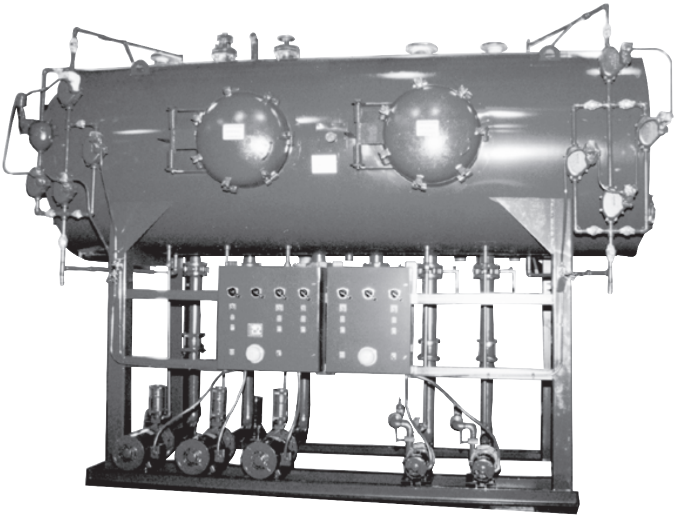
"H" DIMENSION BASED ON 48" ELEVATION

◁┐ INDICATES WHERE SHIPCO PIPING ENDS ┌▷

"ALL DIMENSIONS ARE APPROXIMATE"

NOTE "A"
MAKE-UP CONNECTION IF SINGLE TANK DESIGN
TRANSFER CONNECTION IF TWO TANK DESIGN

.005 DA-STP
.005 DA-STP-2T
PRESSURIZED DESIGN



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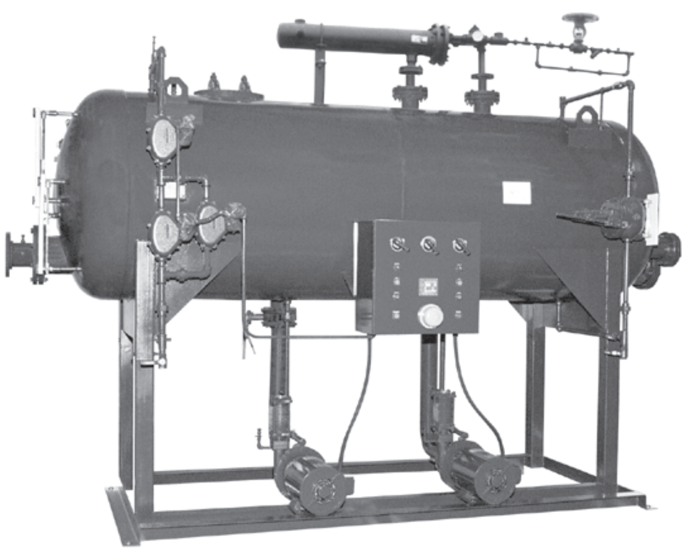

.005 DA-IST