



# **Steam Master**

## ***Steam Generator Installation Manual***

For your convenience, enter your unit's specific model and serial number in the space below. The model and serial number are located on the right-hand side of the electronic controls cabinet.

**MODEL:** \_\_\_\_\_

**SERIAL NUMBER:** \_\_\_\_\_

**Steam Master  
Steam Generator  
Installation Manual**

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# SECTION I - INTRODUCTION

The **CLAYTON STEAM GENERATOR** is manufactured in accordance with the American Society of Mechanical Engineers (ASME) Boiler Pressure Vessel Code (BPVC), Section I. Construction and inspection procedures are regularly monitored by the ASME certification team and by the Authorized Inspector (AI) commissioned by the Jurisdiction and the National Board of Pressure Vessel Inspectors (NBBI).

The NBBI is a nonprofit organization responsible for monitoring the enforcement of the various sections of the ASME Code. Its members are the chief boiler and pressure vessel inspectors responsible for administering the boiler and pressure vessel safety laws of their jurisdiction.

The electrical and combustion safeguards on each **CLAYTON STEAM GENERATOR** are selected, installed, and tested in accordance with the standards of the Underwriters' Laboratories and such other agency requirements as specified in the customer's purchase order.

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## NOTE

It is important that the steam generator/fluid heater, feedwater skid, and all installation accessories and options be installed in accordance with ASME/ANSI Codes, as well as, all applicable Federal, State, and local laws, regulations and codes.

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## NOTE

Clayton startup engineers or service technicians reserve the right to refuse commissioning of any Clayton equipment if Clayton startup/service personnel determines such equipment installation fails to meet the guidelines and requirements outlined in this installation manual.

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## NOTE

Clayton sales representatives and service technicians **ARE NOT** authorized to approve plant installation designs, layouts, or materials of construction. If Clayton consultation or participation in plant installation design is desired, please have your local Clayton sales representative contact Clayton corporate headquarters for more information and pricing.

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# SECTION II - GENERAL INFORMATION

## 2.1 LOCATION

Give careful consideration to your Clayton equipment investment and the equipment warranty when selecting an installation location. The equipment should be located within close proximity to necessary utilities, such as fuel, water, electricity, and ventilation. General consumption data for each model is provided in Table 1 of Section VI. General equipment layout and dimensions are provided in Table 2 of Section VI. For actual dimensions and consumption information, please refer to the data submitted with each specific order.

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### NOTE

Clayton's standard equipment is intended for indoor use only. Clayton's equipment must be protected from weather at all times. The steam generator/fluid heater, and any associated water and chemical treatment equipment must be maintained at a temperature above 45° F (7° C) at all times.

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Maintain adequate clearance around your Clayton equipment for servicing needs. Maintain a minimum clearance of 60 in. (1.5 m) in front of the equipment, a minimum clearance of 36 in. (1 m) to the left and right sides, and a minimum clearance of 18 in. (0.5 m) to the rear of the equipment. Ample overhead clearance, including clearance for lifting equipment, should be considered in case the coil requires removing. Equipment layout and dimensions are provided in Table 2 of Section VI. Review the Plan Installation drawing supplied with the order for specific dimensions and clearance information.

### CAUTION

ALL combustible materials must be kept a minimum of 48 in. (1.2 m) from the front and 18 in. (0.5 m) from the top, rear, and sides of the equipment. A minimum clearance of 18 inches (0.5 m) must also be maintained around the flue pipe. Flooring shall be non-combustible. This equipment must not be installed in an area susceptible to corrosive or combustible vapors.

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### IMPORTANT

KEEP CLAYTON EQUIPMENT CLEAR OF ALL OBSTRUCTIONS. DO NOT ROUTE ANY NON-CLAYTON PIPING, ELECTRICAL CONDUIT, WIRING, OR APPARATUS INTO, THROUGH, OR UNDER CLAYTON EQUIPMENT. ANY OBSTRUCTIONS CREATED BY SUCH NON-CLAYTON APPARATUS WILL VERY LIKELY INTERFERE WITH THE PROPER OPERATION AND SERVICING OF THE

EQUIPMENT. ALL SUCH INTERFERENCE IS THE SOLE RESPONSIBILITY OF THE CUSTOMER. CLAYTON'S PLAN INSTALLATION DRAWINGS, INCLUDING JOB-SPECIFIC DRAWINGS, ARE FOR VISUAL REFERENCE ONLY.

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## 2.2 POSITIONING AND ANCHORING EQUIPMENT

### 2.2.1 General Installation Requirements

Lifting instructions are provided in Appendix A. Proper rigging practices and equipment must be applied when lifting this equipment. Forklifts with roll bars can be used for installations with overhead space limitations.

#### WARNING

DO NOT attach rigging gear to the top coil lifting hook or any part of this equipment other than the main frame.

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Proper floor drains must be provided under the generator(s). **MAKE SURE ALL EQUIPMENT IS LEVELED AND ALL ANCHORING POINTS ARE USED.**

Level the equipment using full-size, stainless steel, shims that match the equipment pads designed and provided on the equipment. Use full-sized anchors to anchor the equipment. Make sure anchors are capable of withstanding operating, wind, and seismic loads that exists in the installation location.

It is recommended the mass of the concrete foundation be sufficient to absorb the dynamic and static forces from the operation, wind, or seismic conditions that exist at the specific equipment installation location. **Accepted concrete construction guidelines, for equipment installation, recommends that the concrete foundation be at least 5 1/2–7 1/2 in. (14–19 cm) thick, depending on soil, underground water, environmental, and seismic conditions.**

If Clayton's steam generator is mounted on a surface other than a concrete foundation, such as a steel structure, then the equipment base frame must be supported on rigid steel beams that are aligned along the length of the equipment base frame. It is strongly recommended that Clayton's equipment be supported with horizontal and vertical main structural members at all its equipment anchor pads.

Perform stress calculations for the steel structure to confirm it has adequate rigidity to minimize baseplate distortion and vibration during operation. Clayton recommends incorporating vibration isolation on this type of installation.

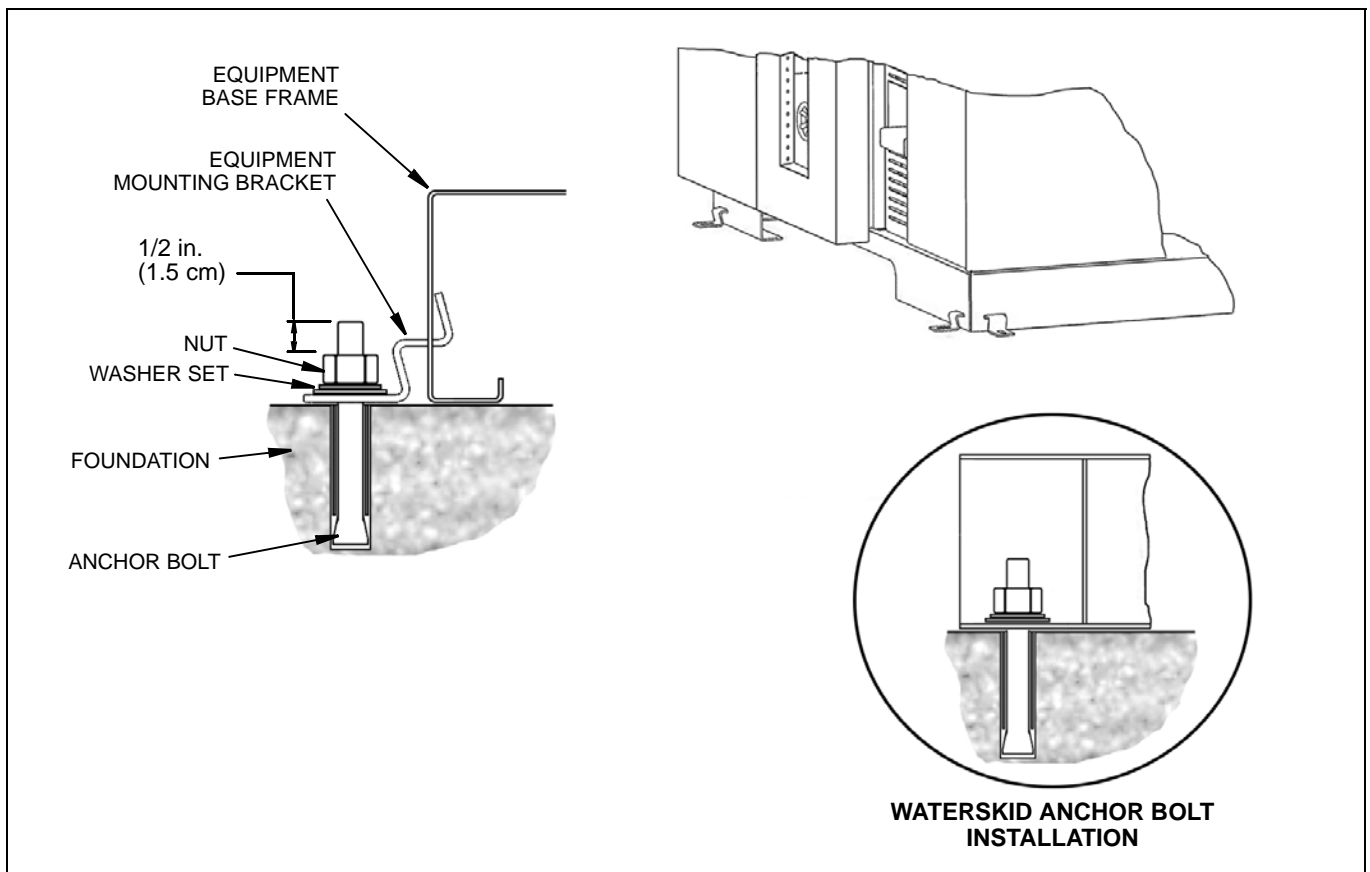
### 2.2.2 Equipment Anchoring

To properly secure the equipment base frames to the foundation, proper anchor bolts are required. The anchor bolt diameter must be fully sized to the anchor bolt holes in Clayton's equipment base frame. For required bolt sizes, see the plan installation drawings for the specific Clayton equipment. The anchor bolt length extending above the foundation should equal the total height of all shimming and leveling devices, the equipment mounting bracket thickness, washer set, anchor bolt nut, and an additional 1/2 in. (1.5 cm) above anchor bolt nut (See Figure 2-1.).

The proper anchor bolt length and its embedded depth must meet all static and dynamic loading from the operation of the equipment, wind loading, and seismic loading.

### CAUTION

Failure to adequately support Clayton's equipment can lead to excessive vibration, which is detrimental to Clayton's product and component life cycle, especially electrical components.



**Figure 2-1** Anchor bolt installation

## 2.3 COMBUSTION AIR

A sufficient volume of air must be continuously supplied to the boiler room to maintain proper combustion. **Boiler room fresh air vents must be sized to maintain air velocity less than 400 scfm with less than 1/4 inch water pressure drop. Ventilation openings must be sized at 3 ft<sup>2</sup>/100 bhp or larger.** As a guideline, there should be 12 cfm of air per boiler horsepower.<sup>1</sup> This will provide sufficient air for combustion and outer shell cooling.

<sup>1</sup> This guideline is based on an installation at about sea level; high altitude installations require more air.

An inlet air duct should be used when there is insufficient boiler room air, when the boiler room air supply is contaminated with airborne material or corrosive vapors, and when noise consideration is required. A suitable inlet weather shroud is required and an air filter should be installed when there is a potential for airborne contaminants. If an inlet air duct is used in cold weather climates, it must contain a motor operated damper with a position interlock switch to prevent freezing of the heating coil. The maximum allowable pressure drop in the inlet air duct system is 0.5 inch water column.

## 2.4 CUSTOMER CONNECTIONS - STEAM GENERATOR

The number, type, and size of required customer connections will vary with equipment size and type of skid package provided. Table 2-1 below identifies the required steam generator customer connections for the various skid packages.

Additional customer connection tables located in Section III provide detailed descriptions of connections for Clayton water treatment packages.

Steam generator installation guidelines are provided in the following sections. Water treatment component installation guidelines are provided in Section III.

**Table 2-1: Customer Connections**

Required Customer Connections Include:	EQUIPMENT PACKAGES		
	Steam Generator only	STEAM GENERATORS WITH	
		Hot-well Tank	Water Skid
Exhaust Stack	X	X	X
Separator Steam Outlet	X	X	X
Safety Relief Valves Discharge	X	X	X
Feedwater Inlet	X	X	X
Coil Drain(s)	X	X	X
Separator Drain	X	X	X
Steam Trap(s) Outlet	X	X	X
Fuel Inlet	X	X	X
Fuel Return (Oil Only)	X	X	X
Atomizing Air Inlet (Oil Only)	X	X	X
Electrical Connection-Primary	X	X	X
Electrical-Generator Skid Interconnect		X	X
Coil Gravity Drain	X	X	X
Fuel Pump Relief Valve (Oil Only)	X	X	X

## 2.5 EXHAUST STACK INSTALLATION

(See Figures 2-2, 2-3, 2-4, 2-5, and 2-6)

### 2.5.1 Installing Exhaust Stacks

**Clayton strongly recommends a barometric damper on all installations.** Proper installation of the exhaust stack is essential to the proper operation of the Clayton steam generator. Clayton specified allowable back-pressure of 0.0 to -0.25 w.c.i. must be considered when designing and installing the exhaust stack. The stack installer is responsible for conforming to the stack draft back-pressure requirements. Ninety-degree elbows should be avoided. Forty-five degree elbows should be used when the stack cannot be extended straight up. *Stacks in excess of 20 ft (6 m) may require a barometric damper. Stacks for all low NOx generators require a barometric damper.*

The material and thickness of the exhaust stack must comply with local code requirements, and be determined based on environmental and operating conditions (exposure to the elements, humidity, constituents of fuel, etc.). The area of free air space between the exhaust stack and building, roof, or flashings must also comply with local codes. The material used for roof flashings must be rated at a minimum of 600° F (315° C). A “weather cap” must be installed on top of the exhaust stack.

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#### IMPORTANT

The specified exhaust stack connection size (shown in Clayton's Plan Installation Drawings) is the minimum required for Clayton's equipment. It is NOT indicative of the required stack size to meet installation requirements or by local codes. All exhaust stack installations must be sized to meet prevailing codes, company and agency standards, and local conditions, as well as, the recommended requirements specified above.

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#### NOTE

Clayton recommends all generators purchased with our integral economizers be installed with stainless steel, insulated, double-walled exhaust stacks. All units operating on light or heavy oil should use stacks constructed with stainless steel. Clayton recommends all heavy oil units use a free-standing, vertical stack, with clean-out access, as shown in Figure 2-3.

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#### NOTE

All oil-fired units must have an exhaust gas temperature indicator installed in the stack.

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A removable spool piece must be installed at the generator flue outlet to facilitate removal and inspection of the heating coil. To permit sufficient vertical lift, the spool piece should be at least 4 ft (1.2 m) tall. The spool installation should be coordinated with the customer supplied rigging. If operating on any

type of fuel oil, an access door must be provided immediately at the generator flue outlet (first vertical section) to provide a means for periodic water washing of the heating coil. The section of the stack located inside the building should be insulated to reduce heat radiation and noise.

Exhaust stacks are to be self-supporting (maximum stack connection load is 50 lbs. {22 kg}) and must extend well above the roof or building, (refer to local building codes). If nearby structures are higher than the building housing the steam generator(s), the stack height should be increased to clear these structures.

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**NOTE**

It is strongly recommended that a back draft damper (full size and motor operated with position interlock switch) be installed to prevent freeze damage to the heating coil. Machine installations, in cold weather zones, that plan to lay the machine up wet and may encounter freezing conditions must install an air-tight back draft damper in the exhaust stack to prevent down-draft freezing.

