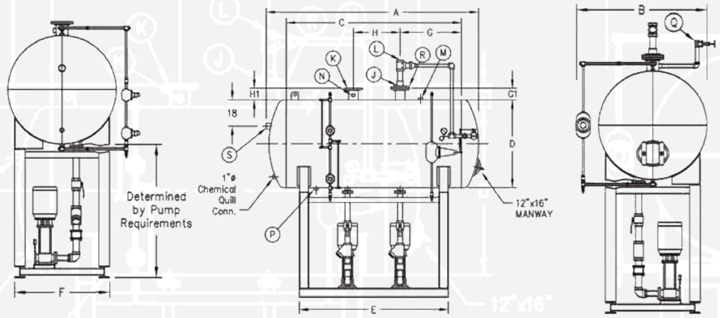
SUPERIOR BOILER

BUILT TO OUTPERFORM

DEAERATOR SYSTEMS

SPRAY SCRUBBER & CUSTOMIZED DUAL COMPARTMENT DEAERATORS

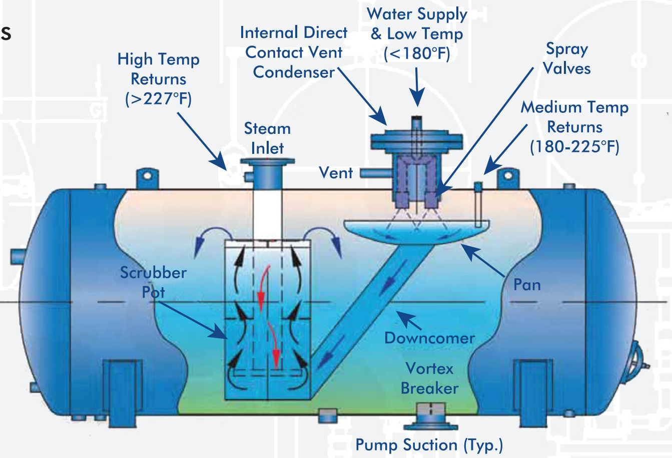
Designed for Maximum Efficiency, Reliability and Durability for Today's Most Demanding Environments.



		SS3.5	SS5	SS7	SS9	SS11	SS14	SS18	SS21	SS24	SS30	SS35	SS40	SS50	SS60	SS70	SS80	SS90	SS100	SS110	SS125	SS150	SS175	SS200	SS225	SS250	SS300
CAPACITY (PPH) X 1000		3.5	5	7	9	11	14	18	21	24	30	35	40	50	60	70	80	90	100	110	125	150	175	200	225	250	300
GALLONS**		150	150	150	180	230	430	430	430	500	675	800	800	1020	1230	1450	1620	1950	1950	2225	2750	3300	3550	4400	4600	5225	6100
STORAGE(MIN)		21	15	10.5	10	10	15	12	10	10	11	11	10	10	10	10	10	10.5	10	10	11	11	10	11	10	10	10
OVERALLS:																											
LENGTH	A	81	81	81	93	117	99	99	99	111	147	105	105	129	153	123	135	159	159	183	165	189	201	237	195	219	243
WIDTH	B	51	51	51	51	51	63	63	63	63	63	75	75	75	75	87	87	87	87	87	99	99	99	84	111	111	111
DIMENSIONS:																											
SHELL LENGTH	C	60	60	60	72	96	72	72	72	84	120	72	72	96	120	84	96	120	120	144	120	144	156	192	144	168	192
SHELL DIAMETER	D	36	36	36	36	36	48	48	48	48	48	60	60	60	60	72	72	72	72	72	84	84	84	84	96	96	96
BASE LENGTH	E	50	50	50	62	86	62	62	62	74	110	62	62	86	110	74	86	110	110	134	110	134	146	182	134	158	182
BASE WIDTH	F	36	36	36	36	36	48	48	48	48	48	60	60	60	60	72	72	72	72	72	84	84	84	84	96	96	96
WATER INLET	G	15	15	15	22	19	22	22	32	24	22	25	26	22	24	32	32	32	32	32	32	29	32	32	34	36	36
	GI	8	8	8	8	8	8	8	8	8	8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
STEAM INLET	H	21	21	21	21	32	32	32	32	32	32	32	32	36	36	36	36	36	36	36	36	46	46	46	46	46	46
	HI	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	12	12	12	12	12	12
CONNECTIONS:*																											
WATER INLET	J	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3	4	4	4	4	6	6	6	6	6	8
STEAM INLET	K	3	3	3	3	4	6	6	6	6	6	8	8	8	8	8	10	10	10	10	10	12	14	14	16	16	16
TEMP RETURN																											
LOW (<180°F)	L	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3	4	4	4	4	6	6	6	6	6	8
MED (180°-227°F)	M	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	4	4	6	6
HIGH (>227°F)	N	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	4	4	6	6
DRAIN	P	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3
MANUAL VENT	Q	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3
VENT CONDENSER																											
(FLG. SIZE)	R	3	3	3	3	3	6	6	6	6	6	12	12	12	12	12	12	12	12	12	14	16	24	24	30	30	36
OVERFLOW	S	1 1/2	1 1/2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	6	6	6	6	6	6

*Up to 300,000 lbs./hr. Oxygen removal in excess of .005 cc/liter. **Larger capacities available upon request.

+ Most economical deaerator system for nearly steady loads
+ Two stage design water is sprayed onto a pan to preheat inlet water and provide partial deaeration, followed by the second stage where the water is forced into the scrubber pot to remove oxygen to .005 cc/liter
+ Custom configurations including: standard dual compartment with attached surge tank, and piggy-back style with surge tank below
+ Available with a stainless steel surge tank or liner
+ Nema 4 single point UL Listed Industrial Enclosure
+ Sizes available up to 500,000 pph



SUPERIOR BOILER

Superior Boiler leads the way in the design and manufacture of industrial and commercial boilers for all market segments. With over 100 years' experience in the industry, our customers don't just trust what we build, they trust the people who build them. Complete boiler systems built to exacting standards, ***made in the USA***, and installed throughout the world.

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ABMA LEADERSHIP FOR THE BOILER INDUSTRY

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LIMITED WARRANTY

Superior warrants all equipment manufactured by it and bearing its nameplate to be free from defects in workmanship and material, under normal use and service within one year from the date the equipment is first placed in use for any purpose, temporary or otherwise, or eighteen (18) months from the date of shipment, whichever shall be less. Except where a different expressed written warranty has been issued, no warranty of any kind, express or implied, is extended by Superior to any person or persons other than its direct buyer.

Superior shall have no responsibility for the performance of any product sold by it under conditions varying materially from those under which such product is usually tested under existing industry standards, nor for any damage to the product from abrasion, erosion, corrosion, deterioration or the like due to abnormal temperatures or the influences of foreign matter or energy, nor for the design or operation of any system of which any such product may be made a part or for the suitability of any such product for any particular application. Superior shall not be liable for any cost or expense, including without limitation, labor expense, in connection with the removal or replacement of alleged defective equipment or any part or portion thereof, nor for incidental or consequential damages of any kind. Any substitution of parts not of Superior's manufacture or not authorized by Superior, or any modification, tampering, or manipulation of Superior's product shall void any and all warranties. Alteration of any parts without express written permission of Superior for a purpose other than that intended shall void any and all warranties. Under no circumstances shall Superior's liability exceed the amount paid to Superior for the original equipment.

It is the owner's responsibility to operate the boiler safely and to follow procedures to ensure proper care and maintenance as per the operations and maintenance manual. This warranty is contingent upon proper evidence that the installation is recorded at the factory; is consistent with Manufacturer's design, operation and maintenance recommendations and meets local codes.

The foregoing warranties shall not apply to products or parts not manufactured by Superior.

