STEAM BOILERS

BY

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October 24, 1989

GENERAL: The problems of a safe and efficient steam generating plant means solving several problems inherent with steam, heat, water, air, and pressure. Water, especially with dissolved air, is aggressive to steel at high temperatures, therefore corrosion is a problem. This is only one of the problems, but each will be dealt with separately.

The top priority in any Boiler installation is SAFETY, therefore common sense, and following code recommendations is a must.

BOILER RATINGS:

1 Boiler Horsepower = 33,600 BTU/Hr.
1 Boiler Horsepower = (approx) 33.5 Pounds/Hour steam
100 BHP = 3350 #/Hr
10,000 #/Hr = 300 BHP

The above ratings are based on feeding the boiler with 212 deg water. Use caution on Process Boilers!!

Each BHP should have approx 5 square feet of heating surface.

NOTE: Boiler may be rated larger than the burner, but never have the burner larger than the boiler!!

Superheated steam--What is it and how do you get it? Used for operating turbines for power generation.

COMPONENTS THAT MAKE UP A STEAM GENERATING SYSTEM:

1. Boilers
2. Boiler safety valves
3. Boiler safety controls
4. Boiler burner
5. Fuels
6. Boiler feed pumps
7. Condensate return system
8. Deaerator
9. Traps
10. Boiler stack
11. Economizer
12. Chemical treatment
13. Boiler blow down
14. Turbulators
15. Fuel handling equipment

BOILER TYPES:

1. Cast Iron Sectional.
2. Fire Tube.
3. Scotch Marine.
4. Water Tube Boilers.

SAFETY VALVES:

1. Size per code.
2. Pipe to outside. Make sure to not reduce the free area.
3. Terminate vertically and use a drain fitting to keep water away from the safety valve.
4. Anchor pipe, as there will be high forces involved.
5. On pressure reducing valves, may use a small and large safety valve to prevent erosion of the large valve.

SAFETY CONTROLS:

1. Low water cut-off.
2. High pressure cut-off.
3. Gas train high and low pressure.
4. Pipe to blow down the sensing lines.

BURNERS:

1. Atmospheric.
2. Power.

FUELS:

1. Gas. Gas train piping. (pipe vent lines)
2. Oil. Fuel Oil Piping
3. Gas-Oil.
4. Heavy Oil. Heating and Piping.

BOILER TYPES:

1. Cast Iron Sectional.
2. Fire Tube.
3. Scotch Marine.
4. Water Tube Boilers.

SAFETY VALVES:

Can combine safety valve piping as long as free area equals both pipes or greater.

1. Size per code.
2. Pipe to outside. Make sure to not reduce the free area.

Use drip pan elbows to prevent water from laying on top of safety valve.

3. Terminate vertically and use a drain fitting to keep water away from the safety valve.
4. Anchor pipe, as there will be high forces involved.
5. On pressure reducing valves, may use a small and large safety valve to prevent erosion of the large valve.

SAFETY CONTROLS:

outlet of relief pipe to point straight up

1. Low water cut-off.

Never want tubes dry and exposed to flame.

2. High pressure cut-off.
3. Gas train high and low pressure. Pressure switch
4. Pipe to blow down the sensing lines.

BURNERS:

1. Atmospheric. Heat goes right up chimney.
2. Power.

FUELS:

1. Gas. Gas train piping. (pipe vent lines) Determined by Users Insurance Co
2. Oil. Fuel Oil Piping Liquids do not burn - have to convert oil to mist or vapor.
3. Gas-Oil.
4. Heavy Oil. Heating and Piping.

Supply and return line for oil. Pump 2-3 times oil needed in order to keep air out.

Factory Mutual
UL

Schools in Illinois are covered by State Code.

Check w/ local utility also for requirements of gas train.

3/96

fuel to heat efficiency

Perfect combination is CO_2 and H_2O vapor.

EFFICIENCIES:

1. Burner Efficiency. CO2-CO-O2-H2O — less O_2 the better

Good boiler 80-85% efficiency

2. Boiler transfer efficiency. Stack temperature. BTU's in to BTU's out

PIPING THE BOILER:

Never 150°F over the medium temp. i.e. steam or water temp.

1. Main Steam Valves.
2. Steam Header.
3. Return Pipe.
4. Condensate Line.
5. Chemical Line.
6. Blowdown.

economizers save 1% efficiency for every 40°F drop in stack Temp.

BLOWDOWN: All steam boilers must have blowdown.

1. Removes Impurities. Surface and Mud Leg.
2. Valving to be two in series. Gate & Quick Opening.
3. Blowdown Tank
4. Continuous Blowdown with preheating.
5. Large Floordrain.

BOILER STACK:

1. Materials steel
2. Location considerations.
3. Thermometer
4. Stack temperatures.

ECONOMIZER:

1. Preheats the boiler feed. Water from boiler feed pump thru economizer to boiler.
2. Lowers stack temperature.

Boiler efficiencies are based upon 212°F water not cold feedwater.

3/96

EFFICIENCIES:

1. Burner Efficiency. CO2-CO-O2-H2O
2. Boiler transfer efficiency. Stack temperature.

CONDENSATE RETURN SYSTEMS:

1. Condensate Receivers.
2. Boiler Feed Systems.
3. Make-up water preheaters.
4. Deaerators.
5. Do not return steam from:
   Autoclaves(sterilizers) or from cooking units.

PIPING THE BOILER:

1. Main Steam Valves.
2. Steam Header.
3. Return Pipe.
4. Condensate Line.
5. Chemical Line.
6. Blowdown.

BLOWDOWN:

1. Removes Impurities. Surface and Mud Leg.
2. Valving to be two in series. Gate & Quick Opening.
3. Blowdown Tank
4. Continuous Blowdown with preheating.
5. Large Floordrain.

TRAPS:

1. Types.
2. Where Used?
3. What Size?

BOILER STACK:

1. Materials
2. Location considerations.
3. Thermometer
4. Stack temperatures.

ECONOMIZER:

1. Preheats the boiler feed.
2. Lowers stack temperature.

CHEMICAL TREATMENT:

1. Boiler Water treatment.
2. Condensate line treatment.

FLASH TANKS:

1. How piped.
2. Economics.

STEAM COILS:

1. Types.
2. Piping.
3. Control.

STEAM CONTROLS:

1. Control Valves. (Strainers on side)
2. Face and By-Pass.
3. Combination.

HUMIDIFIERS:

1. Steam Piping.
2. Controls--use normally closed valve.

NO CONDENSATE RETURN:

1. Cooking kettles and Autoclaves.

BOILER TYPES AND THEIR SELECTION:

Cast Iron Sectional:

Cast Iron sectional boilers are a general use in small systems that range up to 2,000,000 btu/hour. The chief use of these boilers is to replace existing boilers, as they can be assembled in place and do not require a large building opening.

Good points:

Since these boilers are made of Cast Iron, they are not as subject to corrosion as a steel boiler.

Although sold with atmospheric burners, KJWW specifies only power burners unless for small residential uses.

Problems:

Small steaming cavity, therefore good for small closed loop systems only.

Dirty systems cause the boiler to surge.

Maximum pressure on steam is 15 psig.

Fire Box type Boilers:

These boilers are a fire tube boiler and are development of the railroad locomotives. They are very common in schools and hospitals built in the 40's and 50's. Many of these boilers are set on high bases of steel or brick so that they could be coal fired.

Good Points:

Long life expectancy, as it is a steel boiler and can be welded and rewelded forever. Mud legs can be replaced for about $15,000 on a 200 hp boiler.

Due to it's design, any height can be achieved under the boiler for firing various fuels such a coal, sawdust, oat hulls and etc. When using these fuels, specify large flues to prevent clogging. Maybe a soot blowing arrangement is in order.

With the extended base, it is easy to fire coal or sawdust while burning natural gas at the same time. They are used with stokers with a gas burner above the grate.

Has a large water volume and surface area therefore can be used in dirty systems or systems that have a high percentage of make-up water.

Problems:

The design of the "mud legs" create natural pockets for corrosion. Unless maintained exceptionally well, these legs will require replacing every 15 to 20 years.

Maximum pressure for these boilers is approximately 150 psig.

Maximum size is approximately 550 hp. This is due to the transporting problems on a truck.

Subject to thermal shock.

On an existing boiler, if it was designed for coal firing, then turbulators may improve the heat transfer which will improve the efficiency.

Since the bottom of the boiler is firebrick, this must be maintained in good repair. Special care is required to design this base correctly to prevent damage to the boiler room floor.

Typically these boilers are larger in size than the same capacity scotch-marine boiler.

Scotch Marine Boilers:

These boilers, as the name implies, were developed for marine service and then adapted to the building industry. They are fire-tube type boilers and the fuel is burned in the "Morrison" or furnace tube. Since this tube is completely surrounded with water, maximum heat transfer is achieved.

Good Points:

Very compact, as 750 hp boilers can be shipped by truck.

Maximum steam pressure is approx 250 psig.

Good efficiency. Standard is approx 83%.

Not subject to shock as much as other boilers.

Can be fired with gas or light oil. Have problems with heavy oils with some units. Kewanee claims to have a design that will burn coal???

The design is rugged, and many of the waste heat boilers used in incinerator plants are scotch marine type.

Problems:

Maximum steam pressure is 250 psig.