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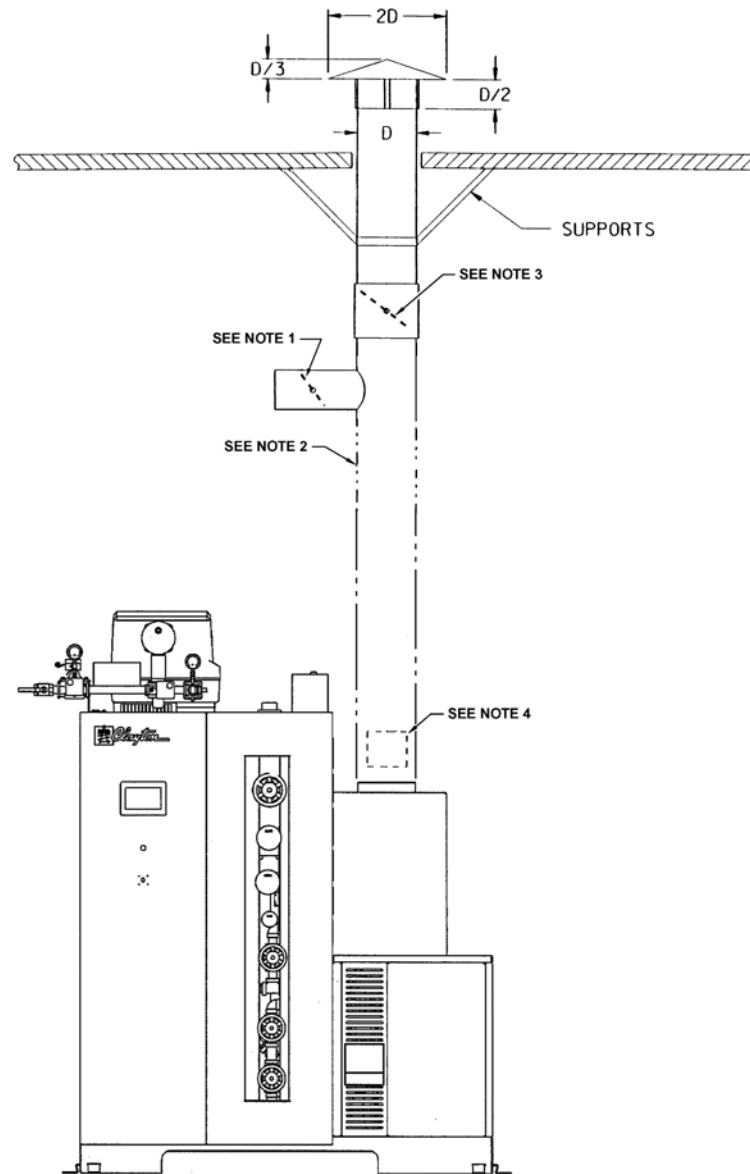
Clayton recommends insulating all exhaust stacks to maintain gas temperatures above dew point.

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Special consideration should be given to installations in and around residential areas. Depending on the design, some noise and harmonic vibration may emanate from the exhaust stack. The noise/harmonics may bounce off surrounding structures and be offensive to employees and neighbors. If this condition occurs, a stack muffler is recommended. In-line stack mufflers are typically used, installed vertically and above roof level. They may be installed horizontally or closer to the equipment.

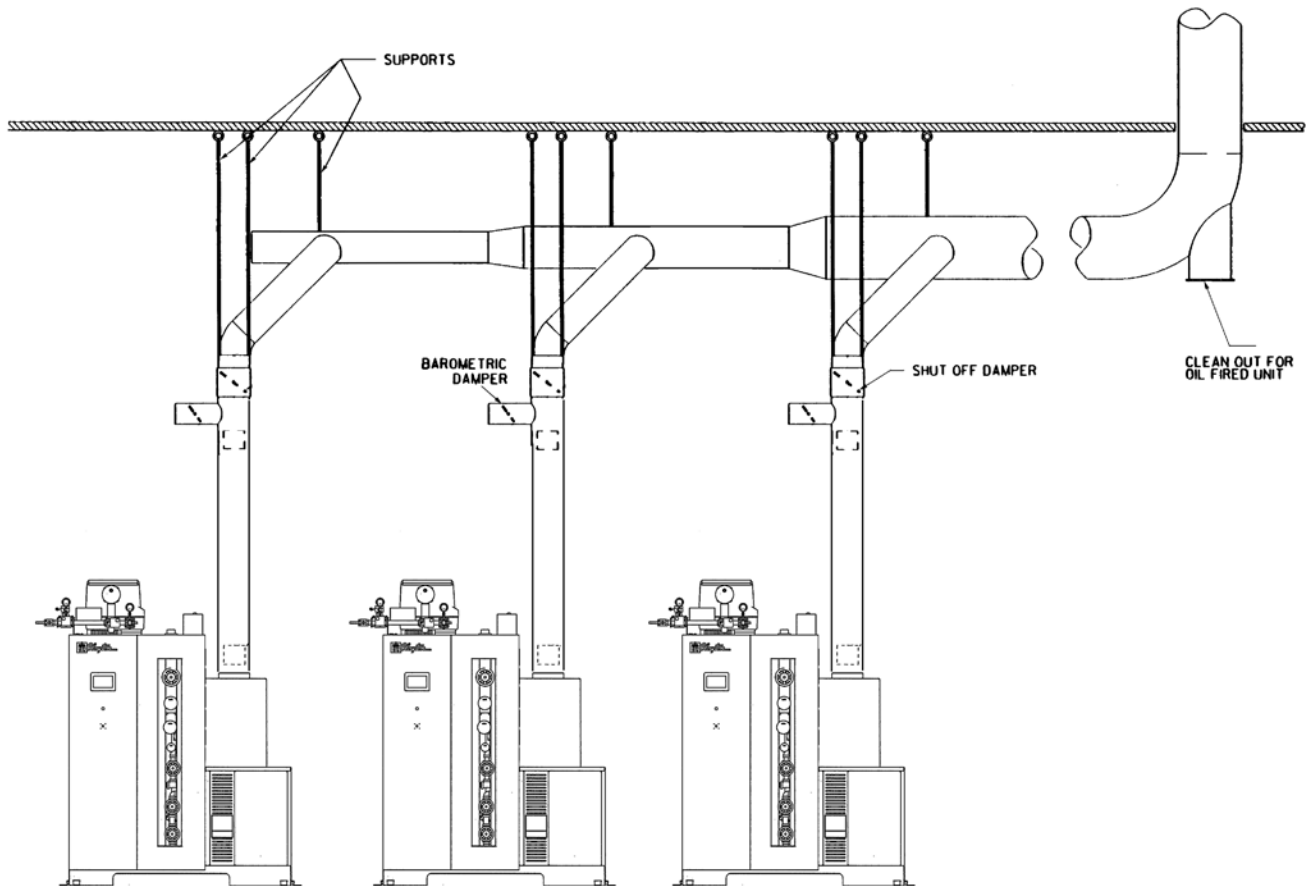
See Figures 2-2, 2-3, and 2-4 for stack configurations.





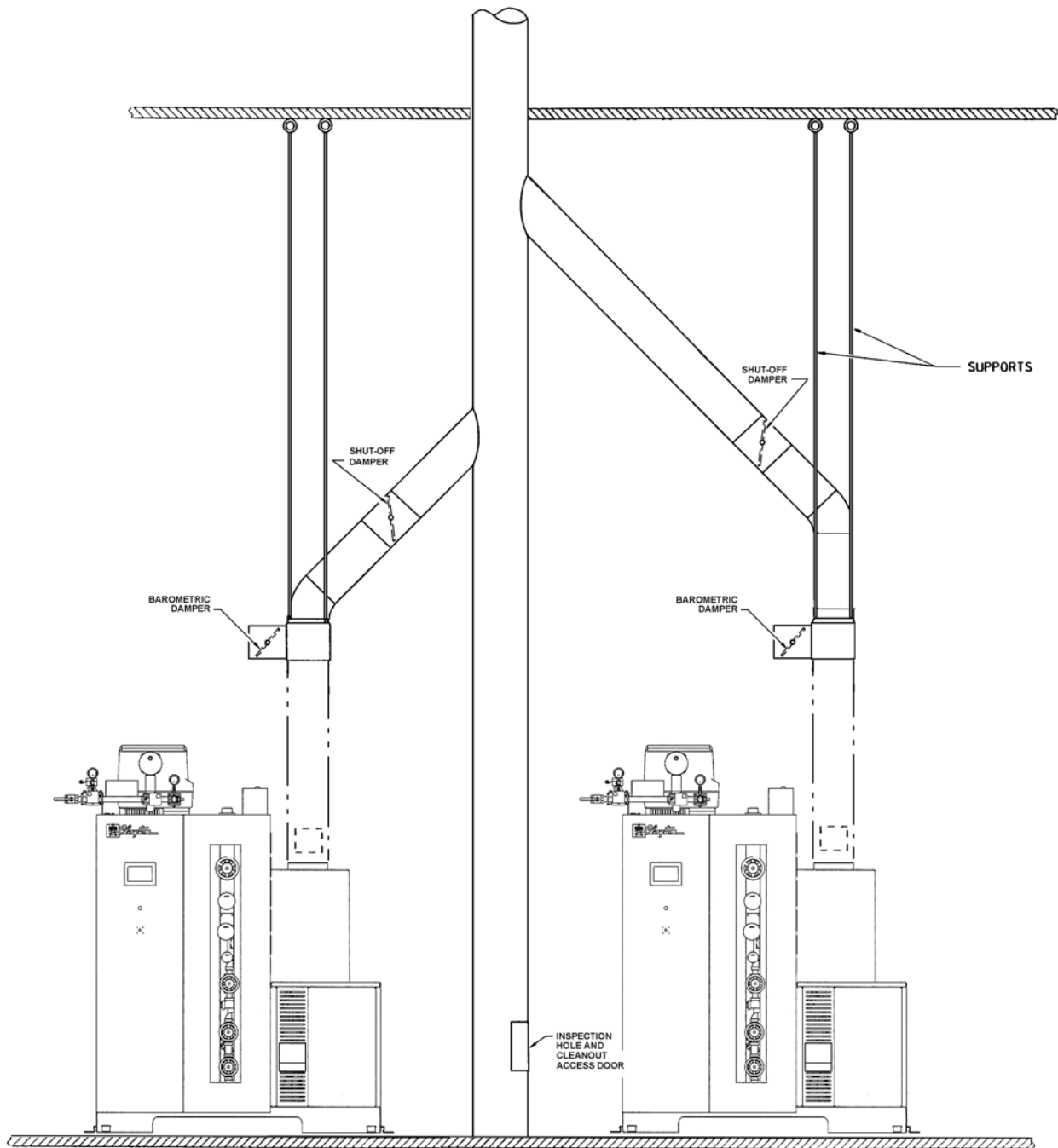
- NOTE 1:** Barometric dampers are recommended on all installations with stack heights over 20 feet (6 meters) and on any low NO<sub>x</sub> units.
- NOTE 2:** A removable, 4 feet (1.2 meters) minimum, stack section is recommended to facilitate steam generator/fluid heater maintenance and repair.
- NOTE 3:** A backdraft damper must be installed in the exhaust stack for installations in cold weather climates. All backdraft dampers must be air-tight and proof-of-position switches.
- NOTE 4:** Oil-fired units require a 2W x 3H feet (0.6W x 0.9H meter) access portal in the stack for inspection and water washing. A floor drain is required at the bottom of the generator under or close to the burner opening.

**Figure 2-2** Standard exhaust stack layout for natural gas and light-oil installations only. Not recommended for heavy-oil machines.



\* See Notes 1 – 4 in Figure 2-2.

**Figure 2-3** Alternate multi-unit exhaust stack layout for natural gas and light-oil installations only.  
Not recommended for heavy-oil machines.

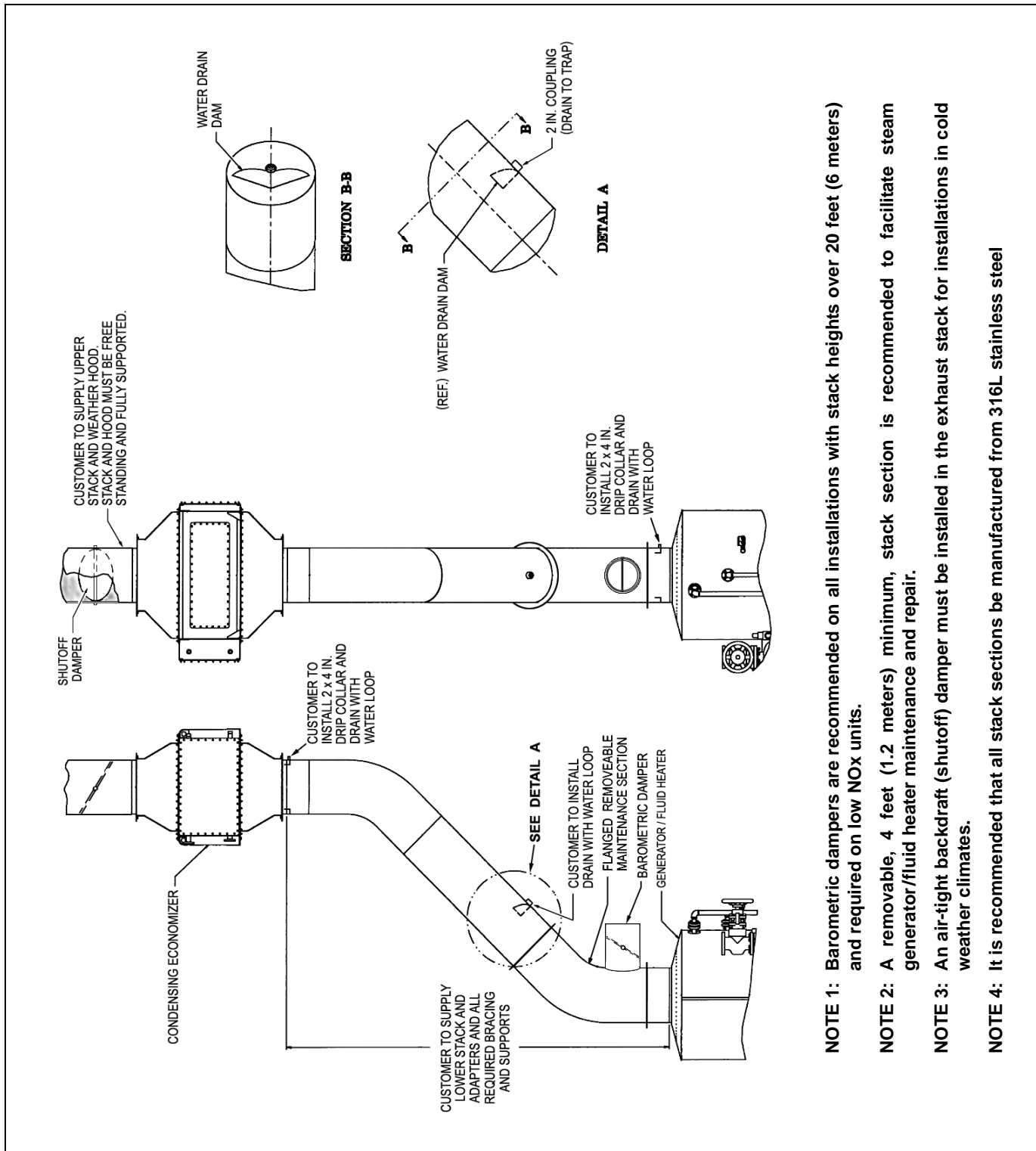


\* See Notes 1–4 in Figure 2-2.