THIS LIMITED WARRANTY IS GOVERNED BY AND CONSTRUED UNDER THE LAWS OF THE STATE, COUNTRY, JURISDICTION, OR PROVINCE IN WHICH THE PRODUCT WAS ORIGINALLY PURCHASED. THE LIMITED WARRANTY TERMS CONTAINED IN THIS STATEMENT, EXCEPT TO THE EXTENT LAWFULLY PERMITTED, DO NOT EXCLUDE, RESTRICT, OR MODIFY BUT ARE IN ADDITION TO THE MANDATORY STATUTORY RIGHTS APPLICABLE TO THE SALE OF THIS PRODUCT TO THE PURCHASER. OUTSIDE THE UNITED STATES AND TO THE EXTENT SUCH WARRANTIES, TERMS AND CONDITIONS CANNOT BE DISCLAIMED AND ARE PERMITTED BY APPLICABLE LAW, SUPERIOR LIMITS THE DURATION AND REMEDIES OF SUCH WARRANTIES AND CONDITIONS TO EIGHTEEN (18) MONTHS OF SHIPMENT FROM THE FACTORY OR TWELVE (12) MONTHS FROM STARTUP, WHICHEVER COMES FIRST. THIS LIMITED WARRANTY GIVES THE PURCHASER SPECIFIC LEGAL RIGHTS, AND THE PURCHASER MAY HAVE OTHER LEGAL RIGHTS, WHICH MAY VARY BY STATE, COUNTRY, JURISDICTION, OR PROVINCE.

There are no express or implied warranties which extend beyond those contained herein.

NOTE: All new boilers must be boiled out or Superior Boiler will void the warranty.

NOTE: WARRANTY VALIDATION: Field start-up report must be completed, dated, signed, and returned within 15 days of field start-up to Superior Boiler ATTN: Sales Department to validate warranty.

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OPERATION & MAINTENANCE MANUAL
TYPE "SS" "TC" SPRAY & TRAY DEAERATOR

Principles of Deaeration

Corrosion

Corrosion in steam systems is caused mainly by the presence of non-condensable gases, such as oxygen and carbon dioxide, or by low pH value of the water. Levels of pH can be raised, but the gases must be removed mechanically from the system.

The gases common to most natural water supplies, and why they appear there, are as follows:

Oxygen

Oxygen constitutes 21% of the earth's atmosphere. Since most water supplies come in contact with the atmosphere, it is logical therefore, that they contain oxygen. A solution of oxygen in water is very corrosive to metals (iron, steel, galvanized iron and brass) widely used in steam systems. The corrosiveness is increased with the presence of lower values of pH, and higher temperatures. In reality, it is necessary to have oxygen in combination with water to cause corrosion. Dry steam containing oxygen is not corrosive. Since steam, however, is eventually returned to its liquid state and is contaminated with oxygen, this must be removed from the water before steam is produced.

Carbon Dioxide

Free carbon dioxide is found, like oxygen, in most natural water supplies. Unlike oxygen, only very small amounts are picked up from the atmosphere. Decaying organic matter forms most carbon dioxide. The carbon dioxide content of rain water is less than 2 ppm; yet, many water supplies contain between 50 and 300 ppm of free CO_2. This difference is due to decaying organic matter present in these supplies.

When free carbon dioxide comes in contact with certain elements or compounds (limestone, chalk, dolomite, magnesite) a large portion will be converted to bicarbonates, which in the combined form, do not exist as gases. At any given pH value, the amounts of bicarbonate, versus free carbon dioxide present, form an equilibrium. When any two of the three mentioned parameters are known, (namely pH, quantity of bicarbonate, quantity of free carbon dioxide), the third may be calculated.

The fact that severe corrosion occurs in **oxygen-free** condensate return piping substantiates that carbon dioxide is corrosive. It is also an accelerating factor in dissolved oxygen corrosion.

PHYSICAL LAWS

The laws associated with gas removal are presented here to better understand the principles of deaeration and degasification. These apply not to only deaerators, but to all forms of mechanical gas removal.

Boyle's Law

The pressure of gas is inversely proportional to its volume when the quantity and temperature remain constant.

Dalton's Law
The total pressure of a mixture of gases is equal to the sum of the pressures which each gas would exert if it occupied the same volume as the mixture. The total pressure of a gas mixture is the sum of partial pressures of the individual components ($PT = P1 + P2 + P3…$). For example: in a mixture of 75% oxygen and 25% carbon dioxide at 100 psi total pressure, the partial pressure of oxygen would be 75 psi and of carbon dioxide 25 psi.

Henry's Law
The quantity of gas dissolved in a liquid is directly proportional to the pressure of gas upon the liquid, at any given liquid temperature. This applies to the individual components of a gaseous mixture as well as a single gas. The concentration of each component, therefore, is proportional to its own partial pressure, and not the total pressure: for example, if a quantity of a gas is dissolved in a volume of liquid at 50 psi pressure, twice as much will be dissolved if the pressure is doubled.

SUMMARY
The solubility of a gas in a liquid decreases as the temperature of the liquid increases. When the liquid reaches its saturation temperature, all uncombined gases are theoretically insoluble, and may be removed.

Certain gases (carbon dioxide, hydrogen sulfide, and ammonia) partially react and combine with ions in the liquid. To effect their more complete removal, adjustments in pH may be necessary. It is clear that a gas can be removed from water by reducing the partial pressure of that gas in the surrounding atmosphere, regardless of the total pressure on the system. This can be accomplished by diluting the surrounding atmosphere with a scrubbing gas, thereby reducing the concentration of the dissolved gas.

MECHANICS OF DEAERATION

A number of studies indicate that to inhibit corrosion in a steam system, the oxygen content must be limited to a maximum level of .01 ppm (.0075 cc/L). A true deaerator will reduce the oxygen level to the .005 cc/liter level, and carbon dioxide to zero. A further benefit of this process is simultaneous preheating of the feedwater. More rapid removal of gases results when the liquid is sprayed in thin films and then violently scrubbed by the incoming steam.

Based upon the previously stated laws, the modern deaerator evolved. This is considered a two stage device, the preheater and the scrubber. A deaerator consists of a pressure vessel in which water and steam are mixed with controlled velocities. This raises the water temperature, thereby liberating the dissolved, non-condensable gases. The effluent may then be considered free from corrosive gases. Their removal by the deaerator protects the boiler, feed pumps, and the entire feedwater system from the damaging effects of corrosion. This is accomplished by reducing their concentration to an insignificant level. It is essential that the deaerator first heat the feedwater to a temperature corresponding to the operating steam pressure, and then vigorously boil and scrub the heated water with fresh steam. This will carry any traces of oxygen or carbon dioxide to the liquid surface. The partial pressures of the oxygen and carbon dioxide in the steam atmosphere will be maintained as low as possible, particularly at the point where the steam separates from the deaerated water. Non-condensable gases must be evacuated from the deaerator at a rate equal to their liberation. A vent condenser is utilized to concentrate the non-condensables as they leave the vessel and avoid unnecessary steam venting.

OPERATION

Incoming water first enters the deaerator, thru spray valves, into a steam atmosphere in the first stage preheater section. There, the water is heated to within 2 degrees of steam temperature, removing virtually all of the oxygen and free carbon dioxide. This is accomplished by spraying the water through self-adjusting spray valves, designed to produce a uniform, thin, controlled film under all load conditions. These efficient valves assure a constant temperature and uniform gas removal.

From the first stage section, the preheated water, containing minute traces of dissolved gases, flows into the second stage, or deaerator section. This section consists of either a scrubber or, in tray type units, tray assemblies. Here the water is brought into direct contact with an abundance of fresh, gas free steam. The steam enters this stage and is mixed with the preheated water. Very little steam is condensed here, as the incoming preheated water has a temperature approaching that of the steam. The water leaving this stage falls into the storage section where it is ready for use. It is now completely deaerated and heated to the steam temperature corresponding to the pressure within the vessel.