Maximum steam capacity is 750 BHP (25,000 #/Hr)

One piece construction, therefore difficult to get into and out of a boiler room. (Can be cut and rewelded, but is expensive.

Turndown on oil is not too great, but a minor problem.

WATER TUBE BOILERS:

These boilers are designed for high pressure systems. They are used in the generation of electrical power. They are built by using a minimum of 2 drums, the upper steam drum and the lower mud drum. Between these drums are connected the tubes that carry the water and steam.

Good Points:

Good for high pressures up to critical presssures.

Unlimited size.

Can be used to burn any fuel as each is more or less custom designed.

Small units, up to approx 250 BHP, can be packaged.

Can superheat steam.

Problems:

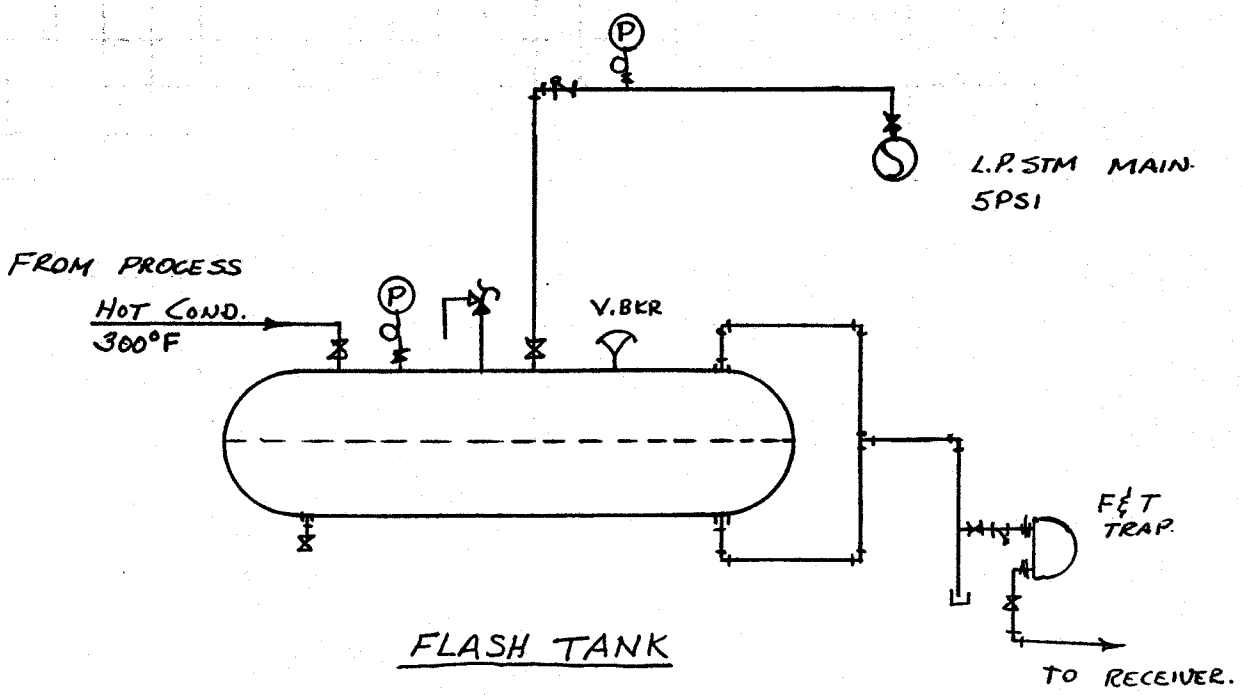
On large field erected units, the labor is expensive.

Small steaming surface, therefore not good to use for process steam.--unless

Water treatment is more critical with these boilers.

KJWW ENGINEERING CONSULTANTS

PROJECT	DATE	BY	PROJECT NO.
STEAM SEMINAR	10-5-89	SCW	30000



FLASH TANK

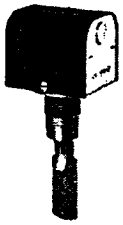
1. ENTERING COND. = 300°
2. LEAVING COND. = 227°
3. EACH # gives UP 300 - 227 = 73°
   = 73 BTU
4. FOR 1000 #/hr of 300° Condensate
   1000 x 73 = 73,000 BTU.
5. 73,000 BTU ÷ 960 BTU/# = 76 #/hr of 5psi Steam. generated.
6. SAVINGS:
   a) Loss of 76 # water/hr (9 gallons)
   b) 73,000 BTU/hr for 8 hours = 5.84 Therms of heat (@ 60¢/therm = $3.50)
   c) Less Chemical Treatment on Boiler.

if the job involves liquid level control, liquid flow or air flow... McDONNELL can help!

McDONNELL Flow Switches for Liquid and Air

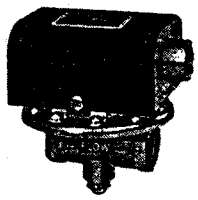
Make or break a circuit with "Flow" or "No Flow" in pipelines and ducts. Over two dozen standard models available to meet almost any job requirement. Below are a few of the many places they are being used as automatic controllers and safety devices:

- Air Conditioning Systems
- Water Supply Systems
- Pump Systems
- Water Cooled Equipment
- Sprinkler Systems
- Water Treatment Systems
- Liquid Transfer Systems
- Duct Heaters
- Exhaust Ventilating Systems
- Make-up Air Systems

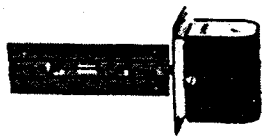


No. FS4-3— Compact, moderately priced, for water service principally. Wetted parts brass and monel.

FS7 Series— For heavier duty service, or process liquids. Standard, vapor-proof or explosion-proof models, with wetted parts either brass or stainless steel.

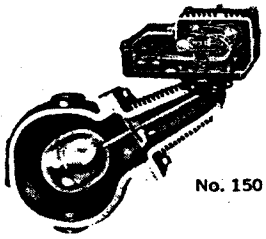


No. FS1— High sensitivity model. Combines response to low flow rates with large flow-through capacity.

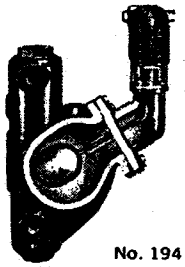


AF1 Series— For use in air ducts. Responds only to velocity of air movement. Full line includes models for low, medium and higher velocity systems.

McDONNELL Pump Controllers and Low Water Cut-offs



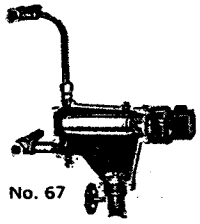
No. 150



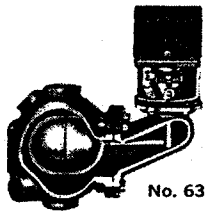
No. 194

These float-actuated switches control the boiler feed pump and provide low water cut-off and alarm. Available for pressures to 250 psi. Choice of mercury switch or magnetic repulsion switch action, round float bowl or integral water column. Used also as float operated switches for high or low level control on tanks and pressure vessels. (For make-up feeders for boiler feed pump systems, see Float-Operated Valves at right.)

McDONNELL Low Water Cut-offs



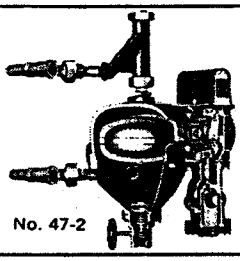
No. 67



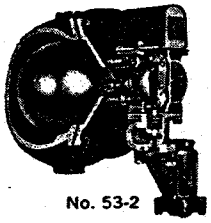
No. 63

These are float-operated controls designed to break the electrical circuit to the boiler firing device in the event of a low water condition. A full line of models is available for both low pressure steam and hot water boilers.

McDONNELL Boiler Water Feeders and Feeder Cut-off Combinations



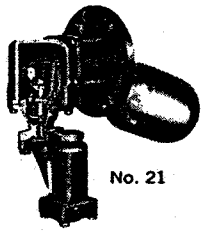
No. 47-2



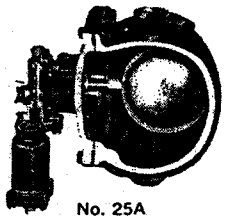
No. 53-2

These controls provide the dual protection of: 1, adding water (mechanically) to maintain a safe minimum water level; and 2, stopping the firing device (electrically) in case of emergency. A complete line is available for most steam and hot water boilers with operating pressures to 75 psi.

McDONNELL Float-operated Valves



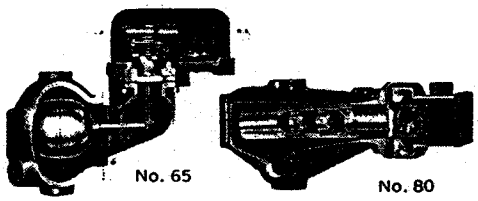
No. 21



No. 25A

Incorporate heavy duty design for use on condensate receivers as well as other tanks and vessels. Several models are available, for either flange mounting or external hook-up. (Ideal for use as Make-up Water Feeders, in systems with Pump Controllers shown at left.)

McDONNELL Float-operated Switches



No. 65 No. 80

Designed to make or break a circuit with rising or falling level in tanks or vessels. Explosion-proof 65 Series for use in Class 1, Groups C and D; Class 2, Groups E, F & G atmospheres. Vapor-proof 165 Series for use out-of-doors. No. 80 for use on oil storage tanks.