**NOTE:** Exhaust stacks connecting to a common main stack must be offset from each other.

**Figure 2-4** Recommended heavy-oil exhaust stack layout for single or multi-unit installations.

## 2.5.2 Installing Exhaust Stacks With External Condensing Economizer



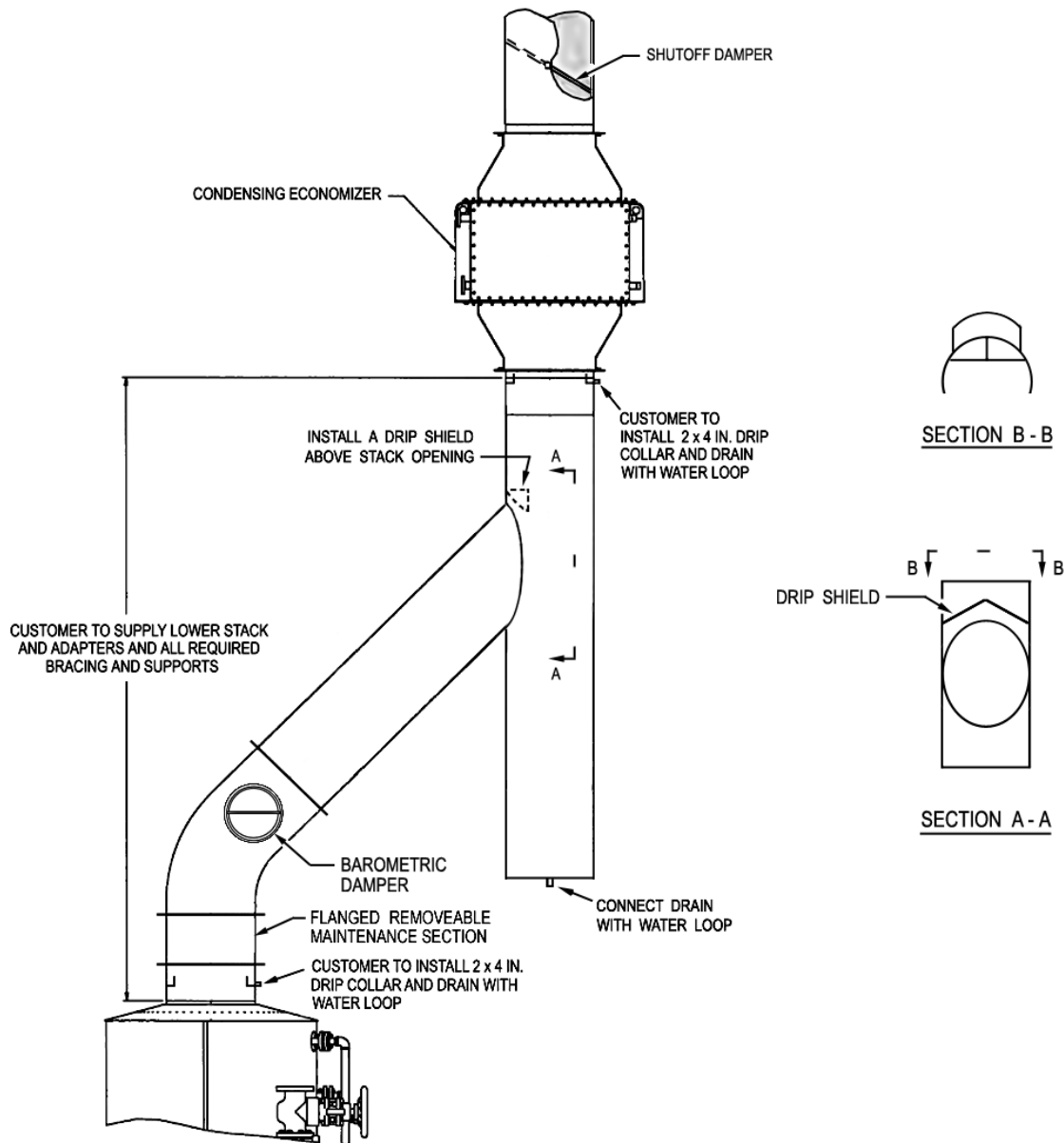
**NOTE 1:** Barometric dampers are recommended on all installations with stack heights over 20 feet (6 meters) and required on low NOx units.

**NOTE 2:** A removable, 4 feet (1.2 meters) minimum, stack section is recommended to facilitate steam generator/fluid heater maintenance and repair.

**NOTE 3:** An air-tight backdraft (shutoff) damper must be installed in the exhaust stack for installations in cold weather climates.

**NOTE 4:** It is recommended that all stack sections be manufactured from 316L stainless steel

**Figure 2-5 OPTION 1:** Recommended exhaust stack installation for steam generator/fluid heaters with Clayton condensing economizer.



**NOTE 1:** Barometric dampers are recommended on all installations with stack heights over 20 feet (6 meters) and on low NO<sub>x</sub> units.

**NOTE 2:** A removable, 4 feet (1.2 meters) minimum, stack section is recommended to facilitate steam generator/fluid heater maintenance and repair.

**NOTE 3:** An air-tight backdraft (shut off) damper must be installed in the exhaust stack for installations in cold weather climates.

**NOTE 4:** It is recommended that all stack sections be manufactured from 316L stainless steel

**Figure 2-6 OPTION 2:** Recommended exhaust stack installation for steam generator/fluid heaters with Clayton condensing economizer.

## 2.6 PIPING

### 2.6.1 General

Make sure no excessive strain or load is placed on any Clayton piping or their connections. Construct secure anchoring and support systems for all piping connected to the steam generator unit and associated water treatment package(s). Make sure anchoring and support systems keep motion and vibration to an absolute minimum. Ensure no extraneous vibrations are transferred to or from Clayton equipment. **DO NOT use Clayton connections as anchor points.**

Spring-loaded pipe hangers are **not** recommended. All customer connections are limited to  $\pm 200$  lb ( $\pm 90$  kg) of load and  $\pm 150$  ft-lb ( $\pm 200$  N•m) of torque in all directions (X, Y, and Z). Properly designed flex lines and anchoring may be used to meet loading requirements. Fuel, combustion exhaust ducts, and fresh air supply connections are not designed for loads.

Pipe routes must not be obstructive or create any potential safety hazards, such as a tripping hazard. Pipe trenches should be considered for minimizing pipe obstructions. Piping used to transfer a hot fluid medium must be adequately insulated.

Pipe unions or flanges should be used at connection points where it is necessary to provide sufficient and convenient disconnection of piping and equipment.

Steam, gas, and air connections should enter or leave a header from the top. Fluids, such as oil and water, should enter or leave a header from the bottom. A gas supply connection must have a 12–18 in. (30–45 cm) drip leg immediately before Clayton's fuel connection.

Prevent dissimilar metals from making contact with one another. Dissimilar metal contact may promote galvanic corrosion.

Globe valves are recommended at all discharge connections from Clayton equipment that may require periodic throttling, otherwise gate or ball valves should be used to minimize pressure drops.

### 2.6.2 Systems

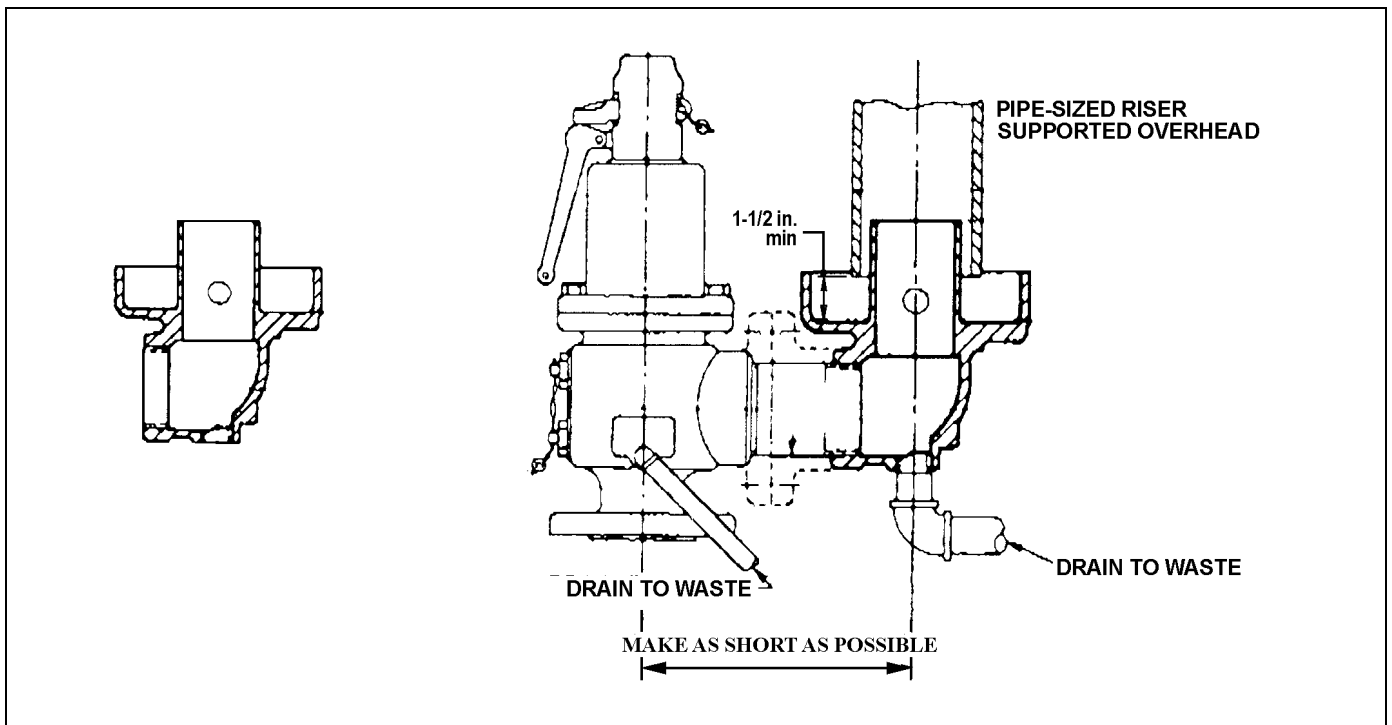
Table 2-2 below is for steam generators rated below 250 psig (17.2 bar). It indicates the recommended material to be used for the various piping systems associated with the installation.

**Table 2-2: Piping Recommendations**

SYSTEM	RECOMMENDED MATERIAL/COMPONENTS
Steam and Condensate System	Steam and condensate system piping should be a minimum Schedule 40 black steel (seamless Grade B preferred). Refer to ASME guidelines for proper pipe schedules. Steam headers should contain a sufficient number of traps to remove condensed steam, and help prevent "water hammer." The separator discharge requires one positive shut off globe valve at the separator discharge flange.
Blowoff/Drain	ASME codes require that all blow-off piping be steel with a minimum Schedule 80 thickness and all fittings be steel and rated at 300 psi. Boiler blow off piping should not be elevated.

**Table 2-2: Piping Recommendations**

<b>SYSTEM</b>	<b>RECOMMENDED MATERIAL/COMPONENTS</b>
Steam Trap(s) Discharge	Steam trap(s) discharge piping should be Schedule 40 black steel. Pipe size should be the same as that of the separator trap(s) connection up to the first elbow. The pipe size must be increased one pipe size after the first elbow, and again after manifolding with additional units. It is preferable to have the trap return line installed so its entire run is kept below the hot-well tank connection (to assist in wet layup). If this is not possible, then the line must be sloped downward toward the hot-well at a rate of 1/8 inch per foot.
Fuel (gas or oil)	Schedule 40 black iron (See Section IV), local agencies/codes may require heavier pipe, and heavier fittings for oil lines.
Atomizing Air (oil only)	Schedule 40 black iron (See Section IV)
Safety Relief Valve Discharge	Safety relief valves must discharge to atmosphere in a direction that will not cause harm to personnel or equipment. The discharge piping must not contain any valves or other obstruction that could in any way hinder the release of steam. A drip pan elbow with appropriate drains should be installed as shown in Figure 2-7.
Back Pressure Regulator	Installing a Back Pressure Regulator (BPR) on all installations is highly recommended by Clayton Industries. A BPR is required for all units sold with Auxiliary Pressure Control (APC), Master Lead-Lag, and automated startup controls. The BPR protects against drying-out and localized over-heating of the heating coil during large steam pressure changes.

**Figure 2-7 Safety Relief Valve Discharge**

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**NOTE**

It is the responsibility of the installer to ensure that all piping and fittings are properly rated (material type, thickness, pressure, temperature) for the intended system application. It is also the responsibility of the installing party to design all piping systems so as to ensure that Clayton specified flow and pressure requirements (See Section VI, Table 1) are satisfied.

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### 2.6.3 Atmospheric Test Valve

An important, yet often overlooked, function of a properly installed steam piping system is the ability to perform full load testing of the steam generator(s) when the main steam header is restricted from accepting steam. This is most commonly encountered during the initial start-up when commissioning a steam generator. This condition will also occur when it is necessary to test or tune a steam generator during periods of steam header or end-user equipment repairs, when header pressure must be maintained to prevent cycling the generator off, or when an overpressure condition exists while in manual operation.

To facilitate full load testing of a steam generator, an easily accessible or chain operated, globe-type, atmospheric test valve ***must be installed*** in the steam header (downstream of a back pressure regulator, if so equipped, and upstream of at least one steam header isolation valve). The atmospheric test valve must be capable of passing 100 percent of the generator's capacity.

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**WARNING**

A discharging atmospheric test valve produces extremely high noise levels. Extended exposure to a discharging atmospheric test valve can lead to hearing loss. Installing a silencer is strongly recommended.

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### 2.6.4 Steam Header and Steam Sample Points

Clayton requires appropriately constructed steam header connections, and at least one steam sample point per generator. All steam header connections from and to Clayton's equipment must originate from the steam header vertically upward prior to changing direction toward Clayton's equipment.

Clayton requires all steam sample connections used to measure steam quality, or efficiency, originate from the steam header vertically upward prior to heading to any sample cooler, water quality, or efficiency testing/measuring equipment. Clayton requires the equivalent of three (3) pipe diameters of uninterrupted straight lengths of steam header prior to and after the sample point.

## 2.7 FEEDWATER TREATMENT

The importance of proper feedwater treatment cannot be over-emphasized. The Clayton steam generator is a forced-circulation, monotube, single pass, watertube-type packaged boiler requiring continuous feedwater treatment and monitoring. The water in the hot-well tank is actually boiler feedwater.



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**NOTE**

It is imperative that proper feedwater treatment chemicals and equipment are in place and operational prior to filling the heating coil.

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The Clayton Feedwater Treatment Manual, furnished with each new unit, provides detailed information regarding Clayton feedwater treatment requirements, products, and equipment.

In general, the feedwater supplied to your Clayton steam generator must:

- Hardness: 0 ppm (4 ppm maximum)
- pH 10.5–11.5 (normal range), maximum of 12.5
- Oxygen free with an excess sulfite residual of 50–100 ppm during operation (> 100 ppm during wet lay-up)
- Maximum TDS of 8,550 ppm (normal range 3,000–6,000 ppm)
- Maximum dissolved iron of 5 ppm
- Free of suspended solids
- Maximum silica of 120 ppm with the proper OH alkalinity

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**NOTE**

Review the Clayton Industries Feedwater Treatment Reference Manual (P/N: R015216) for additional feedwater quality requirements.

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### 2.7.1 Water Softeners

Refer to the Clayton Water Softener Instruction Manual for detailed information regarding the installation, dimensions, and operation of Clayton water softening equipment. Some general guidelines are provided below.

Cold water piping to the water softener(s), and from the water softeners to the makeup water control valve should be schedule 40 galvanized steel or schedule 80 PVC.

Install anti-siphon device (if required by local health regulations) in the raw water supply line.

## 2.7.2 Make-up Water Line Sizing

Table 2-3 shows the pipe sizes required from the water softener to hot-well. The supply pressure must be at least 65 psi (450 kPa).