A reduction in temperature and pressure in the vent condenser is created as the entering water condenses the steam atmosphere. This causes a steam flow toward the vent condenser, carrying with it the liberated gases. Here most of the steam is condensed, and the remainder carries the residual gases thru the vent to atmosphere.

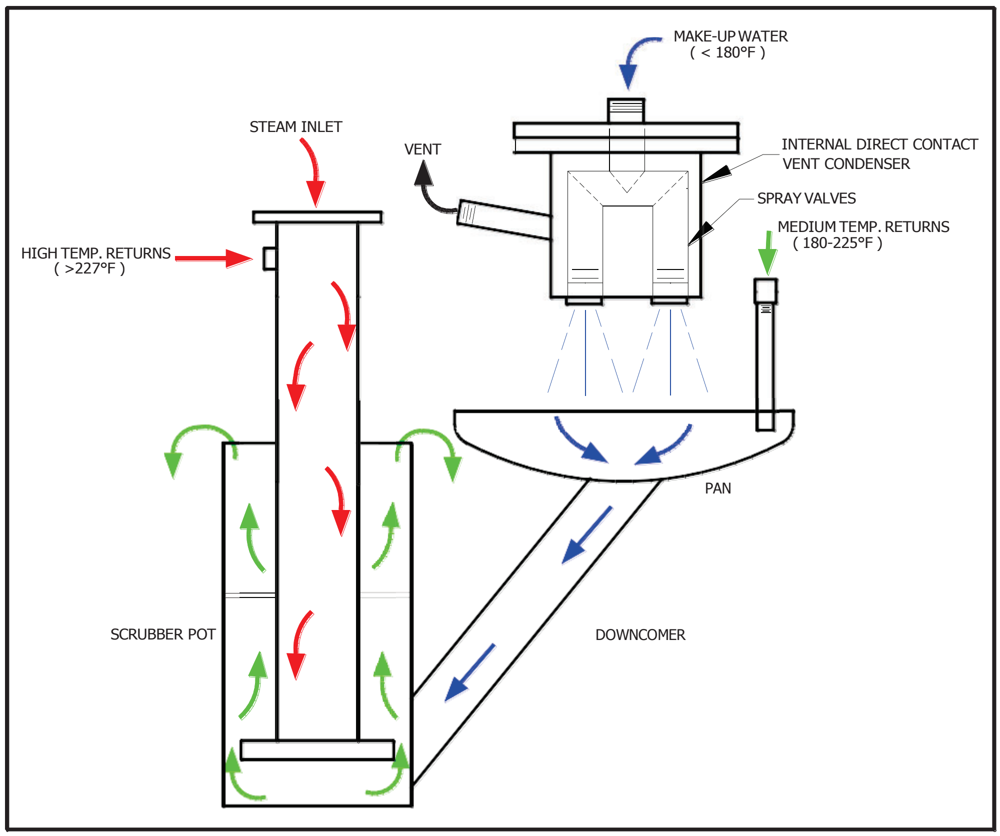


DIAGRAM OF SPRAY DEAERATOR OPERATION

RECEIVING/INSPECTION

This equipment was packed with great care by experienced packers in accordance with Weight and Inspection Bureau specifications. Check ALL equipment immediately upon delivery for shortage or damage and notify carrier promptly. We are **NOT** responsible for damages which occur in transit.

PRE-INSTALLATION ASSEMBLY

Most packaged deaerators will require a certain amount of disassembly at the factory before shipping, to reduce the potential for damaged components. Before the deaerator can be installed, some components will need to be re-assembled. The illustrations and instructions on the following pages are typical in nature, and will serve as a guide to successfully assemble your deaerator. Your deaerator may vary somewhat from the illustrations depending on what options were ordered.

Please refer to the appropriate illustration on the following pages for your equipment (spray, dual compartment spray with surge tank, or tray type deaerator).

All Deaerator Types

1. Position the stand assembly in place on the foundation. Bolt firmly to the foundation.

Note: Once the stand assembly has been positioned and the vessel assembly attached, the assembly cannot be lifted using the loading eyes, as this will place too much strain on the vessel.

2. Lift and set the vessel assembly on top of the stand assembly, lifting at the loading eyes provided on the vessel. Line up matching bolt holes on the top of the stand assembly with mounting holes in the bottom of the vessel saddles. Line up flanges between pump suction piping and vessel flanged connections. Connect mating components using gaskets, bolts, and nuts provided.
3. Reconnect water column/gauge glass piping assemblies at piping unions.
4. Reconnect recirculation piping at unions (if supplied).
5. Install safety valve.

Note: Piping assembly ends will be tagged with letters starting with "A." Find the corresponding tag and letter indicating where the piping assembly will connect to the deaerator. For example: "A" will connect to "A," "B" will connect to "B," etc.

6. Reconnect electrical conduit to water level alarm switches, and water level controls (if equipped with electrically operated controls). Make sure conduits are securely fastened, and abrasion bushings are installed in the conduit ends. Reconnect wiring as per notes on the tags supplied by the factory. Check wiring connections per the wiring diagram supplied in the deaerator control panel.

INSTALLATION

A. Accessibility:

Entire systems should be positioned to permit access to operating controls, instruments, and inspection openings. Additional space should be allotted, if necessary, for platforms and ladders required for otherwise inaccessible areas.

B. Foundations:

Deaerator foundations need not be as massive as those required by rotating or reciprocating machinery. The foundation should be level and designed to support the anticipated load. Calculations should be based upon the maximum, or flooded weight of the entire system including allowances for piping, platforms, stairs, or any other attachments.

C. Rigging:

Qualified riggers should be used to place the system on the foundation. Slings, blocks and all rigging equipment must be carefully placed to avoid damaging or loosening piping, nozzles and other parts of the assembly. The system should be securely bolted to the foundation and shimmed if necessary.

D. Piping:

Prior to piping, a thorough internal inspection should be made. All foreign material or debris must be removed to prevent possible malfunctions. Care should be taken to avoid imposing any piping strain on the vessel or pumps. Provide expansion joints and suitable independently supported pipe hangers where necessary. Isolating valves should be installed to allow for cleaning or repairs. Valve bypasses are recommended around water inlet and steam pressure reducing valves. Vent piping should be vertical and full-size, avoiding any bends or restrictions. To insure continuous venting, a gate valve is factory installed with a pre-drilled orifice in its disc to prevent complete closure.

The piping of the steam pressure-reducing valve is crucial to the proper operation of the deaerator. In service, a pressure-reducing valve produces a lower pressure at its outlet than at its inlet, creating a high steam velocity across the valve seat. In most reducing valve installations, sonic velocity will occur. The extreme velocities that must exist across reducing valve seats cannot be tolerated in piping upstream or downstream of the valve. Excessive erosion and noise would result. In systems where noise of steam flow would be a consideration, it is common practice to limit velocities to between 4,000 and 6,000 feet per minute. The steam velocity chart on page 10 lists steam capacities in pipes under various pressure and velocity conditions.

E. Water Inlet Valve:

E-1 Valve with integral float chamber -

Install valve sub-assembly as shown on drawing with centerline of float chamber at designated operating level. On systems incorporating two valves, one should be located at the operating level, and the second approximately 2” lower. The primary valve will accommodate average flow requirements, with the secondary unit contributing additional capacity to cover entire operating range of the system.

E-2 Valve with internal float -

Install rotary shaft packing box in opening indicated on drawing. Gaining access to the interior of the vessel through the manhole, securely attach float rod with float to the internal portion of the rotary shaft. Mount balancing lever on external portion of rotary shaft and clamp securely with setscrew. Connect turnbuckle assembly to balancing and valve levers, and adjust counterweight so that float will be half submerged. This position is established when equal force is required to both lift or submerge the float.