McDONNELL & MILLER
3500 N. Spaulding Ave., Chicago, Ill. 60618
Telephone: (312) 267-1600 Telex: 25-3378
FLUID HANDL... DIVISION
INTERNATIONAL TELEPHONE...

Bulletin No. B-232

2-10

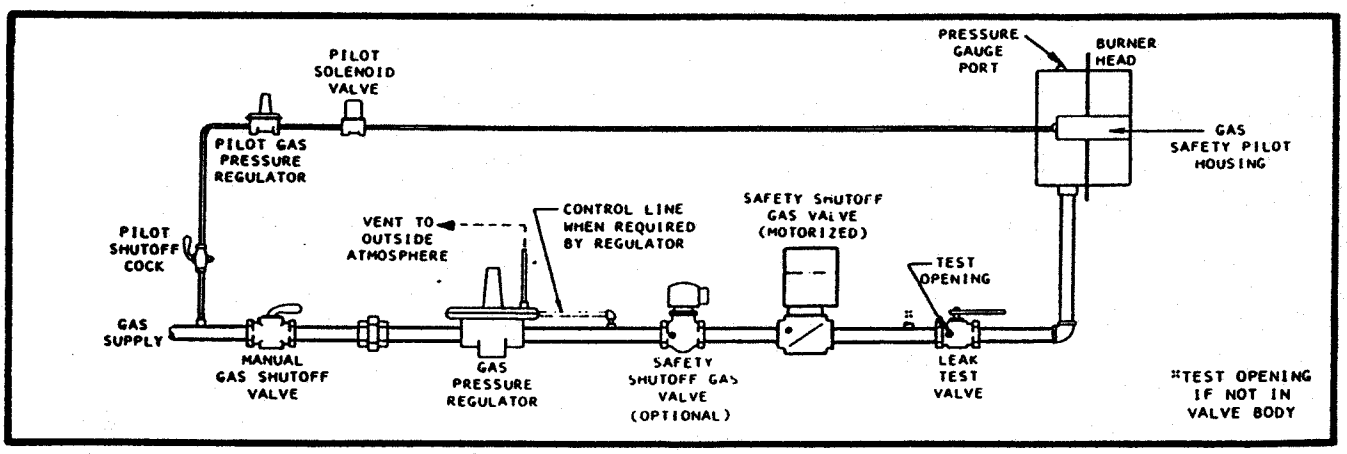
UL/FM Systems

Input Range 400mbh - 2499mbh

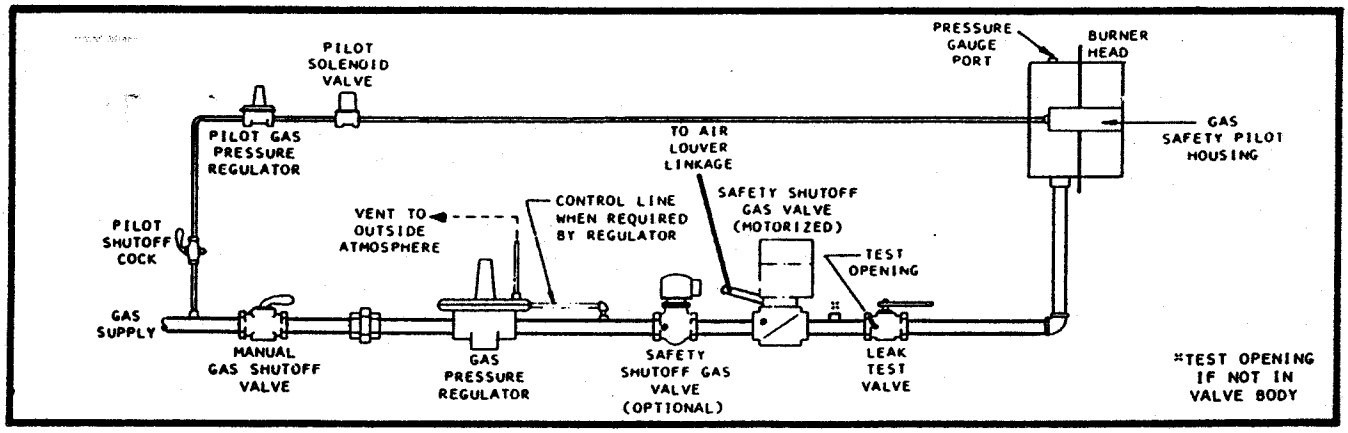
The following systems which meet or exceed FM within this range are required.

NOTE Gas trains shown are for FM "Low Risk" below 50 boiler HP (2499 MBH). For FM "High Risk", use gas trains shown for 2500-5000 MBH input range.

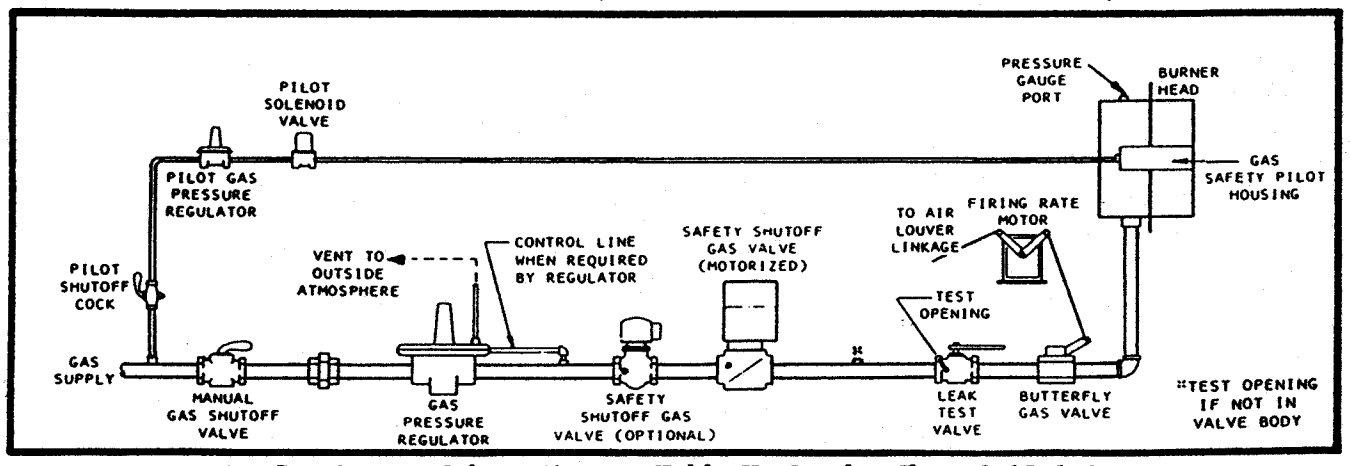
System Designation	Combustion System Function
B	On-Off, Fixed Air and Fuel
H	On-Off or High-Low, Low Fire Start
E2	Modulating, Proven Low Fire Start



"B" Gas System Schematic (see Table II, Catalog Sheet 6-15-1.1)



"H" Gas System Schematic (see Table II, Catalog Sheet 6-15-1.1)



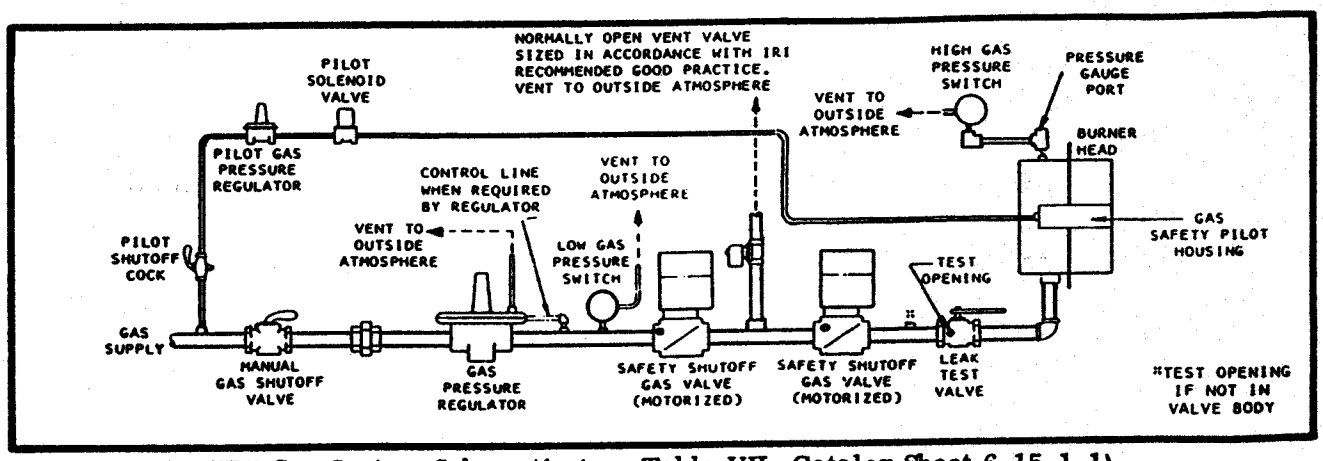
"E" Gas System Schematic (see Table II, Catalog Sheet 6-15-1.1)