Note 1: All models use a makeup water solenoid valve.

Note 2: Water flow is based on 44 lb. per hour per bhp (boiler horsepower).

## 2.8 FEEDWATER SUPPLY REQUIREMENTS

The feedwater supply line sizing will be a minimum of one line size larger than the inlet connection size of the Clayton feedwater pump. Fractional dimensions will be rounded up to the larger whole-sized dimension.

**Table 2-3: Makeup water valve and pipe sizes**

BHP	Make-up Valve (in.)	Minimum Line Size (in.)
15	1/2	1/2
30	1/2	1/2
40	1/2	1/2
75	3/4	3/4
100	3/4	1
125	3/4	1

---

### NOTE

Clayton takes advantage of the limited length and lower velocities to minimize its internal line sizes. This common industry practice works well on Clayton's internal piping and pump head designs. The very short equivalent pipe lengths and quickly dividing flows (lower velocities) within our pump designs yields lower velocities and acceleration head.

Unfortunately, the customer and installing contractor experience the reverse when designing their feedwater piping system. They are usually faced with much longer equivalent length pipe runs and/or have to deal with a pipe required to carry more than one generator's flow. Therefore, it is critical for the installation designer to increase supply line sizes to meet Clayton's requirements for velocity and acceleration head. See paragraph 2.8.2 and 2.8.3.

---

### 2.8.1 Multi-unit Systems

In a multi-unit installation, Clayton recommends running separate supply lines to each feedwater pump. However, in some situations, it may be impractical to run separate supply lines. If a common supply line is chosen, Clayton suggests the following:

- Make proper calculations to ensure velocities and head acceleration requirements are maintained.
- If two or more pumps operate in parallel, with a common suction line, calculate the acceleration head for the common line by assuming that all pumps are synchronized, acting as one large pump. (The capacities of all pumps are added to determine line velocity.)
- Whenever possible, install the suction line header closer to the booster pumps, rather than closer to the individual feedwater pumps.

## 2.8.2 Velocity Requirements and Calculation

Clayton requires the feedwater supply line maintain all flow velocities under one foot per second (1 ft/s). Customers must ensure their line sizing calculations clearly show that supply pipe sizes are sufficiently large to maintain the less than 1 ft/s under all operational conditions. Refer to the charts in Figure 2-8 for velocity requirements.

Velocity of a fluid is the amount of fluid **F**low passing through an **A**rea, and the formula is  $V=F/A$ . Velocity is required in ft/sec for our use, so we must express our generators water flow in cubic feet and divide that by an area expressed in square feet. Clayton's generator water flows are all based on 44 lbs per boiler horsepower per hour; therefore, we must convert the pounds of water to cubic feet of water, and then convert the hour to seconds.

Let us find the velocity of 3 x 150 bhp generators running at 100% in a common manifold. This can be done by first calculating the total flow of water at the maximum firing rate. Since Clayton wants a minimum of 44 lbs/bhp-hr, the total flow required is:

$$F = (3 \times 150 \text{ bhp} \times 44 \text{ lbs/bhp-hr}) = \underline{19,800 \text{ lbs/hr}}$$

Next, we need to convert the flow from lbs/hr to ft<sup>3</sup>/hr by multiplying the flow by the conversion factor of 0.01602 ft<sup>3</sup>/lb of water. The converted flow is:

$$F = 19,800 \text{ lbs/hr} \times 0.01602 \text{ ft}^3/\text{lb} = \underline{317.2 \text{ ft}^3/\text{hr}}$$

Then, we need to convert hours to seconds. Since one hour has 3600 seconds, we simply divide the 317.2 ft<sup>3</sup>/hr by 3600. The converted flow is:

$$F = (317.2 \text{ ft}^3/\text{hr}) \div (3600 \text{ sec/hr}) = \underline{0.0881 \text{ ft}^3/\text{sec}}$$

Now that we have the flow (F), we need to know the area through which it will flow. Area is calculated by the formula  $A = \pi r^2$  where  $\pi$  is a constant equal to 3.14159, and r is the radius of the pipe ID being used. For this example, we will use 3-inch pipe. We will discount the differences between the ID of varying pipe schedules, water temperature, etc., to make this simple for the field. These are not meaningful for a quick check of the installation. To successfully complete the velocity calculation, we need to work with feet, so a conversion from inches to feet is required.

A 3 inch ID pipe has a radius of 1.5 inch. To convert inches to feet, divide the inches by 12 in./ft; therefore, in our example the radius is 1.5 in.  $\div$  12 in./ft = 0.125 ft

$$A = \pi r^2 = 3.14159 \times (0.125 \text{ ft})^2 = 0.049 \text{ ft}^2$$

Now that we have both the desired **flow** (0.088 ft<sup>3</sup>/sec) and the available **area** (0.049 ft<sup>2</sup>) of the 3-inch pipe it must pass through, we can calculate the **velocity**.

$$V = F \div A = (0.0881 \text{ ft}^3/\text{sec}) \div (0.049 \text{ ft}^2) = 1.8 \text{ ft/sec}$$

NOTE: Unfortunately, the velocity (V) in our example exceeds Clayton's maximum ft/sec.

TYPICAL FEEDWATER PIPE VELOCITIES FOR STEAM MASTER												
SCHEDULE 40/Std PIPE												
pipe size	15	25	30	35	40	50	60	75	80	100	120	
3/4"	0.79	1.32	1.59	1.85	2.12	2.64	3.17	3.97	Velocity requirement not satisfied			
1"	0.49	0.82	0.98	1.14	1.31	1.63	1.96	2.45	2.61	3.26	3.92	
1-1/4"	0.28	0.47	0.57	0.66	0.75	0.94	1.13	1.41	1.51	1.89	2.26	
1-1/2"	0.21	0.35	0.42	0.48	0.55	0.69	0.83	1.04	1.11	1.39	1.66	
2"	0.13	0.21	0.25	0.29	0.34	0.42	0.50	0.63	0.67	0.84	1.01	
2-1/2"	0.09	0.15	0.18	0.21	0.24	0.29	0.35	0.44	0.47	0.59	0.71	
3"	0.10	0.11	0.13	0.15	0.15	0.19	0.23	0.29	0.31	0.38	0.46	
3-1/2"	Velocity requirement satisfied				0.11	0.14	0.17	0.21	0.23	0.29	0.34	
4"							0.13	0.17	0.18	0.22	0.27	

SCHEDULE 80/XS PIPE												
SCHEDULE 80/XS PIPE												
pipe size	15	25	30	35	40	50	60	75	80	100	120	
3/4"	0.98	1.63	1.96	2.28	2.61	3.26	3.91	4.89	Velocity requirement not satisfied			
1"	0.59	0.98	1.18	1.37	1.57	1.96	2.35	2.94	3.14	3.92	4.71	
1-1/4"	0.33	0.55	0.66	0.77	0.88	1.10	1.32	1.65	1.76	2.20	2.64	
1-1/2"	0.24	0.40	0.48	0.56	0.64	0.80	0.96	1.20	1.28	1.60	1.92	
2"	0.14	0.24	0.29	0.33	0.38	0.48	0.57	0.72	0.76	0.96	1.15	
2-1/2"	0.10	0.17	0.20	0.23	0.27	0.33	0.40	0.50	0.53	0.67	0.80	
3"	0.11	0.13	0.15	0.15	0.17	0.21	0.26	0.32	0.34	0.43	0.51	
3-1/2"	Velocity requirement satisfied				0.13	0.16	0.19	0.24	0.25	0.32	0.38	
4"						0.15	0.18	0.20	0.20	0.25	0.29	

Figure 2-8 Velocity requirements for 15–120 bhp

The more relevant issue for this example is what size pipe manifold, as a minimum, do the 3 x 150 bhp generators need to meet Clayton's 1 ft/sec maximum flow velocity. This can be calculated using the same velocity equation  $V = F \div A$ . To find an area, we solve the equation for A (area), which is done by multiplying both sides of the equation by A, and dividing both sides of the equation by V; therefore, the area is equal to the flow divided by the velocity, or  $A = F \div V$ .

From our example above, we know that the flow is 0.0881 ft<sup>3</sup>/sec, and the maximum velocity Clayton requires is 1 ft/sec; therefore, we simply divide them to get the area.

$$A = F \div V = 0.0881 \text{ ft}^3/\text{sec} \div 1 \text{ ft/sec} = 0.0881 \text{ ft}^2$$

But we want a pipe size so we must convert an area in ft<sup>2</sup> backwards to a diameter in inches. To accomplish this we simply work the area of a circle backwards. From above we learned that the area of a pipe ID is  $A = \pi r^2$  so to find the r (radius) we simply divide both sides by  $\pi$ , and then take the square root of the result,  $r = \sqrt{(A \div \pi)}$ .

$$R = \sqrt{(A \div \pi)} = \sqrt{(0.0881 \text{ ft}^2 \div 3.14159)} = \sqrt{0.028} = 0.1675 \text{ ft}$$

Remember this is a radius in feet, so we need to convert it to a diameter by multiplying by 2 and converting feet to inches for pipe sizes.

$$\text{Pipe diameter size in feet} = 0.1675 \text{ ft} \times 2 = 0.3349 \text{ ft}$$

Now feet to inches:

$$0.3349 \text{ ft} \times 12 \text{ in./ft} = 4.02 \text{ inch pipe}$$

This shows that the 3 x 150 bhp generators require at least a 4-inch pipe size to manifold all 3 x 150s and meet Clayton's maximum flow velocity of 1 ft/sec. Remember that this must be done for each leg of the entire supply piping system using the specific flows in each leg.

### 2.8.3 Acceleration Head ( $H_a$ ) Requirements

On feedwater supply runs longer than 15 ft (4.5 m), or with multiple pump sets, customers must complete acceleration head loss calculations to show acceleration head losses are less than 0.75 foot/foot of equivalent pipe run for open hot-well systems (water temperatures less than 210° F {99° C}), and less than 0.5 foot/foot of equivalent pipe run for deaerator or semi-closed systems (water temperatures over 212° F {100° C}). UNDER NO CIRCUMSTANCES SHOULD THE IMPACT FROM  $H_a$  TO  $NPSH_A$  BE IGNORED (See paragraph 2.11.1.).

---

#### NOTE

All water flow calculations must be based on 44 lb. per hour per boiler horsepower adjusted for feedwater temperature.

---

## **2.9 FLEXIBLE FEEDWATER HOSE CONNECTION AND CONNECTION SIZING**

A two-foot flexible hose is required for connecting directly to the inlet of a Clayton reciprocating PD pump from the feedwater supply line. In some cases, a two-foot flexible hose may also be required at the reciprocating PD pump discharge outlet. The flexible section must be appropriately rated to satisfy pressure and temperature requirements.

### **2.9.1 Supply Side Connections**

Clayton's reciprocating PD pumps require that the connection made directly to the pump's inlet be a flexible hose section. This hose section should be a bellows-type hose protected by a stainless steel wire mesh sleeve. It must have at least a 24 in. (61 cm) length with a minimum 18 in. (45.5 cm) long-live length. This flexible hose section must be appropriately rated to meet the pressure and temperature requirements of the feedwater supply system. The supply-side piping system must include a pipe anchor directly at the inlet (hot-well/DA) side of the flexible connector.

### **2.9.2 Discharge Side Connections**

A flexible hose section is required at the reciprocating PD pump discharge outlet whenever it is relocated from its original, factory-designed, installation location. This hose section should be a bellows-type hose protected by a stainless steel wire mesh sleeve. It must have at least a 24 in. (61 cm) length with a minimum 18 in. (45.5 cm) long-live length. Because Clayton's mono-flow heating coil design usually increases feedwater discharge pressures from Clayton's reciprocating PD pump, this flexible hose section must be appropriately rated to meet the pressure and temperature requirements of the reciprocating PD pump output. The flexible hose rating requirements for the discharge will differ from the rating requirements for the inlet flexible hose section. Contact Clayton Engineering for the feedwater pressure of the specific generator model.

## **2.10 PUMP SUCTION AND DISCHARGE PIPING SYSTEM DESIGN**

The suction piping system is a vital area of the piping supply system. Therefore, its design requirements deserves more careful planning.

### **2.10.1 General Layout Guidelines**

- Lay out piping so no high points occur where vapor pockets may form. Vapor pockets reduce the effective flow area of the pipe and consequently make pump priming and operation difficult. Vent any unavoidable high points and provide gauge and drain connections adjacent pump.
- Install eccentric-type pipe reducers when required. Make sure these reducers are installed with the flat side up.
- Keep piping short and direct.
- Keep the number of turns to a minimum.
- Keep friction losses to a minimum by incorporating smooth fluid flow transitions in the piping layout. This can be accomplished with long radius elbows, two 45° elbows, or 45° branch laterals instead of tees.

- DO NOT use Clayton equipment for pipe support or pipe anchoring. It is the responsibility of the installation contractor and the customer to provide adequate and proper pipe supports and anchors. Clayton recommends all steam/fluid heaters, PD feedwater pumps, and water treatment skid pipe supports and anchors use floor-mounted structural steel.

## 2.10.2 Pipe Sizing Guidelines

### 2.10.2.1 Suction Piping

Clayton tends to follow the guidelines set forth by the Hydraulic Institute (HI) for positive displacement piston pumps. Equivalent pipe lengths for pipe fittings (elbows, tees, etc.) can be found in the HI reference charts.

---

#### NOTE

While Clayton cannot assume responsibility for the piping system into which our pump is installed, we can provide valuable guidelines for designing a piping system properly.

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Suction line sizing is a major factor in the successful operation of any pump. Many pump problems result from a suction line that is too small in diameter, or too long. A properly designed piping system can prevent problems, such as:

- Fluid flashing—Entrained fluid gases effuse when pressure in piping or pump falls below fluid vapor pressure.
- Cavitation—Free gases in a fluid being forced back into the fluid. These implosions cause severe pressure spikes that pit and damage pump internal parts.
- Piping vibration—This can result from improper piping support, cavitation, or normal reciprocating pump hydraulic pulses.
- Noisy operation—Most present when pump is cavitating.
- Reduced capacity—Can result from fluid flashing. If it is, this is an indication that the pumping chambers are filling up with gases or vapors.

These problems can reduce a pump's life and are a potential hazard to associated equipment and personnel. It is possible to fracture piping and damage the pump components with high pressure surges occurring when fluid is flashing or cavitating.

Suction piping must be a minimum of one size larger than the pump suction connection. The actual line sizes will depend on meeting flow velocity maximums (see Figure 2-8 on page 2-18), acceleration head calculations (see paragraph 2.11.3), and NPSH requirements (see Table 2-4 on page 2-23).

## 2.11 NET POSITIVE SUCTION HEAD (NPSH)

NPSH relates to the pressure (generally in terms of “head” of water, or psi) that a pump needs to prevent flashing or cavitation within the pump, primarily in the suction check-valve area. Flashing and cavitation will reduce necessary flow rates and cause damage to the internal pump components and coil.

NPSH is divided into two important aspects: what is available ( $NPSH_A$ ) from the suction vessel and piping, and what is required by the pump ( $NPSH_R$ ).

### 2.11.1 $NPSH_A$

Pump  $NPSH_A$  is the usable pressure (usually expressed in feet of water column or psi) available at the inlet of the pump. For Clayton systems that typically operate with near-boiling water,  $NPSH_A$  is determined by the elevation difference between the operating hot-well tank water level and the inlet to the pump, minus frictional losses and minus acceleration head losses.

---

#### NOTE

If a hot-well tank cannot be sufficiently elevated to supply the required  $NPSH_A$ , a booster pump will be required. To convert booster pump pressure (psi) to foot of head, use the following formula:  $\text{psi} (2.3067) = \text{ft of water}$ .