E-3 Valve with separate external float operator (mechanical type) -
Install external float operator at operating level as shown on drawing. Connect turnbuckle assembly to float operator arm and valve lever and adjust as described above.

E-4 Valve with external float operator (pneumatic type) -
Install external float operator at operating levels as shown on drawing. Connect pneumatic control tubing between float operator and valve actuator. Adjust actuator as described in instructions accompanying operator and valve assemblies.

F. Overflow Trap:
This should be installed at floor level or as low as possible below the deaerator, for maximum static head, assuring the greatest flow.

G. Insulation:
The deaerator, storage tank, and all equipment carrying hot water or steam should be thoroughly insulated to prevent condensation of steam and loss of heat. Sample connection, thermometer wells and manholes should be left exposed.

DEAERATOR FLOWS

A. Make-Up Water:
Make-up water pressure must be sufficient to overcome the head losses by internal steam pressure, pipe friction, water inlet control and spray valves.

B. Low Temperature Returns:
Condensate returns 30ºF below the deaerator operating temperature, or cooler, should be piped into the opening provided (as shown on drawing) between the water inlet control valve and the spray valve. This permits the water to pass through the complete deaeration cycle; and it is given preference over raw make-up.

C. Medium Temperature Returns:
Returns having a temperature ranging from 30ºF below, up to the deaerator operating temperature should be piped to this opening.

D. High Temperature Returns:
This opening is used for returns having a temperature higher than that of the steam within the deaerator. They enter directly into the steam entrance of the scrubber where they flash to steam and are utilized in the deaeration process.

E. Oil Contaminated Returns:
If exhaust steam comes from reciprocating units such as pumps, engines or compressors, it may contain entrained oil, which must be removed by an oil separator. The oil separator must be of adequate size for maximum steam flow. It should be preceded by a straight pipe equal in length to at least four pipe diameters to prevent turbulence at separator inlet. Connect oil separator drain line to a trap or pipe loop seal.

F. Steam:
Steam is required to heat and deaerate water. Thermodynamic laws determine the quantity of steam necessary for deaeration. In order to accurately calculate the required steam it is necessary to set up a heat balance. The steam consumed by a deaerator consists of that needed to raise the temperature of incoming water to the saturated steam temperature within the vessel, plus carrier steam utilized in venting non-condensables. This quantity is reduced by the introduction of flash steam from high temperature returns. Heat balance calculations should be made using the lowest incoming water temperatures.

The following procedures may be used to calculate steam requirements: "A" and "B" are approximations. "C" is an exact method. Other established procedures are acceptable.

Definitions:

- Q - Total deaerated outlet capacity (#/hr.)
- Qm - Inlet water (under consideration) (#/hr.)
- Qf - Condensate (flashing) (#/hr.)
- P - Steam pressure (psi)
- T1 - Steam temperature (saturated temperature at inlet pressure) (ºF)
- T2 - Water temperature (ºF)
- Hf and Hfg - Enthalpy (at steam pressure, see any steam table) (BTU/Lb.)

Procedures: Sum all of the flows of required steam for inlet water heating and deduct any steam flashed from hot condensate. This sum will be the maximum steam volume required by the deaerator for the load in question. The procedure may be reversed and solved for any amount of make-up required.

A) If the operating steam pressure is between 1 and 5 psig and if the maximum combined inlet water temperature is below 100ºF, the steam required will be one seventh of the outlet flow.

$$\frac{Q\text{ (outlet)}}{7} = \text{steam required}$$

Example: 50,000#/hr. outlet capacity, inlet water entering at 60ºF, deaerator operating at 5 psi;

$$\frac{50{,}000}{7} = 7143\text{#/hr. steam required}$$

B) If the operating pressure is between 1 and 5 psi, and if the inlet water temperature is between 100ºF and 150ºF, the steam required will be one tenth of the outlet flow:

$$\frac{Q\text{ (outlet)}}{10} = \text{steam required}$$

Example: 50,000#/hr. outlet entering at 140ºF, deaerator operating at 5 psi;

$$\frac{50{,}000}{10} = 5{,}000\text{#/hr. steam required}$$

C) Exact Method - perform the following calculations:
With No Flashing condensate

$$\frac{Qm\,(T1 - T2)}{Hfg} = \text{#/hr. steam required}$$

With Flashing Condensate

$$\%\text{ Flash} = \frac{Hf\text{ (higher)} - Hf\text{ (lower)}}{Hfg\text{ (lower)}}$$

$$\%\text{ Flash} \times (Qf) = \text{#/hr. flash steam}$$

$$\frac{Qm\,(T1 - T2)}{Hfg}\ \text{#/hr. flash steam} = \text{#/hr. steam required}$$

ACCESSORIES

A. Relief Valve:

The relief valve furnished is a sentinel type intended to warn of overpressure in the vessel and may not be adequate to fully protect the equipment from excess pressure. Since overpressure in a deaerator is a function of the entire steam system, the user must make suitable provision for sufficient total relieving capacity.

The valve furnished has a hand release lever which should be operated periodically to assure freedom of movement.

B. Vacuum Breaker:

A vacuum breaker is furnished to protect the vessel from external pressure. An open vacuum breaker would indicate an insufficient supply of steam within the deaerator. Operation under this condition will result in oxygen contamination of the stored feed water.

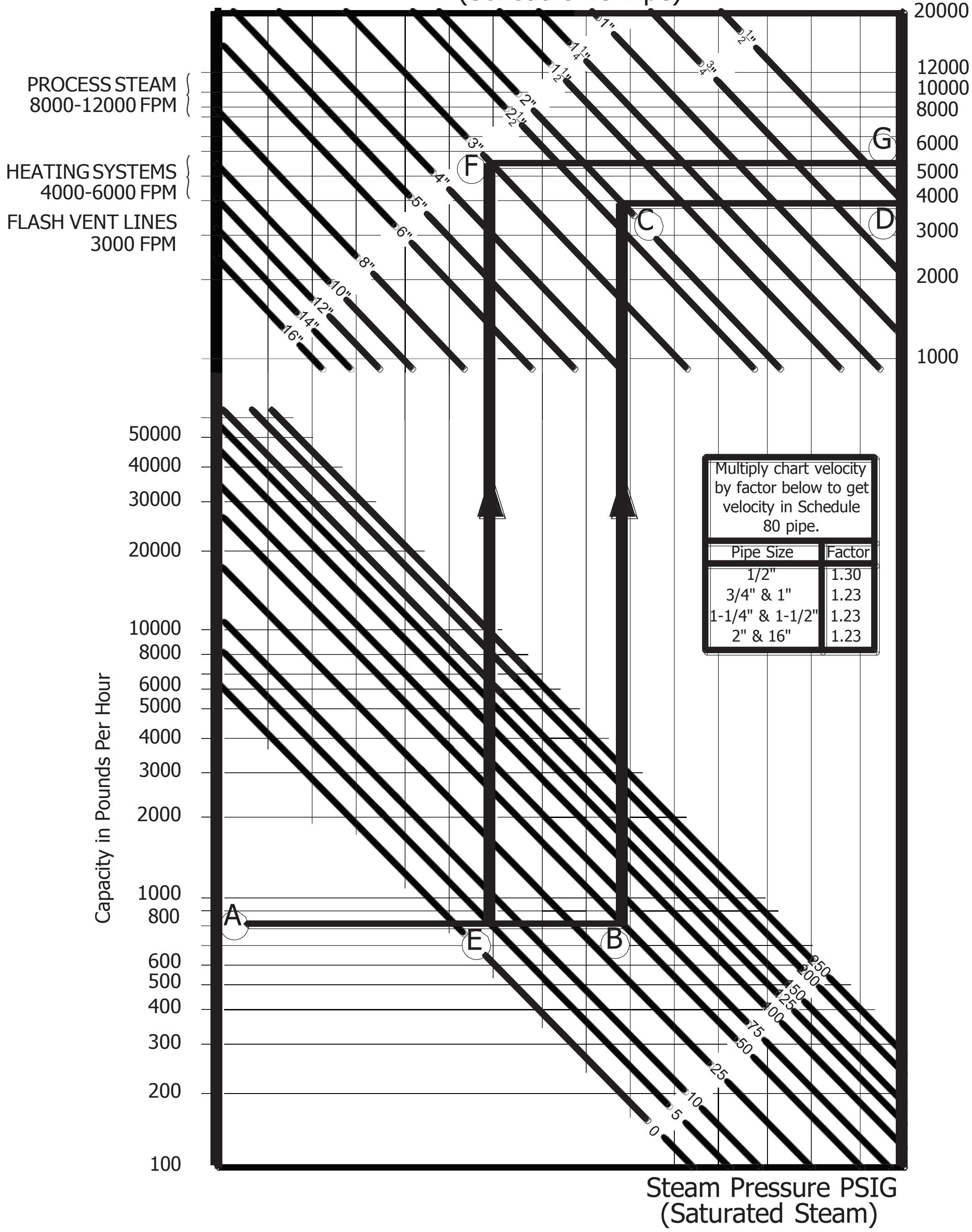
This unit should be checked and cleaned at regular intervals to insure proper operation.