UL/IRI Systems

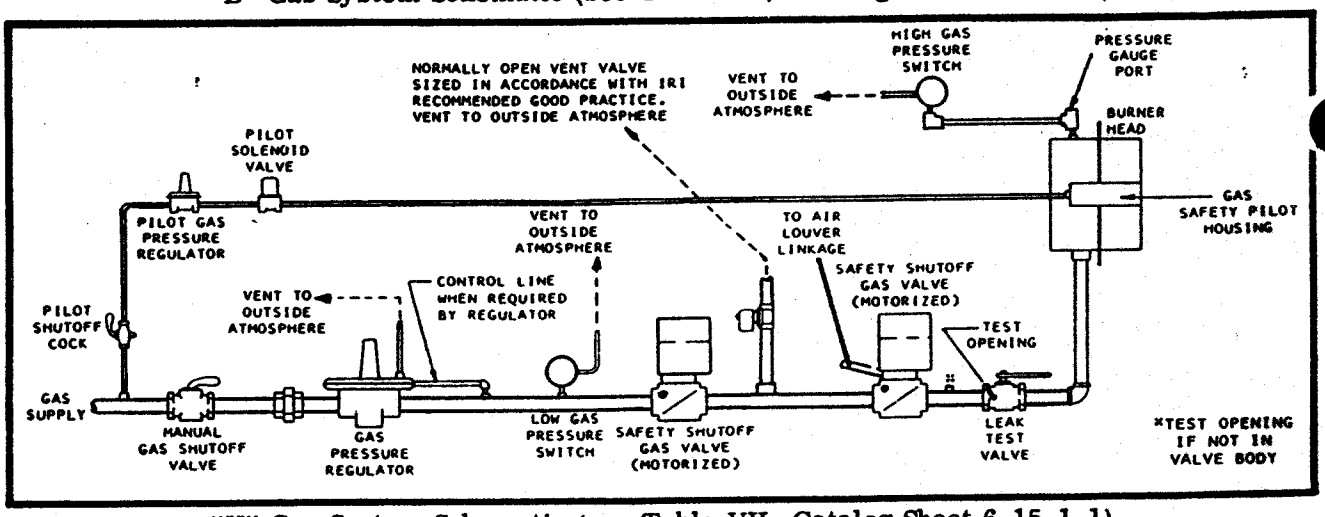
Input Range 400mbh - 2500mbh

The following systems which meet or exceed IRI within this range are required.

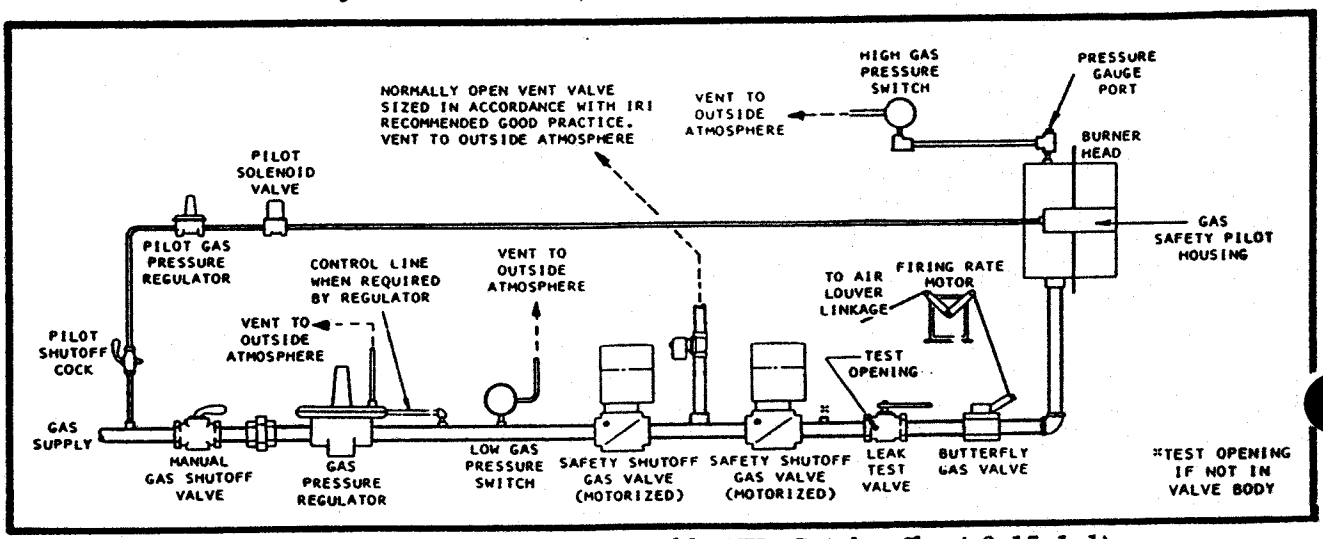
System Designation	Combustion System Function
B	On-Off, Fixed Air and Fuel
H	On-Off or High-Low, Low Fire Start
E2	Modulating, Proven Low Fire Start



"B" Gas System Schematic (see Table VII, Catalog Sheet 6-15-1.1)



"H" Gas System Schematic (see Table VII, Catalog Sheet 6-15-1.1)



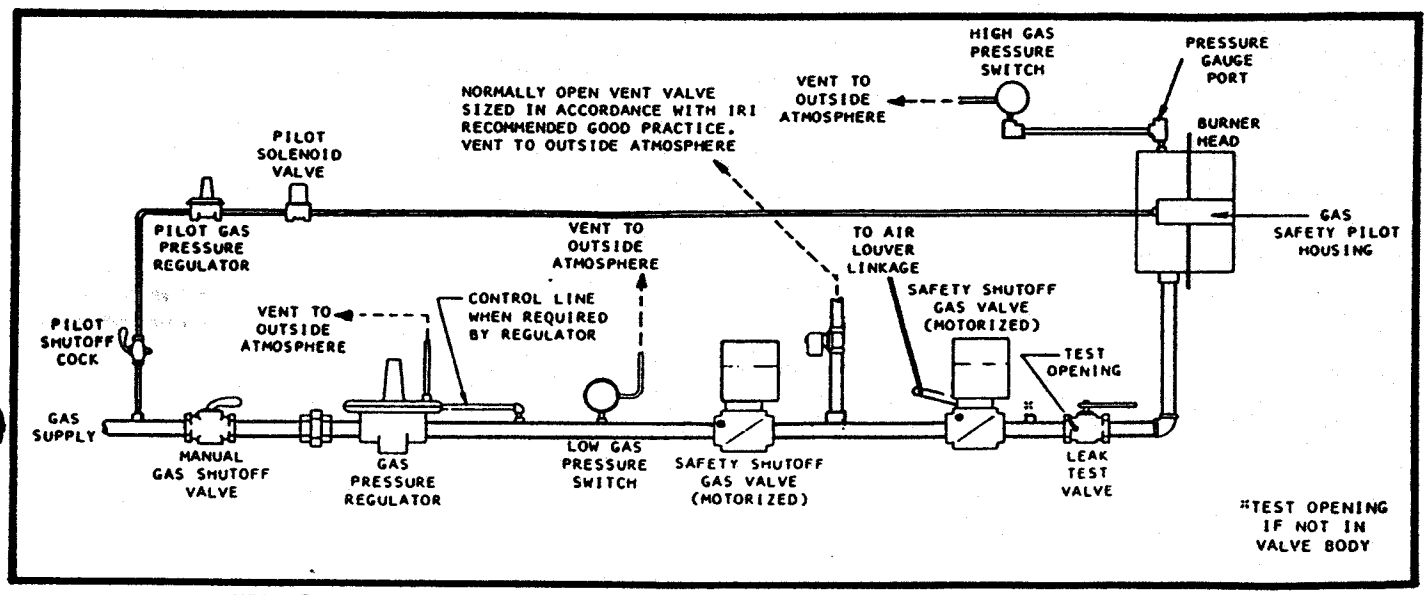
"E" Gas System Schematic (see Table VII, Catalog Sheet 6-15-1.1)

UL/IRI Systems

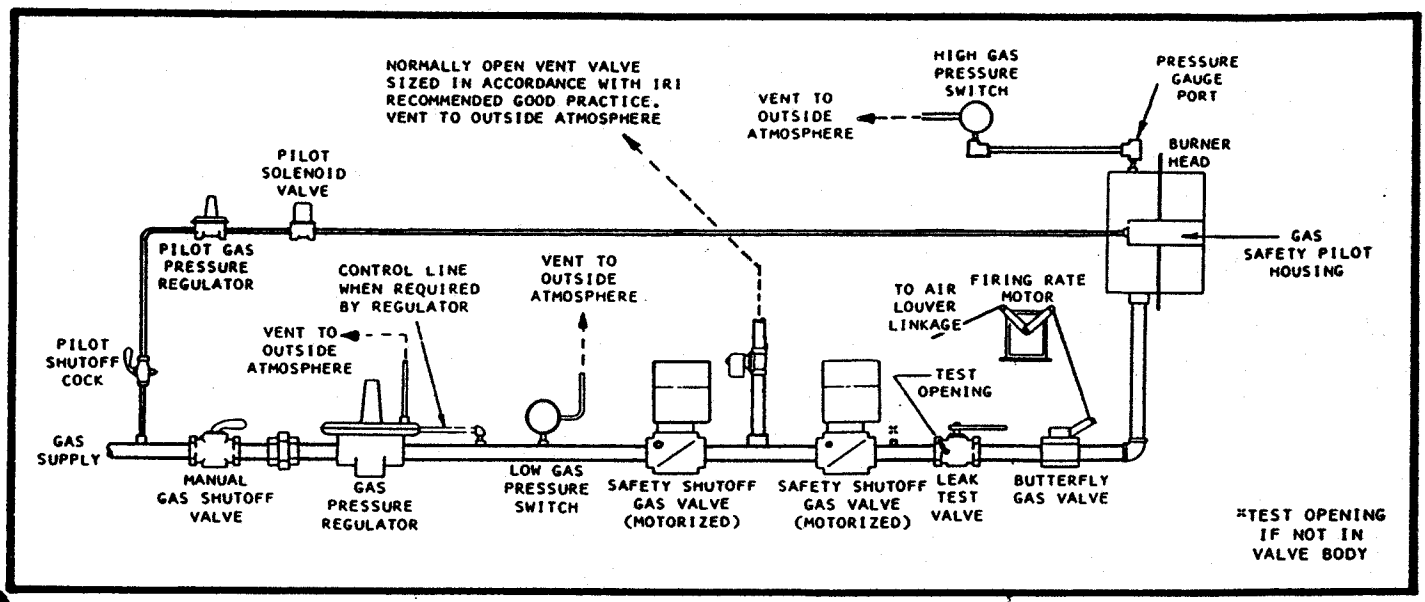
Input Range 2501mbh - 5000mbh

The following systems which meet or exceed IRI within this range are required.