---

Booster pumps should be placed adjacent to the feedwater supply (suction) vessel. The total suction system's  $NPSH_A$  must be greater than the booster pump's  $NPSH_R$ . The discharge head of the booster pump must be sufficient to provide a pressure of at least 25% greater than Clayton's reciprocating PD pump's  $NPSH_R$ , plus pipe friction losses, plus acceleration head losses, and plus 2.5 ft. Velocity and acceleration head design requirements are specified in paragraphs 2.8.2, page 2-17, and 2.8.3, page 2-19, and velocity chart in Figure 2-8, pages 2-18.

- 1) **Suction System:  $NPSH_A = \text{Receiver Elevation Head or Booster Pump Head} - \text{Friction Loss} - \text{Acceleration Head Loss} - \text{Pump Head Elevation (Typically 2.5 ft [0.76 m] above ground.)}$**
- 2)  **$NPSH_R = \text{Clayton Feedwater Pump Net Positive Suction Head Required (See Table 2-4.)}$**
- 3)  **$NPSH_A$  must be at least 25% greater than  $NPSH_R$ . ( $NPSH_A > 1.25 NPSH_R$ )**

**NOTE:  $NPSH_A$  is increased by increasing receiver head, booster pump head, or line size.**

A suction pulsation dampener or stabilizer directly adjacent to the Clayton feedwater pump connection is required.

### 2.11.2 $NPSH_R$

Pump  $NPSH_R$  is the pressure (usually expressed in feet of water column or psi) required at the inlet of the pump that will enable the pump to operate at rated capacity without loss of flow due to flashing or cavitation in the pump. The  $NPSH_R$  is relative to the pump inlet (suction) connection. The  $NPSH_R$  number for a Clayton pump was determined experimentally by Clayton (see Table 2-4).



**Table 2-4: Clayton's NPSH height requirements<sup>a</sup>**

Model	Feet	Meters
CSM-15	7	2.1
CSM-30	7	2.1
CSM-40	7	2.1

<sup>a</sup> Requirements shown are based on Clayton's standard reciprocating PD pump usage. Alternate pumps that require higher NPSH<sub>R</sub> are used on some generators. Check Clayton's P & I D drawing for specific requirements.

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**NOTE**

Water flow is based on 44 lb. per hour per bhp. NPSH<sub>R</sub>s shown are for 150 psi design steam pressure. Higher steam pressures could change these numbers.

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### 2.11.3 Acceleration Head (H<sub>a</sub>)

Unlike centrifugal pumps that provide a smooth continuous flow, positive displacement pumps (typically used by Clayton) cause an accelerating and decelerating fluid flow as a result of the reciprocating motion and suction valves opening and closing. This accelerated and decelerated pulsation phenomenon is also manifested throughout the suction pipe. The energy required to keep the suction pipe fluid from falling below vapor pressure is called acceleration head. For installations with long piping sections, this becomes a significant loss to overcome and must be carefully considered. If sufficient energy is absent, then fluid flashing, cavitation, piping vibration, noisy operation, reduced capacity, and shortened pump life can occur.

To calculate the H<sub>a</sub> required to overcome the pulsation phenomenon, use the following empirical equation:

$$H_a = \frac{LVNC}{gk}$$

where:

H<sub>a</sub> = Head in feet (meters) of liquid pumped to produce required acceleration

L = Actual suction pipe length in feet (meters)

V = Mean flow velocity in suction line in feet per second (m/s) (See Figure 2-8, page 2-18.)

N = Pump speed in rpm (See Table 2-5, below.)

C = Pump constant factor of ...

0.400 for simplex single acting

0.066 for triplex single acting

g = Acceleration of gravity = 32.2 ft/s<sup>2</sup> (9.8 m/s<sup>2</sup>)

k = Liquid factor of...

1.5 for water

1.4 for deaerated water

1.3 for semi-closed receiver water

**Table 2-5: Clayton Pump Speeds**

Generator	CSM-15	CSM-30	CSM-40
Pump Speed (RPM)	220	294	330

Since this equation is based on ideal conditions of a relatively short, non-elastic suction line, calculated values of  $H_a$  should be considered as approximations only.

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**NOTE**

As pump speed (N) is increased, mean flow velocity (V) also increases. Therefore, acceleration head ( $H_a$ ) varies as the square of pump speed.

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**NOTE**

Acceleration head varies directly with actual suction pipe length (L).

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**IMPORTANT**

ACCELERATION HEAD IS A SUCTION PIPING SYSTEM FACTOR THAT MUST BE ACCOUNTED FOR BY THE PIPING SYSTEM DESIGNER. MANUFACTURERS CANNOT ACCOUNT FOR THIS IN THEIR DESIGNS BECAUSE OF THE LARGE VARIETY OF APPLICATIONS AND PIPING SYSTEMS PUMPS ARE INSTALLED IN.

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**NOTE**

If acceleration head is ignored or miscalculated, significant pump and piping system problems (suction and discharge) may result.

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Clayton recommends placing a suction pulsation dampener or stabilizer adjacent to the positive displacement reciprocating pump suction connection. This will help to protect the booster pump from the pulsating fluid mass inertia of the positive displacement reciprocating pump and to reduce the effect of acceleration head.

## 2.12 GENERAL INSTALLATION CONCERNS

### 2.12.1 Charge (Booster) Pumps

Charge (booster) pumps should be sized to 150% of rated Clayton pump volume. Charge pumps must be centrifugal-type pumps—not positive displacement pumps. Recommended pump head for charge pumps is 18–25 psi; low pressure units (15 psi safety valve) should be rated from 7 psi to 8 psi to avoid tripping the limit pressure switch (LPS). Consult Clayton for recommendations when charge pumps higher than 25 psi will be used.

### 2.12.2 Charge Pumps Are Not A Substitute

Charge pumps are not a good substitute for short, direct, oversized, suction lines. They are also not a substitute for the computation of available NPSH, acceleration head ( $H_a$ ), frictional head ( $H_F$ ), vapor pressure, and submergence effects being adequately considered.

### 2.12.3 Multiple Pump Hookup

The preferred configuration for connecting two or more reciprocating pumps in a system is to provide each pump with their own piping system. This will ensure each pump is isolated from the effects of another pump's cyclical demands.

Connecting two or more reciprocating pumps to a common suction header IS NOT recommended. Designing such a pump system can frequently cause severe pump pounding, vibration, and premature check-valve and diaphragm failure. In addition, attempting to analyze the operation of multiple pumps connected to a common suction header through mathematical calculations becomes impossible.

## 2.13 ELECTRICAL

All customer-supplied electrical wiring must be properly sized for the voltage and amperage rating of the intended application. Full load amperage (FLA at 230V) requirements for each model are provided in Table 6-1 of Section VI.

A fused disconnect switch (customer furnished) must be installed in accordance with NEC 430 and should be located within view of the steam generator. The switch should be easily accessible to operating personnel. Clayton provides a set of terminals in the steam generator electrical control cabinet for wiring an emergency stop device (customer furnished).

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#### NOTE

Additional access holes are located in the bottom of the electronics control cabinet.  
DO NOT make any holes in the sides or top of the electrical cabinet(s).

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Clayton strongly recommends surge protection for all its equipment. Isolation transformers are recommended for areas subject to electrical variations due to weather, weak or varying plant power, or old systems.

Isolation transformers are required on all electrical systems that are based on delta distribution systems. Clayton recommends electrical connections be made through a grounded wire system only.

Clayton electronics cabinet devices are rated to function properly at typical boiler room temperatures not exceeding 120° F (49° C). For boiler room installations where temperatures are expected to rise above 120° F (49° C), installation of a Clayton electronics cabinet cooler is required. This cooler requires a supply of clean, dry compressed air at 40 scfm (1.13 m<sup>3</sup>/min.) at 100 psi (6.9 bar).

## **2.14 ELECTRICAL GROUNDING**

Clayton's steam generator, fluid heater, and water skid installations must have an electrical grounding network with a resistance no higher than 2 Ohms to earth ground when measured at its control box(es). Clayton requires a separate, direct earth ground at each of its unit installations.

Grounding wires must be routed directly with electrical power supply wiring and sized according to the connected amperage, but never less than 8 awg. A separate ground wire must be run to each steam generator/fluid heater frame and water skid frame

# SECTION III - CLAYTON FEEDWATER SYSTEMS

## 3.1 GENERAL

Clayton steam generator feedwater systems are designed with an open (hot-well). The selection of the proper feedwater system is determined by the steam generator's application, the installation environment, and other factors. Each system is discussed in detail in later paragraphs in this section.

The feedwater system's pipes, as well as the heating coil, are susceptible corrosion if proper feedwater treatment is neglected. Corrosion in the pipes are due to three fundamental factors—dissolved oxygen content, low pH, and temperature. Oxygen is required for most forms of corrosion. The dissolved oxygen content is a primary factor in determining the severity of the corrosion. Removing oxygen, and carbon dioxide, from the feedwater is essential for proper feedwater conditioning. Temperature and low pH affects the aggressiveness of the corrosion.

Deaerators are designed to remove most of the corrosive gases from the feedwater. Deaeration can be defined as the mechanical removal of dissolved gases from a fluid. There are many types of Deaerators; however, the ones most commonly used for deaerating boiler feedwater are the open (atmospheric), pressurized jet spray, and tray type. To effectively release dissolved gases from any liquid, the liquid must be kept at a high temperature. Deaerators are pressurized above atmospheric pressure (typically 3–15 psig) to maintain the feedwater at a higher boiling point. The increased pressure and temperature releases the dissolved gases from the feedwater and those gases are vented to atmosphere.

Clayton offers an open hot-well, water skid package for the Steam Master steam generator. The skid package options, and required customer connections are described below.

## 3.2 SKID PACKAGES

**A. Individual Components** The steam generator unit and all water treatment components are furnished separately. Placement of each component and its assemblies and interconnections are determined by the installer.

**B. Water Treatment Skid** All water treatment components are mounted on a skid and provided along with the steam generator. Components include receiver, softeners, chemical pumps, blowdown tank, control box, and booster pumps if applicable. Skid piping and electrical interconnections between the skid components are included.

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### NOTE

All Clayton-supplied water skids must be fully grouted in place once leveling and anchoring are complete.

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### 3.3 CUSTOMER CONNECTIONS

The required customer connections for the typical water treatment components included with an open feedwater receiver system is identified in Tables 3-1 and 3-2 below. The type and size of each is provided on supplemental drawings and instructional literature.

**Table 3-1: Hot-well (Open) System**

<b>Customer Connection</b> <b>Skid Type</b>	Feedwater <sup>a</sup> Outlet	Vent	Drain	Overflow	Overflow/ Drain	Condensate Returns	Traps Returns	Steam Heating	Chemical Injection	Makeup Water
None	X	X	X	X		X	X	X	X	X
Condensate Skid	X	X	X	X		X	X	X	X	X
Water Skid	X	X			X	X	X	X	X	X

<sup>a</sup> Feedwater outlet connections apply only on Condensate and Water Skids without Booster Pumps.

**Table 3-2: Hot-well (Open) System**

<b>Customer Connections</b> <b>Skid Type</b>	Booster Pump(s)			Water Softener(s)			Blowdown Tank			
	Inlet	Outlet	Recirc	Inlet	Outlet	Drain	Inlet	Outlet	Vent	Cooling Water Inlet
None	X	X	X	X	X	X	X	X	X	X
Condensate Skid		X		X	X	X	X	X	X	X
Water Skid				X		X		X	X	

### 3.4 OPEN SYSTEM

(See P&ID in Appendix C for reference.)

In an open system, the makeup water, condensate returns (system and separator trap returns), chemical treatment, and heating steam are blended in an atmospheric feedwater receiver tank, (vented to atmosphere - under no pressure). Open feedwater receiver systems are sized to provide the necessary volume of feedwater and sufficient retention time for the chemical treatment to react. Condensate, separator trap returns and feedwater treatment chemicals are injected at the opposite end of the tank as the feedwater outlet connection. This helps to avoid potential feedwater delivery problems to the booster or feedwater pump(s), and to provide sufficient reaction time for the chemical treatment.

Installation guidelines for the feedwater receiver are provided below. Descriptions for the other water treatment and accessory components are provided in Section VII (Optional Equipment) and/or in the Clayton Feedwater Treatment Manual.

---

**NOTE**

All piping to and from the feedwater receiver must remain the same or larger size as the tank connection and not reduced. See Table 3-3 below for connection requirements.

---

**Table 3-3: Feedwater Receiver Connections**

Feedwater Outlet	This is the supply connection for properly-treated feedwater to the booster pump(s) or feedwater pump(s). Depending on the tank size, this connection may be either on the bottom or on the side of the tank. A valve and strainer (0.125 mesh) must be installed in the feedwater supply piping at the inlet to each pump (shipped loose if Clayton furnished - except on Skids). Follow the guidelines outlined in Section 2.8 through 2.12. <b>Feedwater line must be constructed to provide the required NPSH, velocity under 1 ft/s, and acceleration head losses less than 0.75 ft/ft to the feedwater pump inlet.</b> Restrictions in this line will cause water delivery problems that may result in pump cavitation and water shortage problems in the heating coil.
Gravity Fill	Install a pipe tee in the feedwater outlet line just below the feedwater outlet connection. On an elevated receiver system, this pipe tee provides a connection for the gravity fill plumbing coming from the heating coil.
Vent	Vent piping must be installed so as not create back pressure on the hotwell. The vent pipe should be as short as possible, contain no valves or restrictions, and run straight up and out. Ninety degree elbows are to be avoided. A 45° offset should be provided at the end of the vent line to prevent system contamination during severe weather conditions and/or during shutdown periods.
Chemical Injection	One common feedwater chemical injection connection is provided into which all feedwater treatment chemicals are introduced. A check-valve must be installed in the discharge line of each chemical pumping system.
Overflow	No valves are to be installed in the overflow piping. Overflow piping must be plumbed to the blowdown tank discharge piping at a point prior to the temperature valve sensor. The overflow line must be full size, not reduced. Clayton recommends installing a "P-trap" on all overflow lines.
Drain	A valve must be provided in the drain line. As indicated above, the drain line can be tied into the overflow line as long as the line size downstream of the merge remains at least the size of the overflow connection on the tank.

**NOTE**

The feedwater receiver drain and overflow lines (run independently or tied together) may contain up to 212° F water and must be routed to the Blowdown Tank discharge piping at a point prior to the temperature valve sensor.

---

**Table 3-3: Feedwater Receiver Connections**

Condensate Returns, Temperature Control & Sparger Tube(s)	The condensate return connection is the point where all system condensate returns, separator trap discharge, and heating steam are introduced. The hotwell may use one or two condensate return connections, depending on the tank size and return volume. This injection point is located below the water line and connected to a sparger tube(s). Introducing the steam and hot condensate below the water line in conjunction with using the sparger tube reduces the velocity and turbulence created at the injection point, while minimizing flash steam losses and noise. On tanks containing two condensate return connections one is used for system condensate returns, the other is used for the separator trap discharge and heating steam. In all cases, a check-valve must be installed in the condensate return and steam supply lines to prevent back-feeding. The check-valve must be located as close to the feedwater tank as possible. When installing a sparger tube(s) it must be installed so that the holes are in a horizontal position. This is confirmed on Clayton manufactured hot-wells (up to 200 bhp) by visual verification that the “X” stamping on the external section is in the “12 o’clock” position.
--	--

---

**NOTE**

Clayton feedwater receivers are sized for proper flow and chemical mixture. If a customer’s condensate system creates large surges in returns at start up or while in operation, it may cause the feedwater receiver to overflow. Proper evaluation of the condensate return system and final feedwater receiver sizing is the customer’s responsibility.