C. Vessel Pressure Gauges:

Pressure gauges are provided for the steam section and water inlet line. Higher or lower pressures than normal alert the operator of a potential problem.

STEAM VELOCITY CHART

(Schedule 40 Pipe)



EXAMPLE: Given a system with 50 psig steam pressure entering the pressure reducing valve, at a flow of 800 lbs/hr of steam and a reduced pressure of 5 psig, find the smallest sizes of upstream and downstream piping for reasonably quiet steam velocities.

UPSTREAM PIPING: Enter the velocity chart at "A" for 800 lbs/hr. Move horizontally to point "B" where the 50 psig diagonal line intersects. Follow up vertically to "C" where an intersection with a diagonal line falls inside the 4,000-6,000 foot/minute velocity band. Actual velocity at "D" is about 4,000 feet/minute for 2" upstream piping.

DOWNSTREAM PIPING: Enter the velocity chart at "A" for 800 lbs/hr. Follow horizontally to point "E" where the 5 psig diagonal line intersects. Move up vertically to "F" where an intersection with a diagonal line falls inside the 4,000-6,000 ft/minute velocity band. Actual velocity at "G" is about 5,500 ft/minute for 3" downstream piping.

SYSTEM START-UP

A. After the equipment has been completely installed, the following procedures should be followed.

A-1 - Inspect all pipe connections to be sure they are correctly and securely connected. Examine all controls and valves to assure that each is operating freely and properly lubricated where necessary.

A-2 - Thoroughly flush vessel and all associated piping until there is no indication of rust or foreign material. Spray valves and vessel nozzles should be freed of all large pieces of mill scale or debris.

A-3 - Ascertain that all instruments and gauges are operating and indicating correctly.

B. Initial start-up, cold (no steam available):

B-1 - Open vent valve completely, exhausting to atmosphere.

B-2 - Close valve between deaerator and feed pump.

B-3 - Admit water to deaerator by opening gate valve in make-up water line. Fill storage section to operating level, as shown on drawing.

B-4 - Open valve in boiler feed pump suction piping.

B-5 - Start boiler feed pump and fill boiler with cold water.

B-6 - Close valve in deaerator make-up water line.

B-7 - Open scrubber drain valve (in systems equipped with scrubber drain) and drain scrubber.

B-8 - Slowly admit steam, when available, to deaerator until normal operating pressure is obtained. Gradually open the manual valve in the make-up water line, admitting water at a rate sufficiently slow to maintain a positive steam pressure in the vessel. This will be evidenced by a continuous escape of steam through the vent. The incoming water should be manually controlled until it reaches a point sufficient for the water inlet float valve to maintain a proper level. At this level, manual control will no longer be necessary, but the float control should be checked for proper operation. Make any adjustments which may be required to maintain specified operating levels.

B-9 - When a considerable volume of steam is issuing from the vent, throttle back the vent valve until only a plume of vapor can be seen. The water temperature at this point should rise to within three degrees of saturation temperature of the steam at the observed deaerator operating pressure. A lower temperature would indicate insulating pockets of air in the vessel. If this occurs, open the vent valve completely for a few seconds to purge this air from the deaerator. Return the vent valve to its original position.

B-10 - Open steam valve fully.

B-11 - When water temperature rises to within two degrees of steam temperature, the system is ready for service. The pump suction valves may be opened and the vent valve should be adjusted in accordance with Paragraph D. During operation, stored water temperature should correspond to that of saturated steam at the deaerator operating pressure.

B-12 - Check all valves and float controls to be sure proper water level is maintained.

B-13 - Some rumbling may occur with a cold tank. This should disappear as temperature levels increase. Entrapped air is another possible source of rumbling; this should be eliminated as described in Paragraph B-9. The deaerator is designed to remove dissolved gases from the water and will not handle entrained air or air trapped in steam or return piping.

B-14 - When proper operating temperature has been achieved, recheck all piping, flange and manhole bolts, etc., for tightness.

C. Initial start-up, hot (steam available):
C-1 - Open vent valve completely, exhausting to atmosphere.

C-2 - Open steam valve slowly, gradually bring deaerator up to operating pressure. If pressure-reducing valve hunts or pulsates, adjust until pressure remains steady.
C-3 - Gradually admit water to deaerator by partially opening the gate valve in the water inlet line. The rates of steam and water flow should be carefully controlled to maintain a positive steam pressure in the vessel. This will be evidenced by a continuous escape of steam through the vent. Water flow should be manually controlled until it reaches a point sufficient for the water inlet float valve to maintain a proper level. At this level, manual control will no longer be necessary, but the float control should be checked for proper operation. Make any adjustments which may be required to maintain specified operating levels.

C-4 - At this stage, refer to Paragraph B, section 9, under "Initial start-up, cold".

D. Venting:
Vent valve is furnished with an orifice in its gate. This orifice is sized for minimum venting. Heavy concentrations of removed gases may require that the valve be opened wider to permit their release to atmosphere. Water temperature lower than that of saturated steam at the deaerator operating pressure would indicate insufficient venting. The vent valve opening should be adjusted accordingly until proper temperature is indicated.

SHUT-DOWN

A. Temporary (overnight, weekend, etc.)
Recommended procedure is to allow deaerated water to remain in storage section while maintaining steam pressure in the vessel. Close water inlet and outlet valves.

B. Long Term Idle Periods:
The deaerator may be shut-down completely with no steam pressure in the unit. Deaerated water may remain in the vessel. Water inlet valve must be closed before eliminating steam pressure. Cold water entering the unit will condense the steam, causing a vacuum condition, which could result in collapse of the vessel.

START-UP AFTER SHUT-DOWN

A. When steam pressure has been maintained in the deaerator during temporary shutdown, it is only necessary to open the water inlet valve and gradually bring flow to required capacity. Recheck adjustments to maintain proper operating levels, and open outlet valve.

B. When steam pressure has not been maintained, first drain scrubber completely, close valve and proceed in accordance with Paragraph B or C, (system start-up) as appropriate.
CAUTION - the above described procedures **must** be followed to prevent oxygen contamination of stored water, water hammer and rumble in the deaerator scrubber section.

OPERATING RECORD

A per shift or per day record of deaerator steam and water pressures, and temperatures should be maintained. Inspection of all gauges and controls for proper operation should be made at the same intervals.