System Designation	Combustion System Function
H	On-Off
E2	Modulating, Proven Low Fire Start



"H" Gas System Schematic (see Table VII, Catalog Sheet 6-15-1.1)



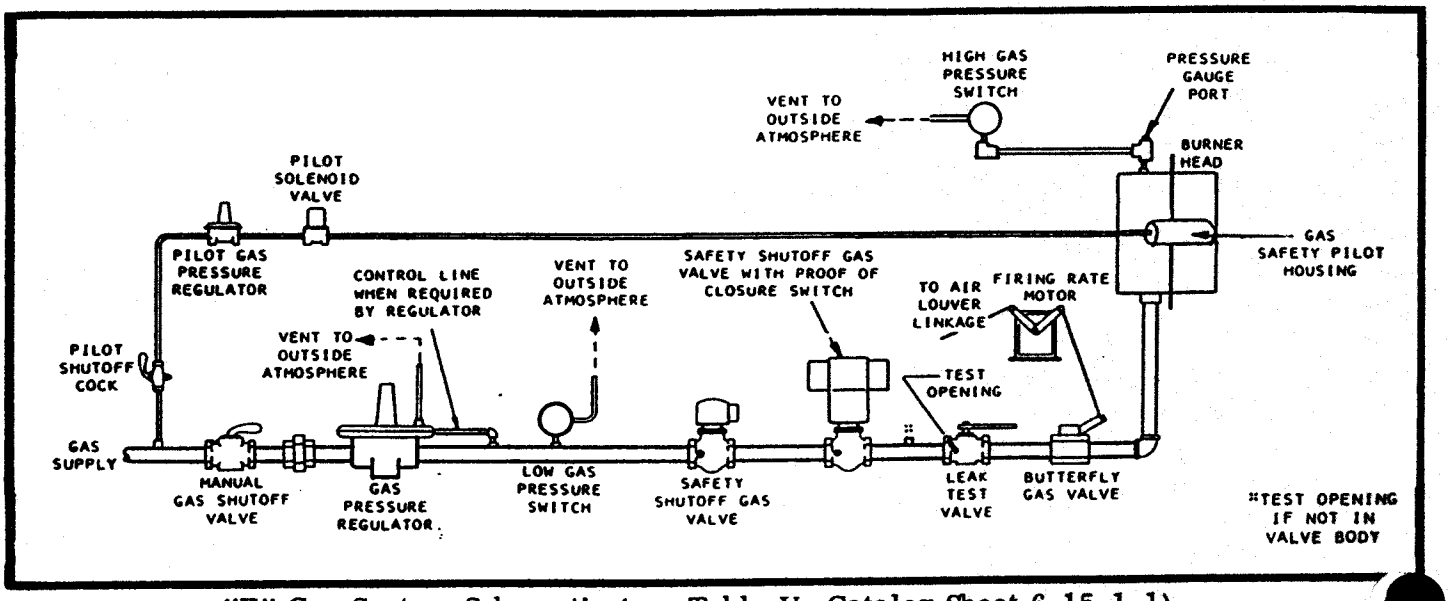
"E" Gas System Schematic (see Table VII, Catalog Sheet 6-15-1.1)

UL/FM Systems

Input Range 5001mbh - 12500mbh

High-low or modulating "E" gas systems which meet or exceed FM within this range are required.

System Designation	Combustion System Function
E2	Modulating, Proven Low Fire Start

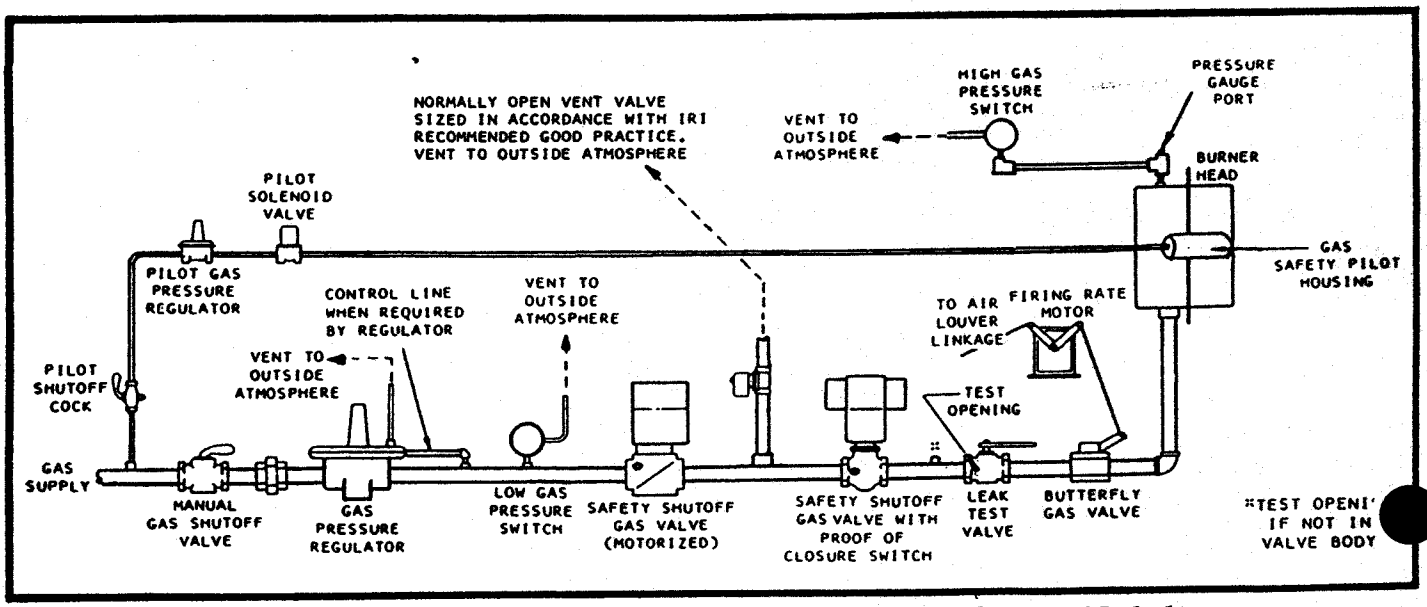


"E" Gas System Schematic (see Table V, Catalog Sheet 6-15-1.1)

UL/IRI Systems

Modulating "E" gas systems which meet or exceed IRI within this range are required.

System Designation	Combustion System Function
E2	Modulating, Proven Low Fire Start



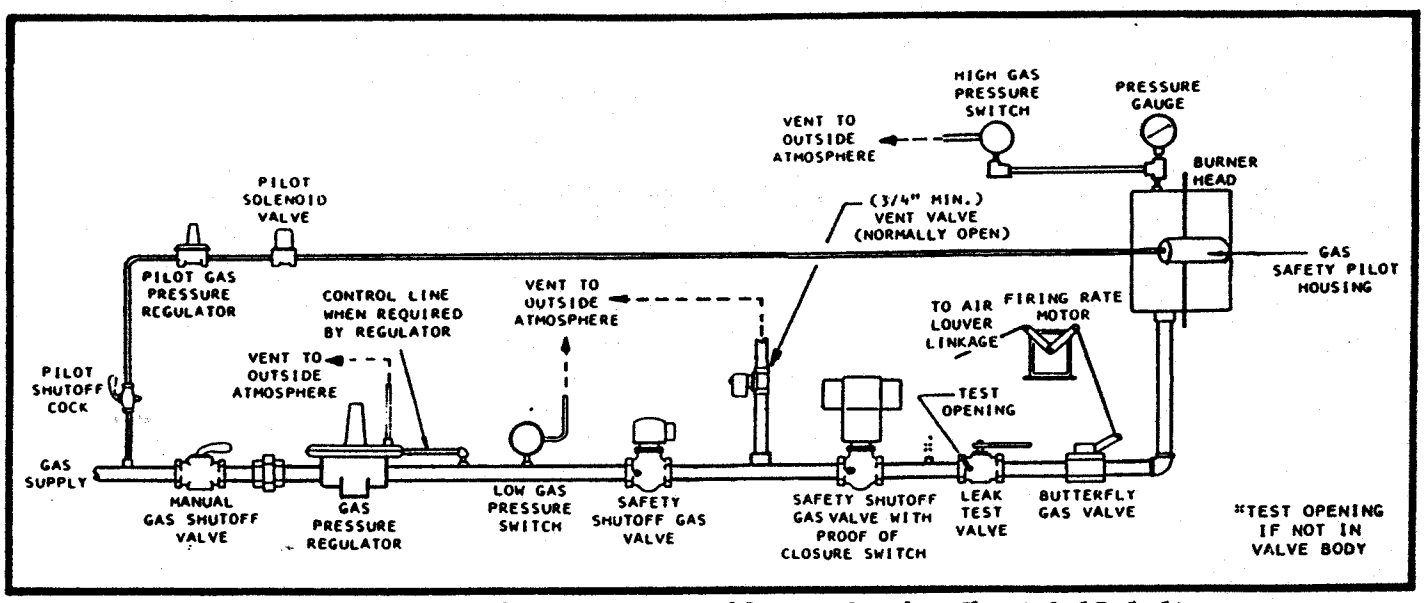
"E" Gas System Schematic (see Table VIII, Catalog Sheet 6-15-1.1)