---



# SECTION IV - FUEL SYSTEM

## 4.1 GENERAL

Clayton's Steam Master steam generators are designed to fire on natural gas, propane, or No. 2 distillate light fuel oil. On combination natural/propane gas and fuel oil machines, each fuel type requires its designated burner manifold to operate. These burner manifolds must be exchanged, manually, to match the fuel-type desired. Characteristics of, and installation guidelines for, both gas and oil fuel systems are described in detail in the following paragraphs.

---

### NOTE

The installing contractors are responsible for ensuring that all piping and fittings are rated for the intended system installation (material type, thickness, pressure, temperature). The installing contractors are also responsible for ensuring the steam system design meets the flow and pressure requirements of a Clayton steam generator (see Section VI, Table 1).

---

## 4.2 NATURAL GAS

Clayton's Steam Master steam generators are built in accordance with ANSI/ASME CSD-1, (C)UL [(Canada) Underwriters Laboratories], FM (Factory Mutual) guidelines, and IRI (Industrial Risk Insurers)/GEGAP compliance. High and low gas pressure switches (with manual reset) are standard on all gas trains.

Unless otherwise stated (liquid petroleum and other gas operation requires engineering evaluation), the standard Clayton gas burner is designed for operation using pipeline-quality natural gas. Gas supply connection sizes and rated gas flows for each model are provided in Tables 1 and 2 of Section VI. The gas supply line must be sized to provide both the supply pressure *and* full rated flow indicated in Table 1 of Section VI without "sagging" (pressure drop). The gas supply pressure must not vary more than  $\pm 5\%$  of Clayton's required supply pressure.

---

### NOTE

All gas supply piping must include a minimum 12-inch drip leg immediately before Clayton's gas train connection, and be fully self-supporting.

---

Gas pressure regulation is required. A regulated minimum of 2 psi gas pressure is required at the inlet to the gas train. Pressure regulators should be sized to pass 25% excess gas at full open position with minimal pressure drop. One-eighth inch vent lines are needed for both the high and low gas pressure switches.

---

**NOTE**

Refer to local codes regarding vent manifolding.

---

## **4.3 OIL**

### **4.3.1 General**

Clayton Steam Master oil-fired steam generators are step-fired and designed with pressure atomizing-type oil burners. A 0.5–10 psig fuel oil pressure is required at the inlet to the fuel oil pump.

---

**NOTE**

All Clayton liquid fuel systems require a fuel return line in addition to the fuel supply line. Clayton recommends fuel return lines have no isolation valve, or only valves with position open locking mechanisms.

---

---

**NOTE**

It is the customer's responsibility to implement and meet state, local and EPA code requirements for fuel oil storage.

---

### **4.3.2 Light Oil**

The Clayton light-oil burner is designed for operation with No. 2 distillate light fuel oil as defined by ASTM D 396 - Standard Specifications for fuel oils.

---

**NOTE**

A fusible-link-actuated shutoff valve is required in the fuel oil supply line when a machine is installed within FM (Factory Mutual) jurisdiction. This is not within the Clayton scope of supply and must be provided by the installer.

---

A Clayton step-fired light-oil fuel system uses a direct-fire ignition.

# SECTION V - TRAP SEPARATORS

## 5.1 GENERAL

Clayton Steam Generators require the same basic boiler feedwater treatment as any other water-tube or fire-tube boiler. All require soft water with little or no dissolved oxygen, a sludge conditioner, and a moderate to high pH. The water supplied from the Condensate Receiver should meet these conditions.

The primary distinction between a Clayton Steam Generator and drum type boiler is how and where the desired pH levels are achieved. The feedwater in the Feedwater Receiver is boiler water for the Clayton but similar to makeup water for the drum type boiler. Conventional boilers concentrate the boiler feedwater in the drum and maintain Total Dissolved Solids (TDS) levels and pH through blowdown. A system consisting of only Clayton Steam Generators uses the Feedwater Receiver much the same way conventional boilers use drums except that blowdown is taken off the separator trap discharge. Typically, drum type boilers cannot tolerate the higher pH levels that must be maintained in the Feedwater Receiver to satisfy Clayton feedwater requirements. Both systems work well independently, however feedwater chemical treatment problems arise when the two are operated in tandem with a common feedwater receiver - Clayton with conventional boiler(s).

The Clayton Trap Separator was designed to remedy the boiler compatibility problem. Using a Trap Separator allows both the Clayton and conventional boiler(s) to operate together while sharing the same Feedwater Receiver. Each system receives feedwater properly treated to suit its respective operating requirements. If a Trap Separator is not used, pH is either too high for the conventional boiler(s) or too low for the Clayton.

## 5.2 OPERATION

The separator trap returns from the Clayton Steam Generator(s) contain a high concentration of Total Dissolved Solids (TDS). This high concentration of TDS is undesirable to conventional boilers because the blowdown rate would have to be increased (and could not be increased enough if the feedwater TDS level was over 3000 ppm). By routing the separator trap returns to the Trap Separator, rather than to the common Feedwater Receiver, the high concentration of TDS in the trap returns is isolated to the Clayton system. This not only eliminates the conventional boiler blowdown problems, but also satisfies the higher pH requirement of the Clayton Feedwater. The construction of a Trap Separator is very similar to that of a Blowdown Tank. Separator trap return enters tangentially creating a swirling action. Flash steam is vented out the top and low pressure condensate is fed to the Booster Pump(s) from the outlet.

This relatively small amount of concentrated water blends with the larger volume of less concentrated feedwater being supplied from the Feedwater Receiver (ideally, the chemical treatment for both systems is injected into the Feedwater Receiver) to produce a mixture of properly treated feedwater entering the Clayton Heating Coil(s). The other boiler(s) receive feedwater containing the pH and TDS levels they require.

## 5.3 INSTALLATION

(Refer to Figures 5-1, 5-2, and 5-3.)

### 5.3.1 General

As shown on Figures 5-3 three sizes of trap separators have been designed to handle a broad range of boiler horsepowers. Typical dimensions for each trap separator are provided in Figure 3. Line sizes for the trap separator connections are provided and should be kept full size (no reductions). The trap separator and connected piping must be properly supported. The trap separator is maintained at the same pressure and water level as the feedwater receiver and should be installed at an elevation that puts the water level midpoint in the sight glass.

### 5.3.2 Trap Separator Vent

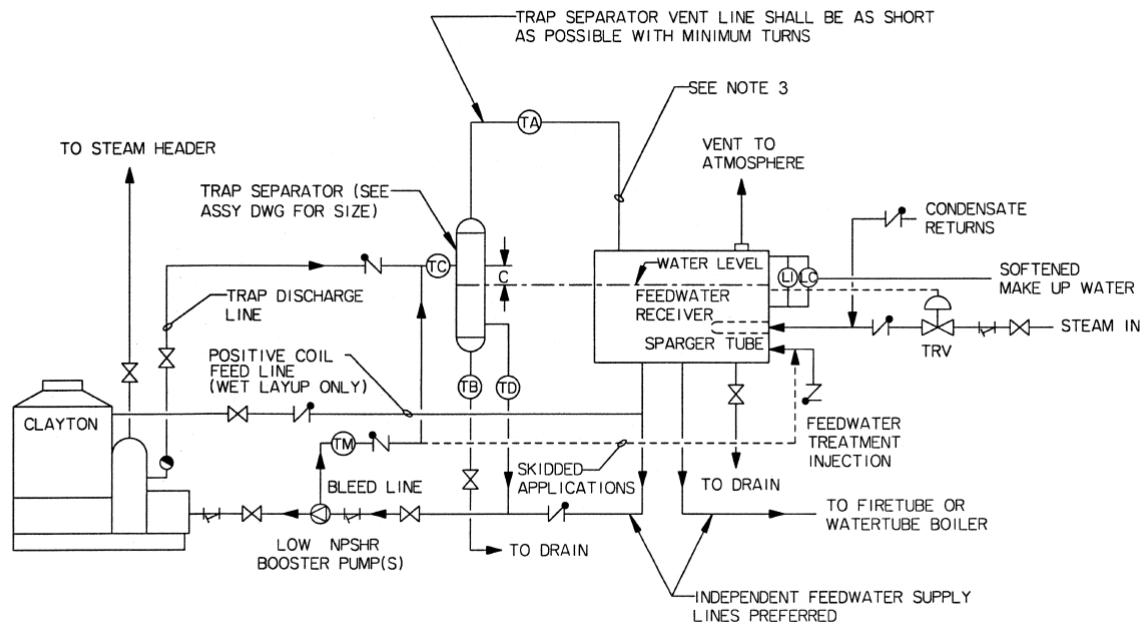
The trap separator vent line must be large enough to handle the flash steam with little or no pressure drop and without affecting the water level. Proper vent line sizes for specific horsepower ranges are indicated on Figures 5-1 and 5-2 and must not be reduced. On deaerator (DA) applications the vent flash steam should be introduced into the same section of the deaerator as the Pressure Regulating Valve (PRV) steam injection. On open system applications, the vent line should be introduced to the top of the feedwater receiver. Refer to Figure 5-1.

The trap separator outlet is tied into the booster pump(s) feedwater supply line from the common feedwater receiver. The outlet piping should be constructed so as to provide the required NPSH to the booster pump(s) inlet. (any frictional loss subtracts from the available NPSH). The outlet piping should contain a minimum number of elbows and fittings, and no valves or check valves.

### 5.3.3 Feedwater Receiver Supply Lines

Provisions should be made for the feedwater receiver to have independent feed lines for the Clayton and conventional boiler feedwater supply. If not isolated, there is a potential for the larger feedwater pumps of the conventional boiler system to draw the water out of the trap separator and away from the Clayton feedwater supply system. This disrupts the chemical treatment in both systems and may cause water shortage and pump cavitation problems in the Clayton system. If independent feed lines are not possible, a swing check valve must be installed in the feedwater supply line to prevent backflow away from the Clayton system. (Refer to Figure 5.1)

## SPECIFICATIONS: TRAP SEPARATOR - ALL GENERATORS



**DIAGRAM OF CLAYTON TRAP SEPARATOR HOOKUP  
W/ OTHER BOILER AND COMMON FEEDWATER RECEIVER**

LINE SIZES		
LETTER	DESCRIPTION	P/N UH33572 UP TO 300 BHP
TC	TRAP RETURN	2" FLG.
TA	TRAP SEPARATOR VENT	3" FLG.
TD	FEEDWATER LINE TO CLAYTON	2" FLG.
TB	TRAP SEPARATOR DRAIN	1-1/2" FPT.
TM	BLEED LINE	1/4" FPT.

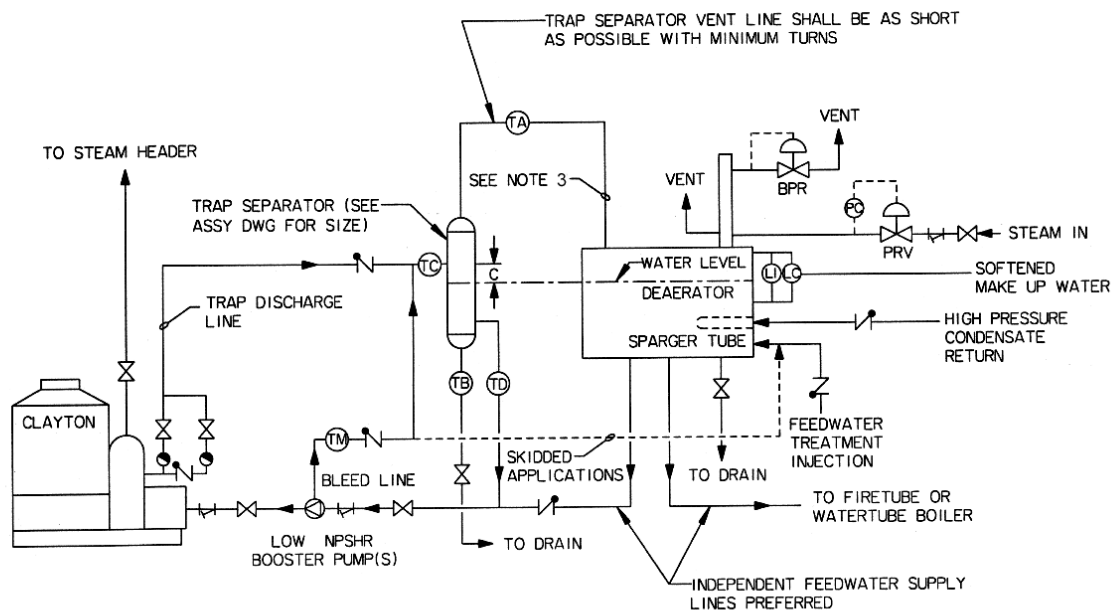
### NOTES:

1. LOCATE TRAP SEPARATOR AS CLOSE AS POSSIBLE TO THE HOTWELL TO SUSTAIN COMMON WATER LEVEL CONTROL AND PRESSURE EQUILIBRIUM.
2. TRAP SEPARATOR USES HEAT FROM CLAYTON TRAP RETURNS TO ISOLATE HIGH TDS CONCENTRATIONS TO THE CLAYTON FEEDWATER CIRCUIT ONLY.
3. HOTWELL MAY REQUIRE AN ADDITIONAL VENT CONNECTION.

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**Figure 5-1** Trap separator hookup with hotwell

## SPECIFICATIONS: TRAP SEPARATOR - ALL GENERATORS



**DIAGRAM OF CLAYTON TRAP SEPARATOR HOOKUP  
W/ OTHER BOILER AND COMMON DEAERATOR**

LINE SIZES		
LETTER	DESCRIPTION	P/N UH33572 UP TO 300 BHP
(TC)	TRAP RETURN	2" FLG.
(TA)	TRAP SEPARATOR VENT	3" FLG.
(TD)	FEEDWATER LINE TO CLAYTON	2" FLG.
(TB)	TRAP SEPARATOR DRAIN	1-1/2" FPT.
(TM)	BLEED LINE	1/4" FPT.

**NOTE:**

1. LOCATE TRAP SEPARATOR AS CLOSE AS POSSIBLE TO DEAERATOR TO SUSTAIN COMMON WATER LEVEL CONTROL AND PRESSURE EQUILIBRIUM.
2. TRAP SEPARATOR USES HEAT FROM CLAYTON TRAP RETURNS TO ISOLATE HIGH TDS CONCENTRATIONS TO THE CLAYTON FEEDWATER CIRCUIT ONLY.
3. DEAERATOR MAY REQUIRE AN ADDITIONAL VENT CONNECTION.