MAINTENANCE

A. Vessel:

A-1 - Bi-weekly
Clean gauge glasses and inspect all controls for proper operation.
Lubricate all moving parts as required.

A-2 - After first month of operation
Check spray valves for foreign matter, which may have accumulated from new piping. Clean if necessary.

A-3 - Semi-Annually
A-3.1 - Inspect spray valves and preheater section for scale or dirt (thin scale formations will not affect efficiency). Remove any accumulation of debris or scale if necessary.
A-3.2 - Clean oil separator trap if employed.
A-3.3 - Inspect relief valve and vacuum breaker for proper operation.

A-4 - Annually
A-4.1 - Drain storage section and remove manhole. Flush out all sediment in storage section and follow with manual cleaning, if necessary. Make certain pump suction openings and piping are clean.
A-4.2 - Inspect scrubber section. Flush out sediment through scrubber drain.
A-4.3 - Carefully inspect all steam and water control devices as well as other accessories. Replace or recondition any parts as required.
A-5 - Check deaerator gauge glasses frequently for the presence of oil. Oil is more damaging than scale in a boiler. If detected, immediate steps must be taken to find its source and eliminate it (Refer to Paragraph C Troubleshooting). After the cause has been found and rectified, the deaerator should be drained and thoroughly cleaned before being returned to service.

B. Pumps:

B-1 - Packing
Check packing glands - DO NOT run dry. Permit a few drops of water per minute to drop from glands. This provides lubrication for the shaft, eliminating burned packing and scored shafts. When tightening gland bolts, do so ONLY when pump is running. Draw up evenly ¼ turn at a time to allow gland pressure to equalize throughout stuffing box.

Replace with Hi-temp packing after six (6) months to one (1) year, depending upon severity of service. Remove all old packing first (do not intermix new and old packing). Insert individual rings so that splices are staggered. When stuffing box is full, adjust gland just tight enough to permit slight leakage as described above - DO NOT RUN DRY.

B-1.1 - Mechanical Seals
It is not recommended that worn seals be re-used. A mechanical seal is similar to a gasket in this respect. Using an old one involves too great a risk of failure, considering the expenses of removing and re-installing a pump. Attempts to lap the seal faces are not recommended under any circumstances.

B-1.2 - Bearings
These will require periodic lubrication, using the grease fittings in the pump frame. For 8 hours daily operation, this should be every thousand hours. Use ball bearing grease of high quality; lithium, lithium soda or calcium base grease is recommended for both wet and dry locations. Do not mix different brands.

Avoid over lubrication, which can result in overheating and bearing failure. Adequate lubrication is assured if grease quantity is maintained at to the capacity of the bearing.

Approximately every six (6) months, bearings should be cleaned by flushing with kerosene and relubricated.

TROUBLESHOOTING

A. Low Temperature:

The only reasons for a deaerator to operate at less than saturated steam temperature are lack of steam or improper venting:

A-1 - Insufficient steam may result from an undersized pressure reducing valve or an insufficient supply of steam due to other causes. The pressure-reducing valve furnished is sized for specific pressures, temperatures, percentages of returns and make-up water. Changes in these values will affect its operation.

A-1.1 - Improper piping of the pressure reducing valve will also alter its operation. Refer to Paragraph D under "Installation" for sizing steam piping.

A-2 - Insufficient venting can be traced to the vent valve and its associated piping. This valve is furnished with an orifice in its disc sized for minimum venting. Rapid accumulation of released gases may require that the valve be opened wider to accommodate their evacuation to atmosphere. Low water temperature is an indication of insufficient venting. Adjust valve opening accordingly. Vent piping must be vertical, full size, and free of bends or obstructions. No other valves should be installed in this line.

B. Vibration, Rumble and Hammer:

These can be caused by low steam pressure or blockage of internal steam passages in the deaerator.

B-1 - Low steam pressure may result from an undersized pressure reducing valve, improper steam piping, malfunction of the pressure reducing valve or an insufficient supply of steam. Check size, capacity, proper operation of pressure reducing valve as well as steam supply and pressure.

B-2 - If steam piping and controls are not at fault, it will be necessary to drain the vessel and examine all internals for debris or other blockage.

C. Oil Contamination:

A likely source would be one of the following:

C-1 - Condensate contaminated by oil, possibly from a leaking heat exchanger.

C-2 - Improper grade of oil used in steam driven equipment.

C-3 - Oil separator not draining properly.
After locating and rectifying the cause, the deaerator must be drained and thoroughly cleaned before returning to service.

D. Water Level:

D-1 - Wide fluctuations in water level are to be avoided since they may cause rumbling or variations in both temperature and pressure. The following precautions should be observed:

D-1.1 - Check water inlet valve for proper operation. Water supply pressures differing from those originally specified will result in inadequate or erratic supply. Remedy by using a properly sized valve or adjusting water supply pressure.

D-1.2 - Sudden slugs of water will cause severe variations in steam pressure. These can be the result of large volume returns from a condensate pump, or an oversized water inlet valve. Inlet water flows should be as smooth as possible to avoid sudden steam pressure drops, which will cause flashing and cavitation in the boiler feed pumps.

D-1.3 - Make certain that total water flows (returns and make-up) do not exceed rated deaerator capacity.

E. Pumps:

Unusual noise may be caused by several factors, as follows:

E-1 - Cavitation
At any given temperature, all liquids have a definite pressure at which they will boil. It follows, therefore, that a liquid will boil at any temperature, if the pressure is reduced sufficiently. All pumps have a specific net positive suction head (NPSH) requirement. If this positive head is not available, pump cavitation will develop, resulting in severe damage.

The required NPSH has been provided in this system, including additional height to overcome suction line friction losses.

Suction piping is intentionally oversized to further reduce these losses.

Any unusual restriction, such as a clogged strainer, in the suction piping will cause cavitation. The existence of such an obstruction can best be determined by a thorough visual check or by installing a compound gauge (reading in vacuum and pressure) in the pump suction line close to the pump. A thoroughly clean and unrestricted line will produce a pressure reading on the gauge, while the pump is running, equal to the operating pressure of the deaerator plus the static head available. This head is measured in feet from the water level to the pump suction centerline and converted to PSIG by dividing by 2.31. A slight variance may be observed due to friction losses in suction piping. Any restriction must be corrected immediately or severe pump damage will result.

E-2 - Another source of noise would be a misaligned coupling between pump and motor. Check this by applying a straight edge across coupling halves at 90º and 180º. Straight edge should rest evenly on both coupling halves. Shim pump and/or motor, if necessary, to bring coupling into perfect alignment vertically and laterally. Check pump for free rotation by turning coupling manually.

E-3 - Be sure piping connections at pump are properly aligned and supported to eliminate any strain on pump casing. Forcing piping into place will result in misalignment of pump, causing noise and structural damage.

E-4 - Vibration can be induced by bent or broken shafts, worn bearings, or binding of the impeller due to foreign matter entering the pump. Worn or damaged shafts and bearings must be replaced. Remove any contaminants in the pump and replace damaged parts. It is essential that the source of contamination be found and eliminated **BEFORE** returning the pump to service.

F. Overflow:

An overflow condition may result from malfunction of the trap or the water inlet valve.

F-1 - Inspect trap for accumulated dirt at the valve seat and clean, if necessary. Periodically remove the drain plug and drain sediment.

F-2 - If trap is functioning properly, inspect water inlet float for possible water-logged condition. Make certain that water inlet valve control linkage is properly adjusted to maintain specified operating level in deaerator.

G. Motors:

Any number of reasons exist for motor failure. Some of the most common are as follows:

G-1 - Tripped starter overload - Reset and check motor and pump for proper operation.

G-2 - Improper power supply - Check voltage and motor nameplate requirements.

G-3 - Incorrect connections - Check wiring diagram.

G-4 - Mechanical failure - Check for free rotation and examine bearings.