UL/FM Systems

Input Range 1250lmbh and above

Modulating "E" gas systems which meet or exceed FM within this range are required.

System Designation	Combustion System Function
E2	Modulating, Proven Low Fire Start

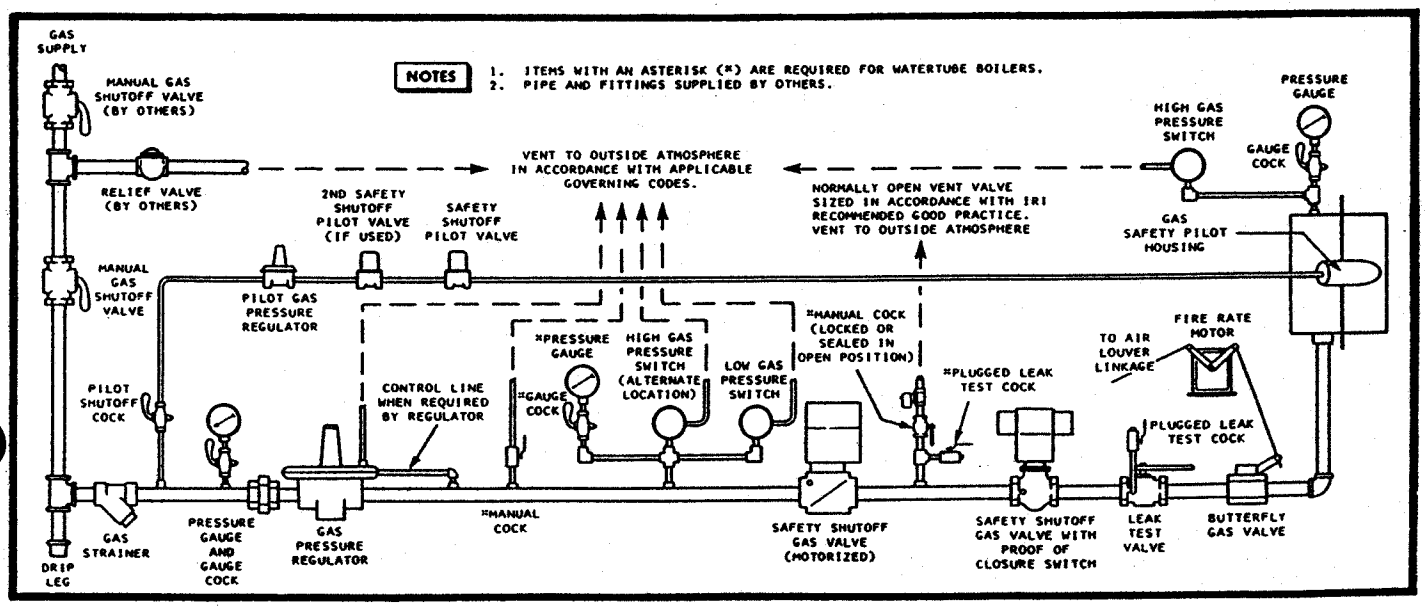


"E" Gas System Schematic (see Table VI, Catalog Sheet 6-15-1.1)

UL/IRI Systems

Modulating "E" gas systems which meet or exceed IRI within this range are required.

System Designation	Combustion System Function
E2	Modulating, Proven Low Fire Start



"E" Gas System Schematic (see Table VIII, Catalog Sheet 6-15-1.1)

KUNKLE
CAST IRON Accessories

FIGURE 299

DRIP PAN ELBOWS

The illustration below shows Kunkle discharge elbow and drip pan unit attached to Figure 252 safety valve with female NPT outlet. For safety valves with flanged outlets—2" to 6"—use companion flange, short nipple and drip pan elbow, Figure 299, all same size as valve outlet.

8" Elbow has integral 125# ANSI Flange.

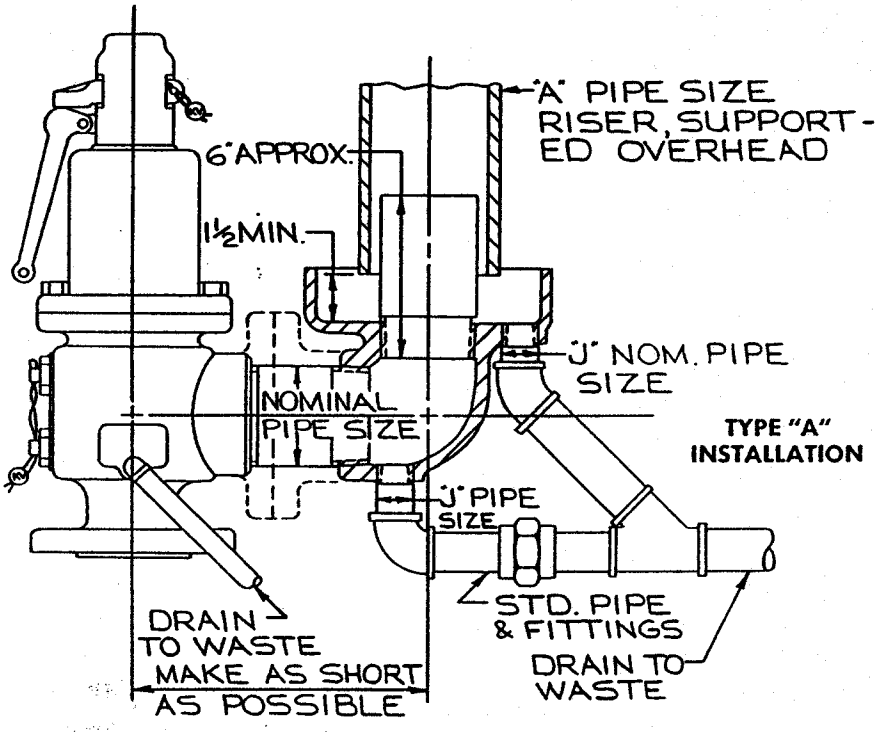
RECOMMENDED INSTALLATION

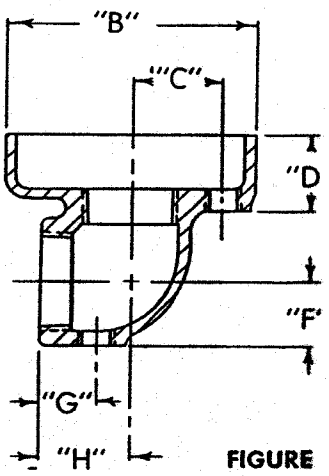
IMPORTANT—Length of discharge piping must be kept to a minimum. For design considerations see articles, "Steam Flow Through Safety Valve Vent Pipes" by H. E. Brandmaier and M. E. Knebel (Dec. 1975) and "Analysis of Power Plant Safety and Relief Valve Vent Stacks" by G. S. Liao (Nov. 1974) available through ASME Publications.

Type "A" installation—for power boilers and unfired pressure vessel service.

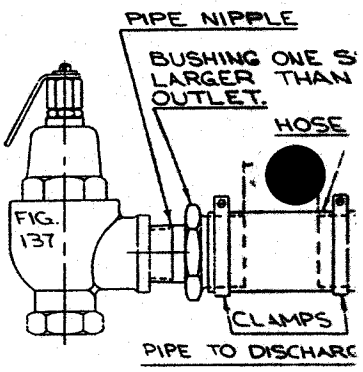
Type "B" installation—for hot water boiler and generator service (160 PSIG/250° F. max.).

Type "C" installation—for low pressure steam boiler service (15 PSIG max.).