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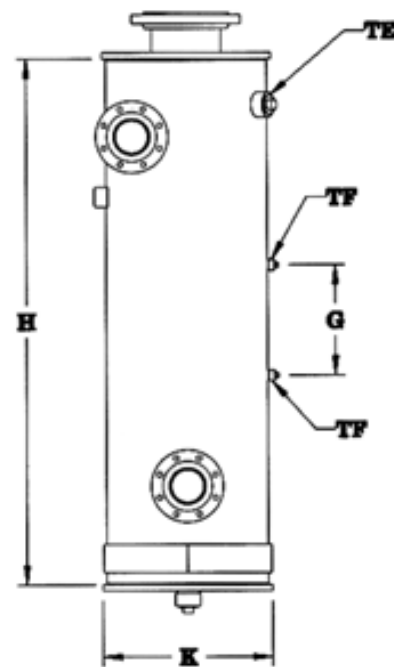
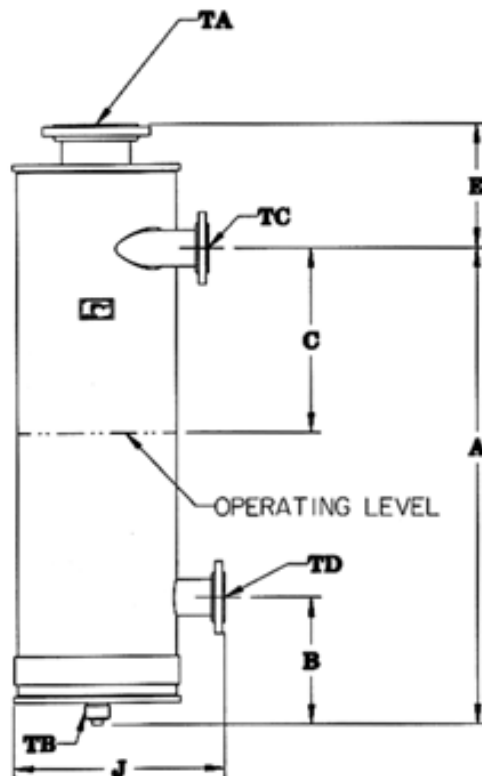
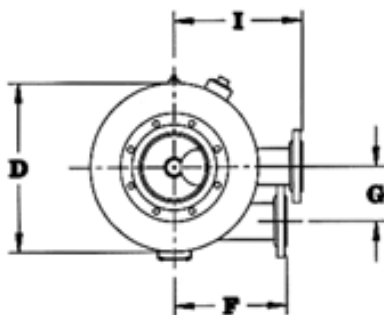
**Figure 5-2** Trap separator hookup with deaerator

**SPECIFICATION: TRAP SEPARATOR - ALL GENERATOR**

TA - (TRAP SEPARATOR VENT)  
 TB - (CLEANOUT)  
 TC - (TRAP SEPARATOR INLET)  
 TD - (TRAP SEPARATOR DRAIN)  
 TE - (INSPECTION PORT)  
 TF - (GAUGE GLAS CONNECTION)

NOTE: ALL FLANGES ARE 150# R.F.

<b>BHP</b>	0-300
<b>OPERATING VOLUME</b>	12 GAL
<b>FULL VOLUME</b>	18 GAL
<b>PART #</b>	UH33572
<b>A</b>	27.94
<b>B</b>	13.19
<b>C</b>	9.88
<b>D</b>	14.00
<b>E</b>	9.63
<b>F</b>	12.38
<b>G</b>	5.06
<b>H</b>	29.75
<b>I</b>	12.38
<b>J</b>	19.88
<b>K</b>	15.00



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**Figure 5-3** Trap separator dimensions

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# **SECTION VI - TECHNICAL SPECIFICATIONS**

## **6.1 GENERAL**

The following pages contain Tables with general reference information intended to assist in the installation of your Clayton SigmaFire steam generator. The information is provided only for standard Clayton thermal products. Specially designed equipment, such as Clayton Steam Generators with Low NOx Burners, are addressed in Supplemental Instructions.

## **6.2 AGENCY APPROVALS**

All standard SigmaFire steam generators are designed and built to meet ANSI, ASME, Boiler Pressure Vessel Code Section I, ASME CSD-1, IRI/GEGAP, FM, UL, CUL, and CRN requirements.

The marine listings ABS, USCG, DNV, and CCG, are available.

## **6.3 CONSTRUCTION MATERIALS**

Only high quality materials are used in the manufacturing of the Clayton Steam Generator.

The Heating Coil in the generator is manufactured by Clayton using ASME SA178 or SA192 steel tubing. All welds are performed by Clayton ASME certified welders. The coil is then hydrostatically tested to 1.5 times the design pressure or 750 psig (52 bars) which ever is greater. The coil is encased in a mild steel jacket that contains all combustion gases.

The steam separator shell is constructed of SA53 seamless black pipe. The heads are made of ASME SA 285 carbon steel. The separator also has openings for steam safety relief valves.

## **6.4 FLAME SAFEGUARD**

Combustion safety control is accomplished by an Electronic Safety Control (ESC) flame monitoring system. The ESC is a microprocessor-based, burner management, control system designed to provide proper burner sequencing, ignition, and flame monitoring protection. In conjunction with limit and operating controls, it programs the Burner, Blower Motor, ignition, and fuel valves to provide for proper and safe burner operation. The control monitors both pilot and main flames. It also provides current operating status and lockout information in the event of a safety shutdown.

The programmer module, a component of the ESC, provides functions such as pre-purge, recycling interlocks, high-fire proving interlock, and trial for ignition timing of the pilot and main flame. Burner flame is monitored by a flame sensor mounted in the Burner Manifold Assembly. The flame signal is sent to the amplifier module in the ESC. An optional display module may be added to provide read-outs of main fuel operational hours and the flame signal.

## **6.5 SAFETY CONTROLS**

In addition to the combustion safety control, the following safety devices are continuously monitored during the Steam Generator operation.

### **6.5.1 Temperature Control Devices**

There are three temperature control devices that continuously monitor the machine. The first device monitors the temperature of the steam to prevent against a superheat condition. The second and third temperature devices are a dual element thermocouple that provides continuous monitoring of the coil face temperature in the combustion chamber.

### **6.5.2 Regulator Approvals**

Fuel systems are designed to comply with ANSI/ASME CSD-1, Underwriters Laboratory, FM approval, and IRI/GEGAP.

### **6.5.3 Steam Limit Pressure Switch**

A steam limit pressure switch protects against an over-pressure condition.

### **6.5.4 Combustion Air Pressure Switch**

A combustion air pressure switch is used to prove that sufficient air is present for proper combustion.

### **6.5.5 Pressure Atomizing Oil Nozzles**

The Steam Master fuel system uses pressure atomizing oil nozzles—no pressurized air supply required.

### **6.5.6 Pump Oil Level Switch**

A switch is available that monitors the Clayton feedwater pump crankcase oil level for both a high and low oil level condition.

### **6.5.7 Overcurrent Protection**

The electrical circuits (primary and secondary) and all motors are protected against an overcurrent condition.

## **6.6 EQUIPMENT SPECIFICATIONS**

### **6.6.1 Modulating steam generators/fluid heaters.**

Table 6-1: Specification

	Units of Measurement	CSM-15	CSM-15-SE	CSM-30	CSM-30-SE	CSM-40	CSM-40-SE
Boiler Horsepower	bhp	15	15	30	30	40	40
Heat Input: Gas	Btu/hr	619,907	590,735	1,239,815	1,181,471	1,653,086	1,575,294
Net Heat Output	Btu/hr	502,125	502,125	1,004,250	1,004,250	1,339,000	1,339,000
Equivalent Output (From and at 212 °F feedwater and 0 psig steam.)	lbs/hr	518	518	1,035	1,035	1,380	1,380
Design Pressure (See Note 1.)	psig	150	150	150	150	150	150
Steam Operating Pressure	psig	65 – 125	65 – 125	65 – 125	65 – 125	65 – 125	65 – 125
Gas Consumption — at maximum steam output (See Note 2.)	ft <sup>3</sup> /hr	620	591	1,240	1,182	1,653	1,575
Burner Controls (modulating gas)		4:1 turndown	4:1 turndown	4:1 turndown	4:1 turndown	4:1 turndown	4:1 turndown
Efficiency (gas fired)	%	81	85	81	85	81	85
Electric Motors — design pressure 150 psi	hp	Blower = 0.31 Pump = 0.75	Blower = 0.31 Pump = 0.75	Blower = 0.51 Pump = 0.75	Blower = 0.51 Pump = 0.75	Blower = 0.70 Pump = 1.5	Blower = 0.70 Pump = 1.5
Electric FLA — based on 230 vac (See Note 3.)	A (amp)	10	10	11	11	15	15
Gas Supply Pressure Required	psig	2	2	2	2	2	2
Water Supply Required	gph	133	133	265	265	353	353
Heating Surface	ft <sup>2</sup>	78.6	110.9	141.0	199.1	152.8	228.2
Customer Connections:							
Feedwater Inlet	in.	1.5	1.5	1.5	1.5	1.5	1.5
Steam Trap Discharge	in.	1.0	1.0	0.75	0.75	1.0	1.0
Separator Blowdown	in.	1.0	1.0	0.75	0.75	1.0	1.0
Economizer Drain	in.	1.0	1.0	1.0	1.0	1.0	1.0
Supply Gas Inlet	in.	0.75	0.75	0.75	0.75	1.0	1.0
Steam Discharge Outlet	in.	1.5	1.5	1.0	1.0	1.5	1.5
Safety Relief Valve	in.	1.0	1.0	1.0	1.0	1.0	1.0
Exhaust Gas Outlet	in.	7.88	7.88	9.88	9.88	9.88	9.88
Overall Rough Dimensions							
length	in.	69	69	77	77	85	85
width	in.	50	50	56	56	56	56
height	in.	82	82	89	89	97	97
Weight							
Installed (wet)	lbs	2,502	2,689	3,328	3,548	3,567	3,791
Shipping	lbs	2,424	2,601	3,152	3,350	3,350	3,593
NOTE:							
1. Design pressure is currently limited to 150 psig.							
2. Based on natural gas with a high heat value (HHV) of 1,000 Btu/ft <sup>3</sup> .							
3. Continuous running 230 vac / 1 ph / 60 Hz power supply required.							

## 6.6.2 Table 6-1 Supplemental Information

### NOTE

All values are rated at maximum continuous firing rate.

- A. Net heat output is calculated by multiplying boiler horsepower by 33,475 Btu/hr. Net heat input can be calculated by dividing net heat output by the rated efficiency.
- B. Gross steam output, from and at 212° F, is calculated by multiplying boiler horsepower by 34.5 lb/hr.
- C. Thermal efficiencies are based on high heat or gross caloric (Btu) values of the fuel. Efficiencies shown are nominal. Small variations may occur due to manufacturing tolerances. Consult factory for guaranteed values.
- D. Consult factory for motor horsepowers for units with design pressures above 300 psi.
- E. Except where noted, indicated full load amperage (FLA) is for 230 VAC primary voltage supply. See paragraph 2.7, Section II, to obtain FLA for other voltages. Consult factory for FLA for Units with design pressures above 300 psi.
- F. Oil consumption based on 140,600 Btu/gal. of commercial standard grade No. 2 oil (ASTM D396).

$$\text{Oil Consumption} = \left( \frac{33,475 \text{ Btu/hr}}{\text{bhp}} \right) (\text{bhp}) \left( \frac{100}{\text{efficiency}} \right) \left( \frac{1 \text{ gal.}}{140,600 \text{ Btu}} \right)$$

- G. Natural Gas consumption based on 1000 Btu/ft<sup>3</sup> gas. Use the following formula to determine gas consumption for gases with other heat values:

$$\text{Gas Consumption} = \left( \frac{33,475 \text{ Btu/hr}}{\text{bhp}} \right) (\text{bhp}) \left( \frac{100}{\text{efficiency}} \right) \left( \frac{1 \text{ ft}^3}{1,000 \text{ Btu}} \right)$$

- H. Water supply is based on 44 lb/hr per boiler horsepower.

## 6.7 EQUIPMENT LAYOUT AND DIMENSIONS

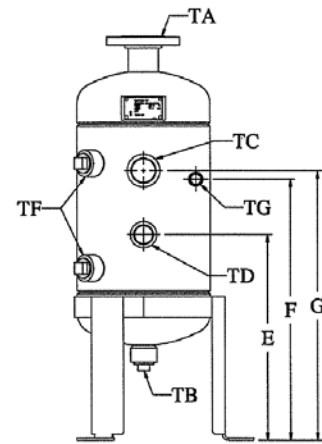
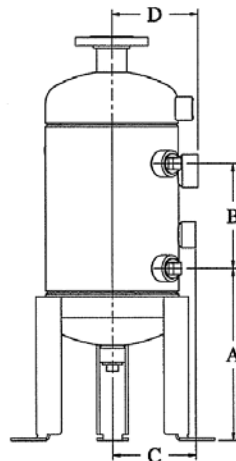
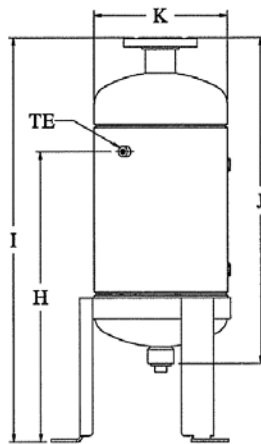
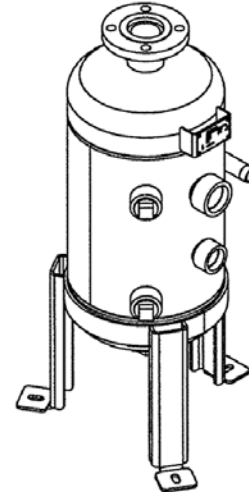
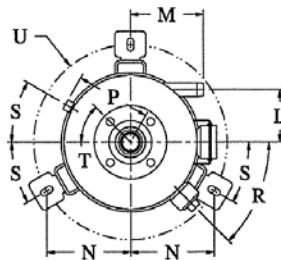
### NOTE

The steam generator layouts and dimensions given in this section are approximate. The illustration in each figure is a general outline that depicts multiple steam generator models. Refer to the corresponding tables that follow each figure for the specific steam generator model dimensions.

### 6.7.1 Blowdown Tanks

<b>PART #</b>	<b>UH35841</b>
FULL VOLUME	11 GALLON
MODEL	SF25 / 200
BHP RATING	25 BHP 200 BHP
DRY WEIGHT	123 LBS.
A	16.44
B	10.00
C	8.00
D	8.25
E	19.63
F	24.94
G	25.75
H	27.69
I	38.56
J	31.08
K	Ø 12.75
L	5.00
M	7.00
N	8.01
P	7.19
R	45°
S	30°
T	45°
U	Ø 18.50

TA = VENT  
 TB = DRAIN  
 TC = HOTWELL OVERFLOW - NOT APPLICABLE  
 TD = WATER OUTLET  
 TE = WATER COOLER SAMPLE INLET  
 TF = INSPECTION  
 TG = BLOWOFF INLET



#### NOTES:

1. ALL FLANGES ARE 150# R.F.
2. ASME SECTION VIII, DIV 1. ("U" STAMP)
3. MAWP TEST = 100 PSI @ 338° F MAX. / 0° MIN.
4. HYDROSTATIC TESTED @ 150 PSI.

**Figure 6-1** Blowdown tank dimensions and specifications

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# SECTION VII - OPTIONAL EQUIPMENT

## 7.1 BOOSTER PUMP(S)

Booster pumps are required on an open system when the required NPSH to the feedwater pump cannot be achieved from an elevated hot-well.

Booster pumps must be sized to provide 150 percent of the total system water flow at 150 percent of the total system head pressure. Total system head pressure includes the Clayton feedwater pump  $NPSH_R$ , plus calculated pipe losses, and plus acceleration head loss.

Most systems use two pumps. One of the two pumps is a standby pump, or the usage of the two pumps are alternated to balance operating hours. Only booster pumps with mechanical seals rated at a *minimum* of 250° F (121° C) should be used. The booster pumps cannot be rated at a discharge pressure that is lower than the system operating pressure

---

### NOTE

Each booster pump must have a 1/4 inch (6 mm) recirculation line, with a check-valve, piped from the discharge side of the pump back to the condensate receiver. This prevents overheating during “dead head” conditions. Clayton recommends using this return line to facilitate chemical injection at a common manifold on the condensate receiver.

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## 7.2 BLOWDOWN SYSTEM

### 7.2.1 Blowdown Tank

The Occupational Safety and Health Administration (OSHA) requires that high temperature discharges be cooled to a temperature below 140°F (60°C) prior to entering a drainage system. A blowdown tank performs this function. All blowdown and high temperature drain lines are to be piped to the blowdown tank. A capillary tube-type temperature sensor, mounted in the blowdown tank discharge line, actuates a temperature control valve, also mounted in the discharge line, to inject cooling water into the hot fluid. The temperature control valve can be adjusted to achieve the desired discharge fluid temperature. The blowdown tank vent should be a straight run of full size iron or steel pipe.