G-5 - Short circuited windings - Indicated by blown fuse or failure to start. Motor must be replaced.

G-6 - Overload - Check pump for proper operation and free rotation.

G-7 - One phase open in three phase circuit - Check power supply lines.

G-8 - Vibration
- G-8.1 - Check alignment of pump and motor.
- G-8.2 - Defective bearing - Replace.
- G-8.3 - Polyphase motor running single phase - Check for open circuit.

H. Controls:

H-1 - Blown Fuses
- H-1.1 - Check motor for short-circuited windings.
- H-1.2 - Incorrect connections - Refer to wiring diagram.
- H-1.3 - Improper power supply - Check voltage and motor nameplate requirements.

H-2 - Starter overload tripped - Reset and inspect pump and motor for proper operation.

H-3 - Motor fails to start
- H-3.1 - Make certain boiler level switch is functioning properly.
- H-3.2 - Check control circuit for continuity.

H-4 - High/low alarm system not operating.
- H-4.1 - Relays defective
- H-4.2 - High or low alarm switch not operating properly.

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Superior Boilerworks, Inc. Dissolved Oxygen Test Procedure

Introduction: Deaeration of Boiler feedwater is a crucial element in the maintenance and efficiency of your boiler system. The mechanical deaeration supplied by Superior Boilerworks is an important part of your boiler room equipment. The deaerator requires very few day to day adjustments except to assure there is enough steam to maintain saturation condition in the deaerator, and to provide sufficient steam venting to completely purge all gasses from the deaerator.

In monitoring your deaerator there are several parameters that should be routinely monitored.

- **Pressure.** Operating pressure should be well regulated and not very greatly.
- **Temperature**. An operating deaerator should heat the water to within 4 deg. F. of the saturation temperature at the steam pressure within the unit. **NOTE: If you don't properly heat the water you do not deaerate the water. This is the primary and most important step for good deaeration.**
- **Venting.** Proper venting will purge the gases from the system, thereby eliminating the possibility of the gases being reintroduced to the water.

Dissolved Oxygen (DO) Testing. The following has been taken from the American Boiler Manufacture Association (ABMA). A Guideline, Deaerator Performance Testing, 2017.

The deaerator test procedure should be agreed on by all parties prior to selection of the system or the procedure should be defined in the system specifications. The test procedure should define:

The following defines the information required for the testing and recorded on the accompanying Data Sheets.

1. The testing equipment and test method used for the test.
2. The location of the test.
3. The time at which the test will be performed.
4. The duration of the test period.
5. The number of tests to be performed.
6. The operating conditions during the test.

1. ***The Test Equipment***. When performance testing for a new installation Superior Boilerworks recommends the CHEMetrics K-7511 0-20 ppb kit. A sample cooler shall be used to temper the testing sample. The use of a properly calibrated, highly accurate K1100 sensor, which is a luminescent sensor measuring dissolved oxygen specifically optimized for measurements in water processes in the power industry, can be used for on-going testing but not allowed in the initial test phase of the deaerator. The measurement may be performed online. Visual test kits may be used to validate online testing.

2. ***The Location of the Test**.* The system must be tested at the actual installation. The sample should be drawn from the discharge of the feedwater pump for the most consistent pressure with less variations.

3. ***The Time of the Test**.* The test should be performed after the system is completely installed and at a time when the conditions of the test procedures can be satisfied.

4. ***The Duration of the Test.*** The test should be conducted after the system has been operating at steady state conditions at full load for a period of at least four (4) hours before the sample for the test is drawn. The sample valve should be open for at least 30 minutes prior to collecting the sample for testing. The test time should be 30 minutes per load case, during this time at least 15 readings should be taken.

    a. Based on ten (10) minute or less storage capacity, the steady state operational time should be at least four (4) hours.
    b. Based on more than ten (10) minute storage capacity, steady state operation should be achieved for a minimum turnover of 20 times storage capacity.

5. ***The Number of Tests to be Performed**.* Normally, one operating point is sufficient to determine if a system is performing properly. Normally, 100% of the system capacity is the appropriate operating point to use. If additional operating test points are required, the number should be defined prior to the purchase of the system.

    If multiple operating points are to be tested, the system must be brought to the new operating point and operated at steady state conditions at the new operating point for at least four (4) hours prior to drawing the sample for test.

6. ***Operating Conditions for the Test.*** The test should be performed at steady state conditions, which are defined as:

    a. <u>Load</u>. Normally the system is operated at full capacity. If the customer would prefer to test the system at another operating point, that point should be defined in advance.
    b. <u>Inlet Water Flow</u>. The inlet water should be at a constant flow rate for at least four (4) hours before the test is run. This is normally the flow rate that corresponds to 100% of load. If the system is designed for 100% cold, fresh water make-up, the test should be run at this point. If the system is designed for a higher average input water temperature, the system should be tested with this flow rate.
    c. <u>Discharge Water Flow Rate</u>. The water should leave the deaerator at a constant rate which is equal to the load at the capacity at the chosen test point.
    d. <u>Operating Pressure</u>. The operating pressure should be constant for the period of the test. This includes the four-hour period prior to collecting the test sample. Constant pressure is defined as a variance of ½ psi on either side of the pressure set point.
    e. <u>Vent</u>. The vent must be opened to allow adequate steam to pass to vent the non-condensable gases that are released. The vent must be set at a constant point for the entire period of the test.
    f. <u>Preparation for the Test</u>.

        1. The source of the sample for the test should be drawn from a sample point in the vicinity of the deaerator water outlet such as the vessel, downcomer, or outlet

of the storage vessel. To connect online instruments a representative sampling point as close as possible to the outlet of the deaerator must be used. Special attention should be paid to the tightness of the connection to prevent air leaking inside.

2. Turn off all system recirculation lines and any condensate recovery (if applicable) for the duration of the test.
3. Turn off the oxygen scavenger at least 24 hours (operating hours) before the test is to be run.
4. Operate the deaerator at the output capacity desired for the test for a period as defined in 4(a) and 4 (b) above.

Testing. Perform the test with stainless steel tubing with a stainless steel sample cooler and isolation valves on the inlet and outlet of the sample cooler. Testing shall be performed with the sample temperature of less than 20 degrees Fahrenheit above ambient temperature The sample should be read within five seconds of extraction from the system. Perform at least five tests at the operating condition chosen. Use the lowest test(s) to establish the actual level of performance. Tests which show higher levels of non-condensable gases are assumed to be contaminated and should be discarded. From the measuring data obtained from online measurements a half-hour average should be determined (readings should be done with a frequency of at least every 2 minutes).

The Test Equipment Identify the testing equipment and test method used for the test.

____

____

The Location of the Test. Identify the location of the test. Specify the point on the DA that the sample is being taken from.

____

____

The Time of the Test Has the system been completely installed and is the test at a time when the conditions of the test procedures can be satisfied (full load operation)?