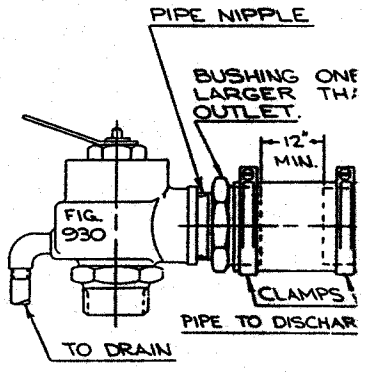




FIGURE



TYPE "B" INSTALLATIO



TYPE "C" INSTALLATIO

DIMENSIONS

Size*	A	B	C	D	E	F	G	H	J	Wt. Lbs.
2"	3	6¼	2⅛	1¾	3⅜	1 11/16	1½	2 ¼	½	6
2½"	3½	7⅜	2¾	2⅜	4⅜	1 15/16	1⅝	2 1/16	¾	10½
3"	4	8	3⅛	2¼	4⅞	2 5/32	1¾	3 ⅛	¾	14
4"	6	9⅝	3¾	2½	5¾	2 ⅞	1¾	3 ¾	¾	26
6"	8	12¾	5⅛	3⅛	7⅛	4 3/16	2⅜	5 ⅛	¾	62
8"	10	16½	6⅜	3¾	9⅛	5 ⅜	7	10 ¾	1	102

* Safety Valve Outlet and Fig. 299 Size.

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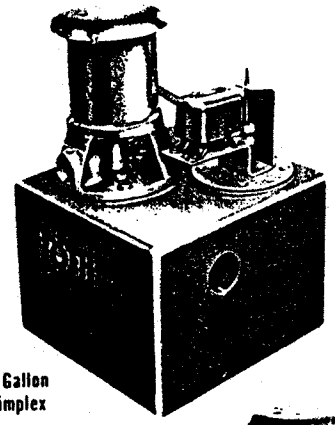
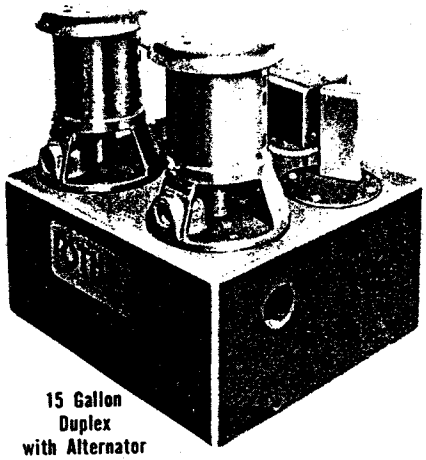


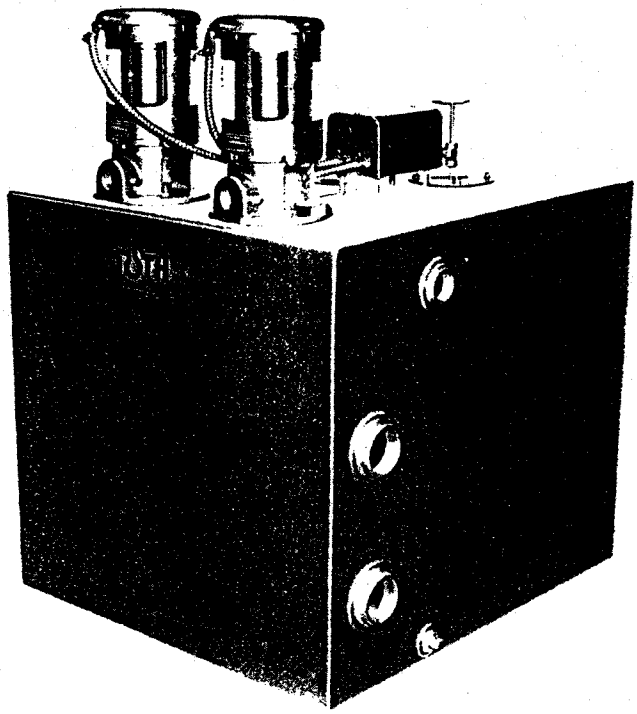
8 Gallon
Simplex

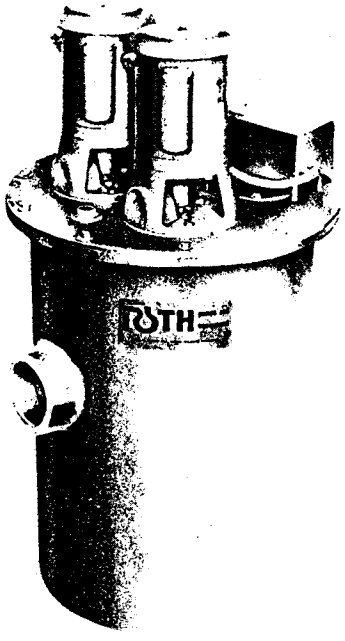


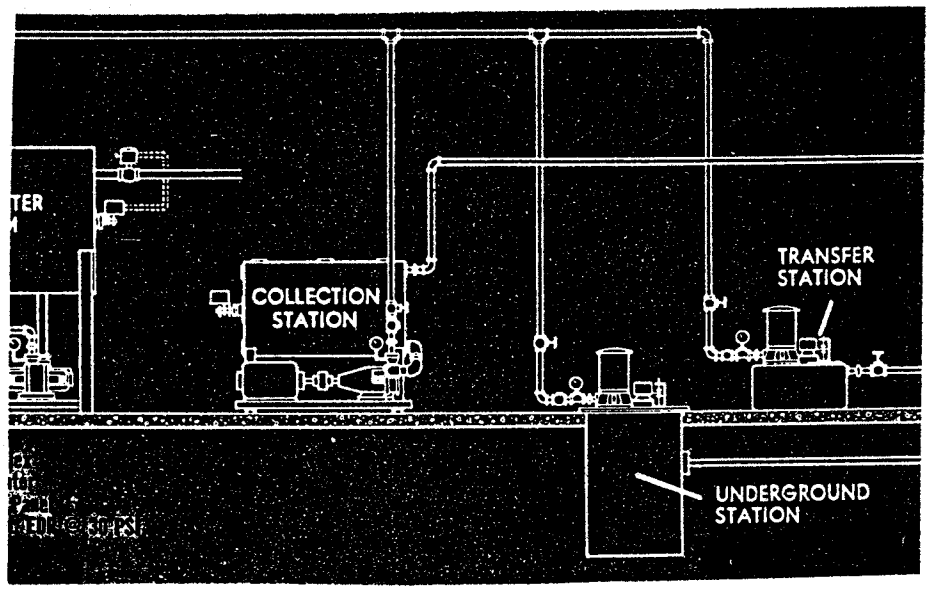
15 Gallon
Duplex
with Alternator

**For peak storage, set float low.
Will not vapor bind at 210°F.**

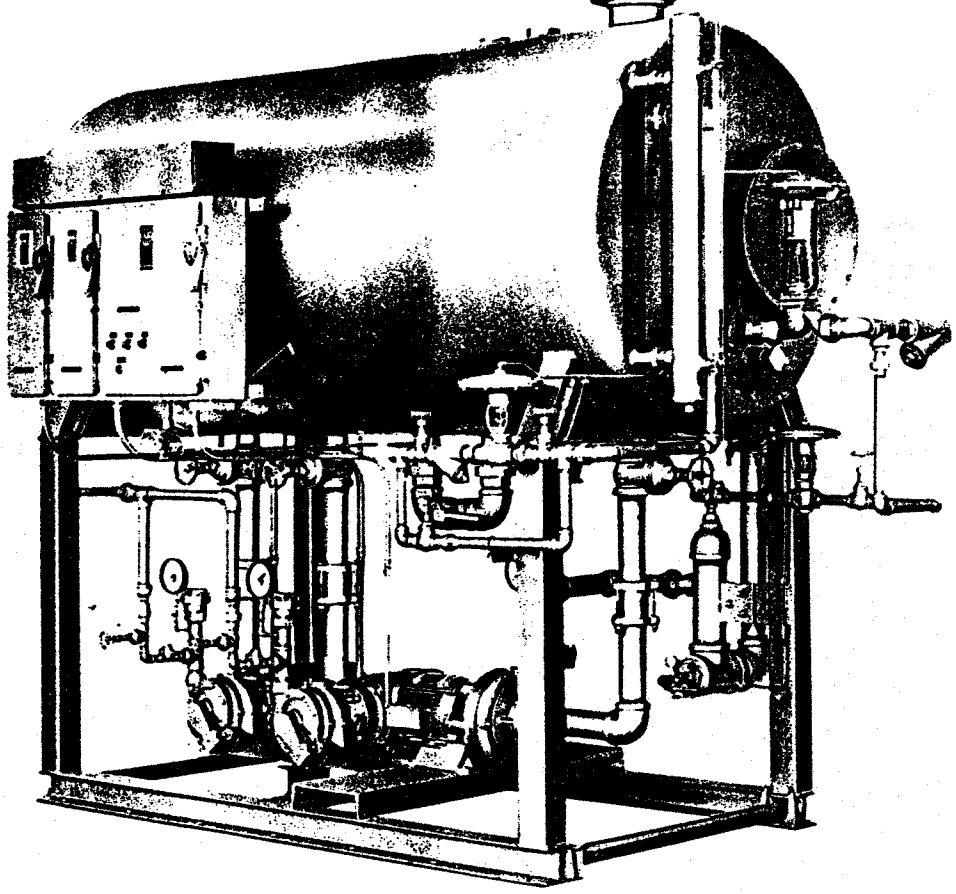
**For high temperature, set float high.
Will not vapor bind at 212°F.**