____

____

The Number of Tests to be Performed The test should be conducted after the system has been operating at steady state conditions for a period of at least four (4) hours before the sample for the test is drawn. The system was designed for a Steam Pressure of 5 psig and water temperature at 227.1 degrees Fahrenheit. If system is running below 227 degrees then refer to troubleshooting guide to correct problem. To determine steady state conditions the following must be recorded every 15 minutes

Beginning time of test: Time _________

- Steam Pressure ___________
- Water Temperature ___________
- Water Inlet Pressure ___________

15 minute mark: Time _________

- Steam Pressure ___________

- Water Temperature ____________
- Water Inlet Pressure ____________

30 minute mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

45 minute mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

1 hour mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

1:15 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

1:30 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

1:45 minute mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

2 hour mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

2:15 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

2:30 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

2:45 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

3 hour mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

3:15 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

3:30 mark: Time __________
- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

3:45 mark: Time __________

- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

4 hour mark: Time __________

- Steam Pressure ____________
- Water Temperature ____________
- Water Inlet Pressure ____________

A minimum of 5 readings should be taken, see above paragraph on testing. A stainless steel sample cooler should be employed to take the sample, similar but not exclusive to a Neptune SC 316 Sample Cooler. The sample valve should be open for at least 30 minutes prior to collecting the sample for testing.
After determining the test kit to be used follow the directions on the kit for the most accurate results. Superior Boilerworks recommends the Chemetrics K7511 test kit

Results from Test sample #1 ___________
Results from Test sample #2 ___________
Results from Test sample #3 ___________
Results from Test sample #4 ___________
Results from Test sample #5 ___________
Results from Test sample #6 ___________
Results from Test sample #7 ___________
Results from Test sample #8 ___________
Results from Test sample #9 ___________
Results from Test sample #10 ___________

If 7ppb has not been achieved refer to troubleshooting guide to correct problem.

Have the operating conditions during the test been achieved?

Operating Pressure 5 psi +/-0.5, 15 psi max.
Operating Temperature 225-227degF

See ‘Operating Conditions for the Test’ above to ensure compliance. Have all Operating Conditions been met and holding stable for the duration of the test?

____

____

Employee Responsible for Test: Date:

______________________________ ______________________

Print

____

Signature

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Superior Boilerworks, Inc. Troubleshooting Guide for Deaerator Systems

Introduction: Deaerators are the piece of boiler room equipment that gets very little to no notice until something goes wrong. Then the entire system can be at risk if not corrected in a timely manner.

This troubleshooting guide is to help you first to understand the proper performance of a deaerator feedwater system and secondly to help recognize the problems that can occur in the normal day to day operation of the deaerator.

Deaerator operation: A deaerater preheats the boiler feedwater and assists in removing harmful non-condensable gases such as oxygen, carbon dioxide and ammonia from the feedwater system. These gases promote corrosion within the entire boiler system and can lead to premature boiler failure and replacement.

During proper operation, the water exiting the unit should be within 1 deg. F. of the saturated steam at the deaerator's operating pressure. For example; if the deaerator's operating pressure is running a stable 5 psig then the temperature of the water will be 226 deg. F. The oxygen content should be at a consistent .oo5 cc/Liter and no evidence of corrosion. Also, issuing from the vent valve exhaust piping should be a continuous 15-25 inch steam plume.

Following are a list of gauges provided for troubleshooting the deaerator. Once the deaerator is set-up and running satisfactory, and in a stable condition fill in the numbers as a future reference.

1. Deaerator's Operating Pressure ___________
2. Deaerator's Storage Section Temperature ___________
3. Water In-Let Pressure ___________
4. Pump Pressure Gauge, Discharge ___________

PROBLEM: HIGH O2 LEVELS

POSSIBLE CAUSE:

- Insufficient heat- This condition is said to exist when the difference between the saturated steam temperature at use pressure and the outlet water temperature is in excess of 3 deg. F.
- Make sure the pressure and temperature gauges are working properly.
- Insufficient venting. Check steam plume from deaerator. Typically, an 18-24 inches of height without wind flow. Manually increase the opening of the vent valve let system stabilize and then recheck the storage section temperature.

- Steam Pressure. Reducing valve not operating correctly, check to see that the valve operates freely make sure all instrument lines to the controller are connected properly and reducing valve is adjusted correctly.
- Improper spray from nozzles. Check nozzle for free movement and ensure no sediment or deposits have accumulated on the nozzle seat, check for broken spring. If a tray DA check that the trays are installed correctly and not collapsed.
- Check water and steam flow rates versus deaerator's design. Trays and inlet steam valves are designed for specific flow ranges. Install correctly sized equipment.
- Not steady stat condition. Often, high oxygen measurements can be traced to inadequate test procedures. In order to conduct a proper test, it is important that there be a sufficient stabilization period and steady state conditions. As a general rule, if there is a downward trend in oxygen content measurements, steady state condition has not yet been attained.

PROBLEM: HIGH DEAERATOR PRESSURE AND/OR TEMPERATURE

POSSIBLE CAUSE

- Steam Pressure Reducing valve not operating correctly, check to see that the valve operates freely make sure all instrument lines to the controller are connected properly and reducing valve is adjusted correctly.
- Steam Trap. Overflow Steam Trap not functioning correctly, check to see that the trap is not blowing live steam.
- Relief Valves. Check the relief valves on the deaerator and the main steam supply system for proper operation.

PROBLEM: LOW DEAERATOR PRESSURE AND/OR TEMPERATURE

POSSIBLE CAUSE

- Steam Pressure Reducing valve not operating correctly, check to see that the valve operates freely make sure all instrument lines to the controller are connected properly and reducing valve is adjusted correctly.
- Improper spray from nozzles. Check nozzle for free movement and ensure no sediment or deposits have accumulated on the nozzle seat. Check for broken spring. If a Tray DA check that trays are installed correctly and not collapsed.
- Incorrect Steam/Water ratio. Excessive load demand from boiler(s) and/or greatly reduced condensate flow to deaerator. Check operating criteria to design parameters.
- Overflow in deaerator. Makeup valve not functioning properly. Level control not functioning properly.

PROBLEM: FLUCTUATING OPERATING PRESSURE

POSSIBLE CAUSE

- Insufficient steam supply
- Batch addition of condensate and/or makeup water
- Maintain storage section water level within tighter range. Check adjustment on boiler feedwater and makeup level controls

- Pressure reducing station chattering due to being oversized.

PROBLEM: HIGH OR LOW WATER LEVEL OR OVERFLOWING DEAERATOR

POSSIBLE CAUSE

- Malfunctioning level control system. Makeup valve not functioning properly. Level control system not functioning properly.
- Leaking heat exchanger. Check connections and piping on the heat exchanger.

PROBLEM: VENT PLUME INCONSISTENT AND/OR DISAPPEARING PERIODICALLY

POSSIBLE CAUSE

- Pressure reducing station chattering due to being oversized.
- Pressure reducing station sensor either improperly installed or faulty, causing large lad in response times.
- Cold water makeup addition control too broad
- Periodic loss of condensate
- Malfunctioning level control system. Makeup valve not functioning properly. Level control system not functioning properly.

PROBLEM: VENT PLUME CONTAINS ENTRAINED WATER

POSSIBLE CAUSE

- Cracked internal vent condenser or cracked condenser shroud
- Blown spray nozzles or spray distribution system
- Improper vent piping. Piping should be as short and as vertical as possible.
- Water carry over. Reset the vent flow.

PROBLEM: RELIEF VALVE BLOWING

POSSIBLE CAUSE

- Over pressurized due to excessive supply of exhaust or flash steam.
- Reducing valve not operating correctly, check to see that the valve operates freely make sure all instrument lines to the controller are connected properly and reducing valve is adjusted correctly

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EXTENDED OUTDOOR STORAGE FOR DEAERATORS

If newly delivered Deaerators are to be stored for a long period, the following steps are required:

1. The Deaerator should be placed on cross-ties under the legs, preferably on a concrete or asphalt surface.

2. Make certain that all water has drained out of the shell and all piping. Plug all remaining open connections in the Deaerator shell and close all blowdown valves. Remove the manway cover and place trays of silica gel desiccant in vessel. The condition of the desiccant should be checked weekly, and it should be replaced when it changes color.

3. The electrical enclosures and panels will also require silica gel in cloth bags to protect against condensation. These bags should also be checked weekly.

4. The entire Deaerator should be covered with a tarp with emphasis on protection for the pump, motors, and all electrical components.

SUPERIOR BOILER WORKS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGE TO THE UNIT DURING THE STORAGE PERIOD IF THE ABOVE PROCEDURE IS NOT FOLLOWED.

Form: SBWBOSDA