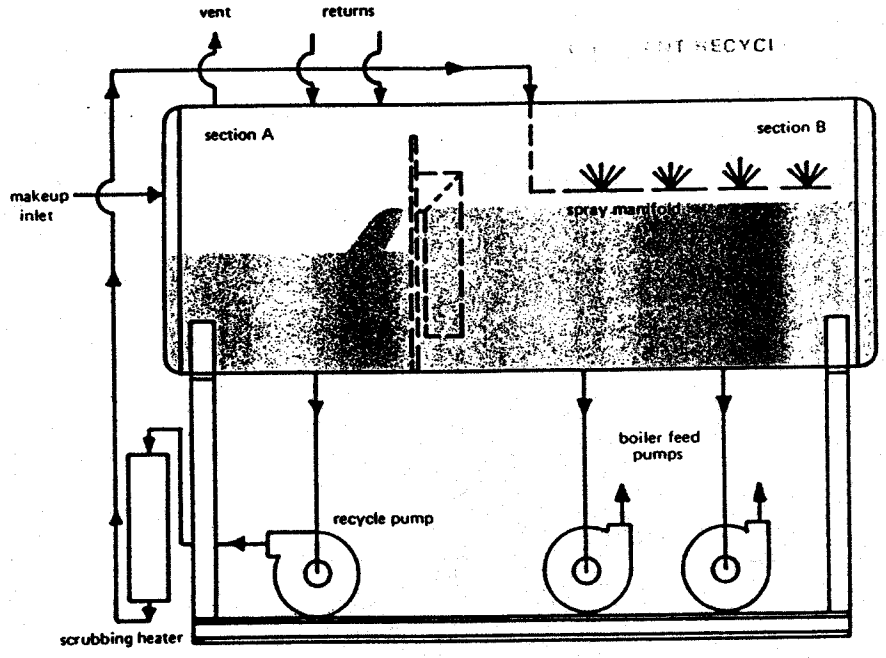






Deaerator



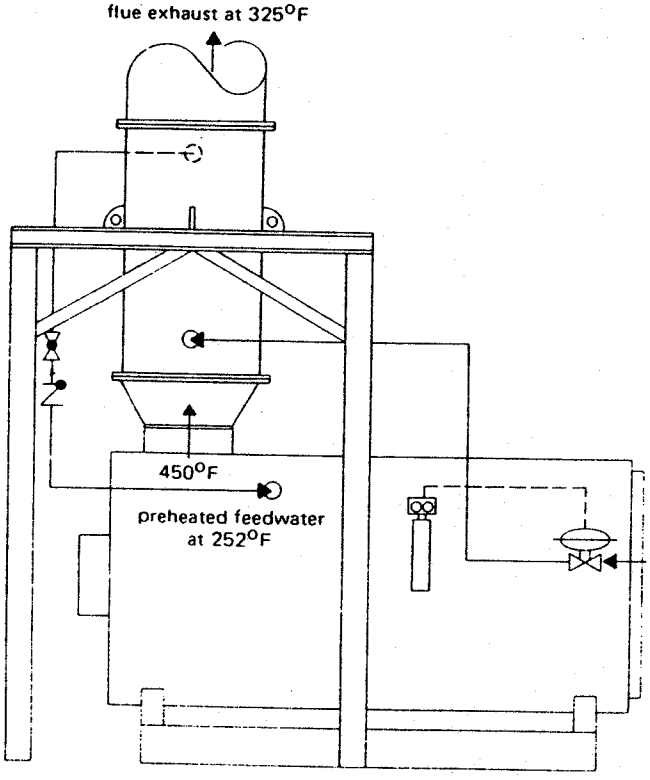

vent
returns
section A
section B
makeup inlet
spray manifold
boiler feed pumps
recycle pump
scrubbing heater

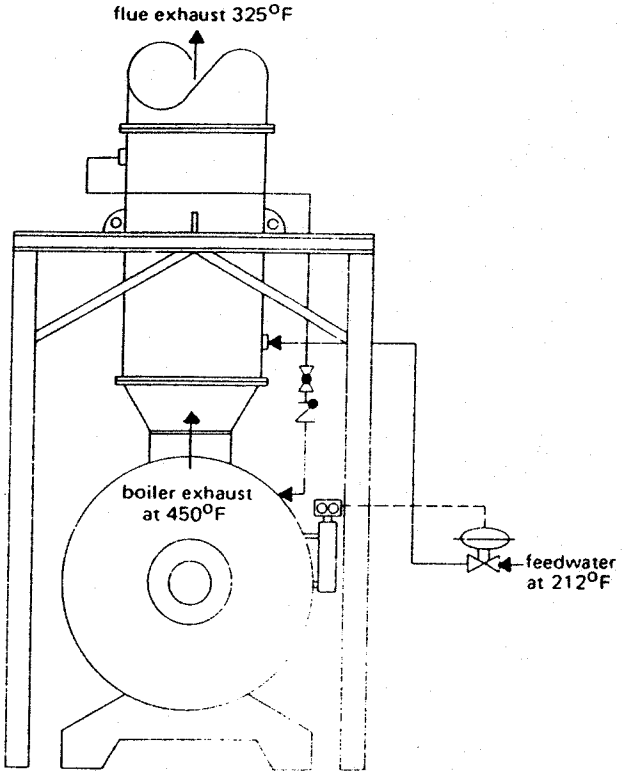
ECONOMIZER

10 to 80[illegible] hp
Firetube or Watertube boilers

SAVES FUEL ... SAVES ENERGY ...

Engineered to efficiently recover invisible heat from boiler flue gases! Designed by the people who lead the way in Hot Water Heat Recovery





STEAM TRAP SELECTION GUIDE

The chart below lists various steam trapping applications and enables the correct choice of trap to be made. The Fig. No. refers to the installation sketches given on pages 10 to 20.

A = First Choice B = Alternate Choice

Application	Spirax Sarco FT Range (Float/ Thermostatic)	Spirax Sarco FT/TV/SLR (Float/Thermo-static with Steam Lock Release)	Spirax Sarco FT/SLR (Float/Steam Lock Release	Spirax Sarco TD Range (Thermo-dynamic)	Spirax Sarco BPT (Balanced Pressure Thermostatic)	Spirax Sarco SM (Bimetallic)	Spirax Sarco Thermoton (Liquid Expansion)	Spirax Sarco IB Range (Inverted Bucket)	Fig. Nos.
CANTEEN EQUIPMENT									
Boiling Pans – Fixed	A	B	B[1]	B[1]	B				17, 18
Boiling Pans – Tilting		A	B		B				19
Boiling Pans – Pedestal	B	B	B[1]		A[2]				
Steaming Ovens					A[2]				
Hot Plates	B	B	B[1]		A[2]				
FUEL OIL HEATING									
Bulk Oil Storage Tanks				A				B[1]	43, 44, 45
Line Heaters	A							B[1]	
Outflow Heaters	A							B[1]	46
Tracer Lines & Jacketed Pipes				B	A[3]	B	B		49, 50, 51
HOSPITAL EQUIPMENT									
Autoclaves and Sterilizers	B	B	B[1]		A			B	16
INDUSTRIAL DRYERS									
Drying Coils (continuous)	A				B	B		B	27
Drying Coils (grid)					B	A		B[1]	28
Drying Cylinders	B	A	B[1]					B[1]	30, 32
Multi Bank Pipe Dryers	A				B			B[1]	29
Multi Cylinder Sizing Machines	B	A	B[1]					B[1]	31
LAUNDRY EQUIPMENT									
Garment Presses	B			A				B	34
Ironers and Calenders	B	A	B[1]	B[1]	B			B[1]	33
Solvent Recovery Units	A			B				B	35
Tumbler Dryers	A	B	B[1]					B[1]	15
PRESSES									
Multi Platen Presses (parallel connections)	B			A				B	39, 40
Multi Platen Presses (series connections)				A[1]				B[1]	41
Tire Molds	B			A	B			B	42
PROCESS EQUIPMENT									
Boiling Pans – Fixed	A	B	B[1]	B[1]	B				17, 18
Boiling Pans – Tilting		A	B						19
Brewing Coppers	A	B	B[1]					B[1]	26
Digesters	A			B[1]				B[1]	22
Evaporators	A	B	B[1]					B[1]	25
Hot Tables				B	A				23
Retorts	A							B[1]	20, 21
Bulk Storage Tanks				A[1]				B[1]	43
Vulcanizers	B			A				B[1]	24
SPACE HEATING EQUIPMENT									
Shell & Tube Heat Exchangers	A	B	B[1]					B[1]	8
Heating Coils	A	B	B[1]					B[1]	13, 14, 15
Radiant Panels & Strips	A	B	B[1]	B[1]				B[1]	10
Radiators & Convection Cabinet Heaters	B				A	B			9
Overhead Pipe Coils	B				A			B[1]	11, 12
STEAM MAINS									
Horizontal Runs	B			A	B[2]			B	5
Separators	A			B	B[2]			B	4, 7
Terminal Ends	B			A[1]	B[2]			B[1]	6
Shut Down Drain (Frost Protection)					B[3]		A		
TANKS AND VATS									
Process Vats (Rising Discharge Pipe)	B			A	B			B	36
Process Vats (Discharge Pipe at Base)	A			B	B			B	37
Small Coil Heated Tanks (quick boiling)	A				B			B	
Small Coil Heated Tanks (slow boiling)							A		38

1. With air vent in parallel 2. At end of cooling leg Minimum length 3 ft *(1m)* 3. Use special tracing traps which offer fixed temperature discharge option.