### 7.2.2 Automatic TDS Controller

Total dissolved solids can be controlled automatically. This is accomplished by installing a TDS (conductivity) sensing probe in the feedwater line, this is connected to the Clayton Boiler Master controller that, in turn, controls a dump valve installed in the trap discharge line. The discharge from the dump valve is then piped to the blowdown tank. Refer to Drawing R016099. Feedwater testing is still required per the Clayton Feedwater Manual.

### **7.2.3 Continuous Blowdown Valve**

The continuous blowdown valve, if used, is installed in the trap discharge line. It consists of a needle valve that is throttled for the proper flow rate to keep TDS within parameters. Refer to Drawing R016099.

## **7.3 VALVE OPTION KIT**

The valve option kit consists of a separator drain valve, coil gravity drain valve, coil blowdown valve, and separator-trap discharge valve. The valve kit also includes the required hardware, such as nuts, bolts, gaskets, and pipe nipples, for the valve installation. With the exception of generator skids and the steam trap discharge valve, all valves are shipped loose for customer installation. If the valve option kit is not supplied by Clayton, it is the customers responsibility to provide these valves. All these valves are required for proper installation and operation.

## **7.4 SOOT BLOWER ASSEMBLY**

For steam generators that burn oil, a provision for steam soot blowing is required. Clayton Industries can provide an optional steam pipe spool piece with all piping and valves required for the proper removal of accumulated soot. If this item is not purchased the customer must supply a valved line from the steam header to the soot blow inlet for this purpose.

## **7.5 PRESSURE REGULATING VALVES (BPR/PRV)**

### **7.5.1 Back Pressure Regulators**

Back Pressure Regulators (BPR) are required where the system requirements exceed the capacity of the steam generator/fluid heater, where there are rapidly cycling loads, such as those created from a fast-acting motorized valve, or on steam generators/fluid heaters that are started remotely or automatically, such as master lead-lag or auxiliary pressure control systems. It will control the minimum pressure within the steam generator/fluid heater during these periods and, as a result, prevent entrained liquid from flashing. This results in a more stable operation. The BPRs assure that sufficient pressure is maintained in the steam generator/fluid heater to protect the heating coil from a possible overheat condition. BPRs are recommended on all Clayton installations. On installations with multiple steam generators, a BPR must be installed at each steam generator.



### 7.5.2 Clayton Back Pressure Regulators

Clayton BPRs are spring-loaded, diaphragm-operated. The BPR must be installed in the separator discharge piping (as shown in Figure 1).

Install the Clayton BPR vertically with the outlet at the top.

### 7.5.3 Buyout (non-Clayton) Back Pressure Regulators

For buyout BPRs, refer to the manufacturer's installation and operator instructions for proper installation.

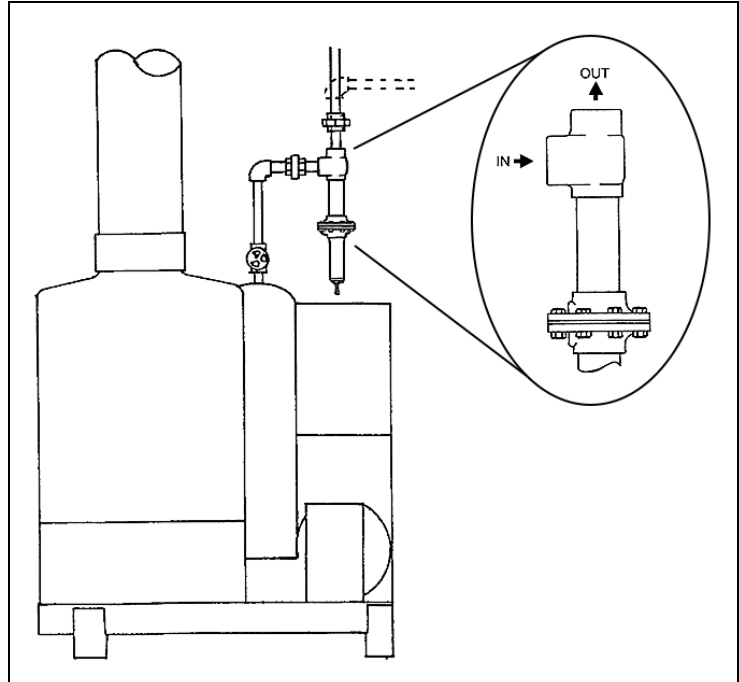
### 7.5.4 Pilot-Operated and Electro-Pneumatic Back Pressure Regulators

Pilot-operated BPRs are designed to be mounted at the steam header top elevation, immediately next to the steam stop valves above Clayton's separator. They are not meant to be floor mounted. Fluid traps must be incorporated into the pilot lines to prevent BPR liquid lockout. Customers who desire mounting BPRs at floor level must use pilotless, electro-pneumatic BPRs.

Electro-pneumatic BPRs (Figure 2) may be purchased from Clayton Industries. Electro-pneumatic BPRs require additional PLC module hardware and control programming in the electrical control box.

### 7.5.5 Pressure Regulating Valves

Pressure Regulating Valves (PRV) control the pressure in the feedwater supply vessel, either D/A or Semi-closed Receiver (SCR) Systems. These valves ensure positive pressure is maintained on these vessels. The PRV receives steam from the main header and injects steam into the tank when a drop in pressure is detected. A check-valve must be installed in this line to protect the system in the event of flooding the tank.



**Figure 1 - Clayton BPR Installation**

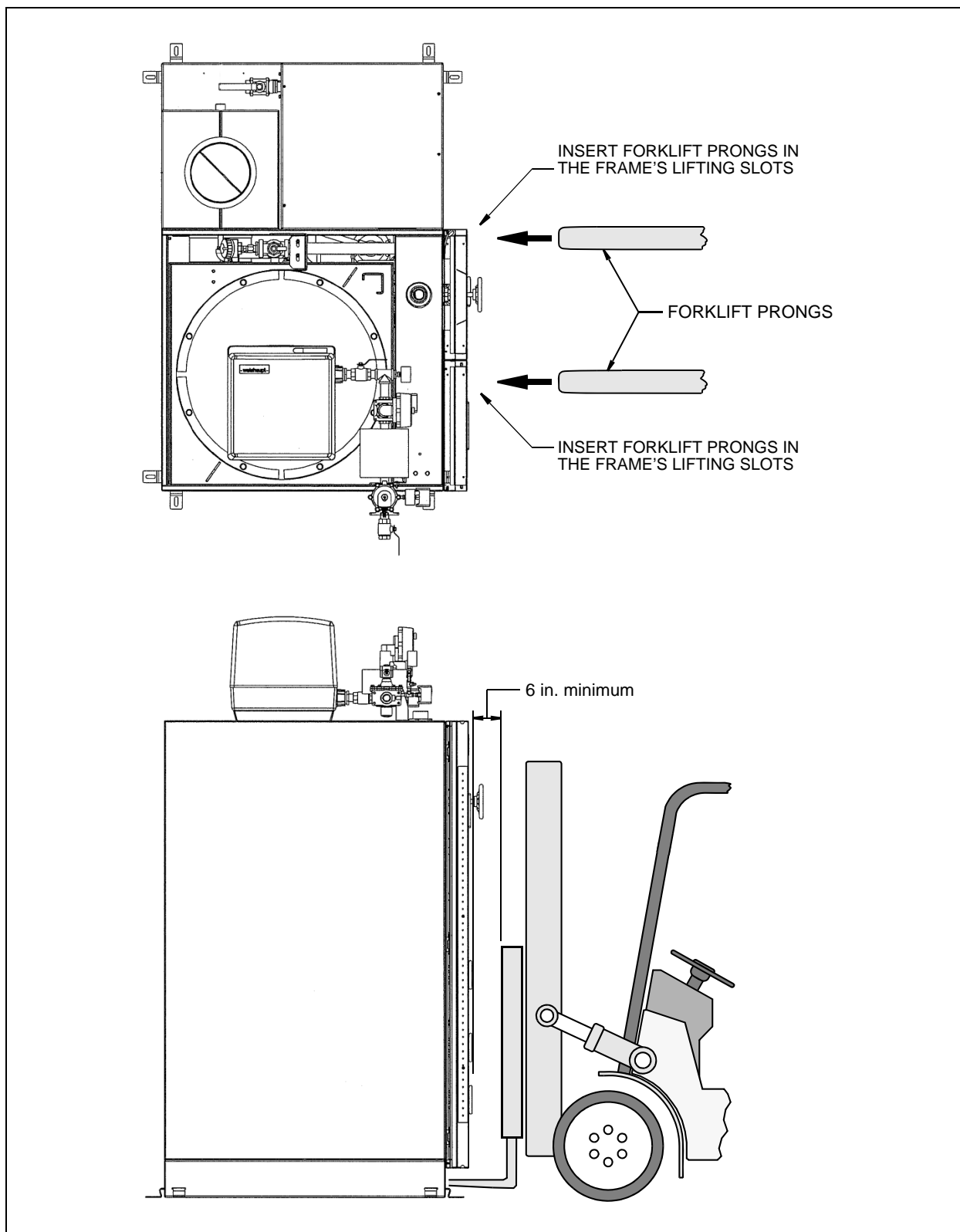


**Figure 2 - Electro-pneumatic BPR valve (for illustration purpose only, actual valve may be different)**

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# **Appendix A**

## **Steam Generator Lifting Instructions**



**Fig. 1 - Use a forklift truck to for moving Steam Generators**

**Lifting Instructions (See Fig. 1 above.)**

1. Use appropriate-sized forklift truck for lifting and moving the Steam Generator/Fluid Heater.
2. Lift unit from heating coil side.
3. Insert forklift prongs in the lifting slots in the frame of the unit.

**CAUTION**

DO NOT lift from any other part of the unit except from the lifting slots!

4. Maintain a minimum clearance of six inches between the forklift and any component of the unit.

## **NOTES**

# Appendix B

## Saturated Steam Pressure-Temperature Table

GAUGE PRESSURE PSIG	TEMP F	GAUGE PRESSURE kPa	TEMP C	GAUGE PRESSURE PSIG	TEMP F	GAUGE PRESSURE kPa	TEMP C	GAUGE PRESSURE PSIG	TEMP F	GAUGE PRESSURE kPa	TEMP C
60	308	413.6	153	270	413	1,861.5	211	600	489	4,136.8	254
70	316	482.6	158	280	416	1,930.5	213	650	497	4,481.6	259
80	324	551.5	162	290	419	1,999.4	215	725	509	4,998.7	265
90	331	620.5	166	300	422	2,068.4	217	750	513	5,171.1	267
100	338	689.4	170	310	425	2,137.3	218	775	517	5,343.4	269
110	344	758.4	173	320	428	2,206.3	220	800	520	5,515.8	271
120	350	827.3	177	330	431	2,275.2	222	825	524	5,688.2	273
130	356	896.3	180	340	433	2,344.2	223	850	527	5,860.5	275
140	361	965.2	183	350	436	2,413.2	224	875	531	6,032.9	277
150	366	1,034.2	186	360	438	2,482.1	226	900	534	6,205.3	279
160	370	1,103.2	188	370	441	2,551.1	227	925	537	6,377.7	281
170	375	1,172.1	191	380	443	2,620.0	229	950	540	6,550.0	282
180	380	1,241.0	193	390	445	2,689.0	230	975	543	6,722.4	284
190	384	1,310.0	196	400	448	2,757.9	231	1000	546	6,894.8	286
200	388	1,378.9	198	410	450	2,826.9	233	1050	552	7,239.5	289
210	392	1,447.9	200	420	453	2,895.7	234	1100	558	7,584.2	292
220	396	1,516.8	202	440	457	3,033.6	236	1150	564	7,929.0	295
230	399	1,585.7	204	460	462	3,171.5	239	1200	569	8,273.7	298
240	403	1,654.7	206	480	466	3,309.4	241	1250	574	8,618.4	301
250	406	1,723.6	208	500	470	3,447.3	243	1300	579	8,963.2	304
260	409	1,792.6	210	550	480	3,792.1	249	1350	584	9,307.9	307

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# **Appendix C**

## **Piping and Instrumentation Diagrams (P & I D)**

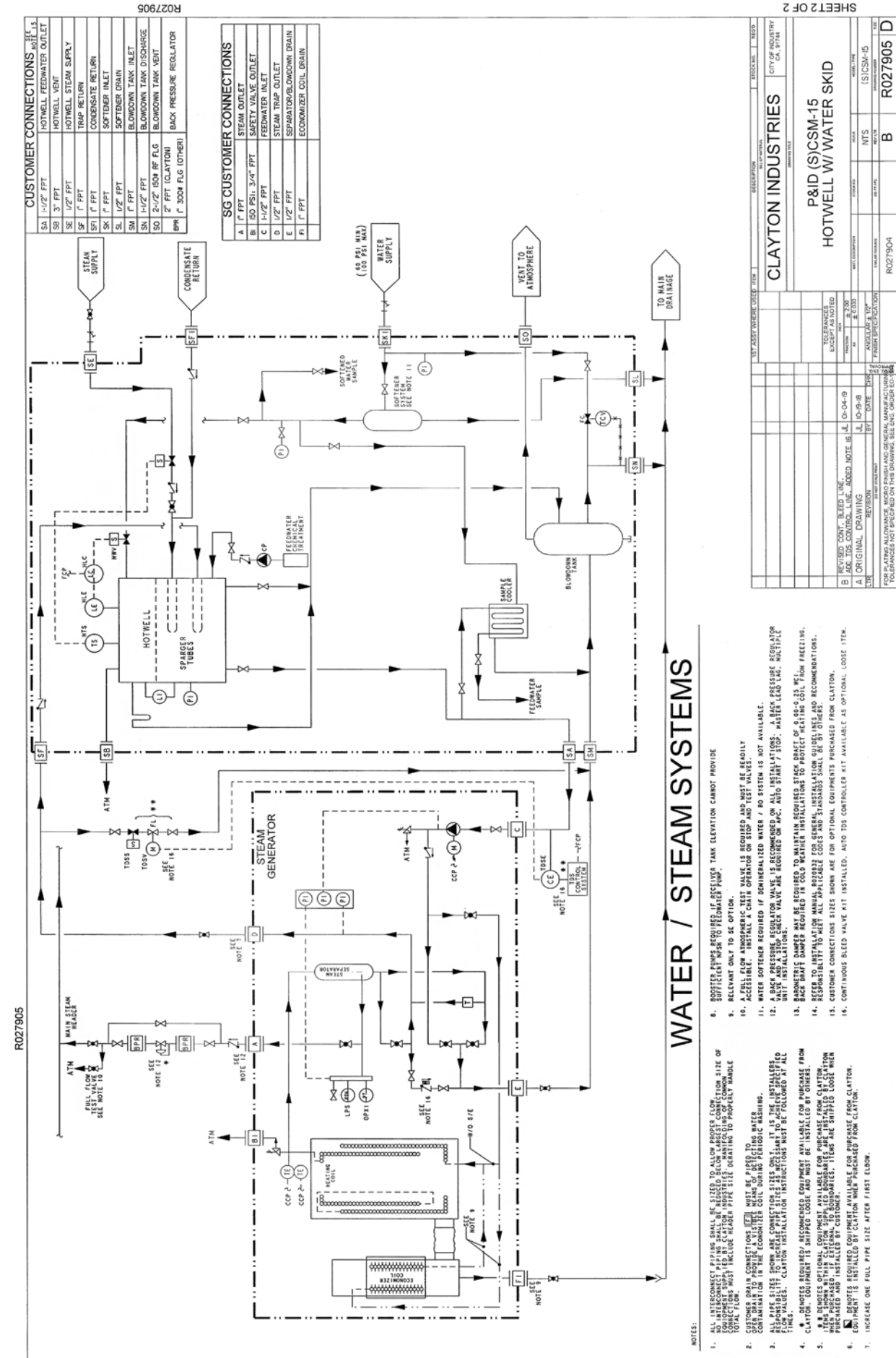
## Contents

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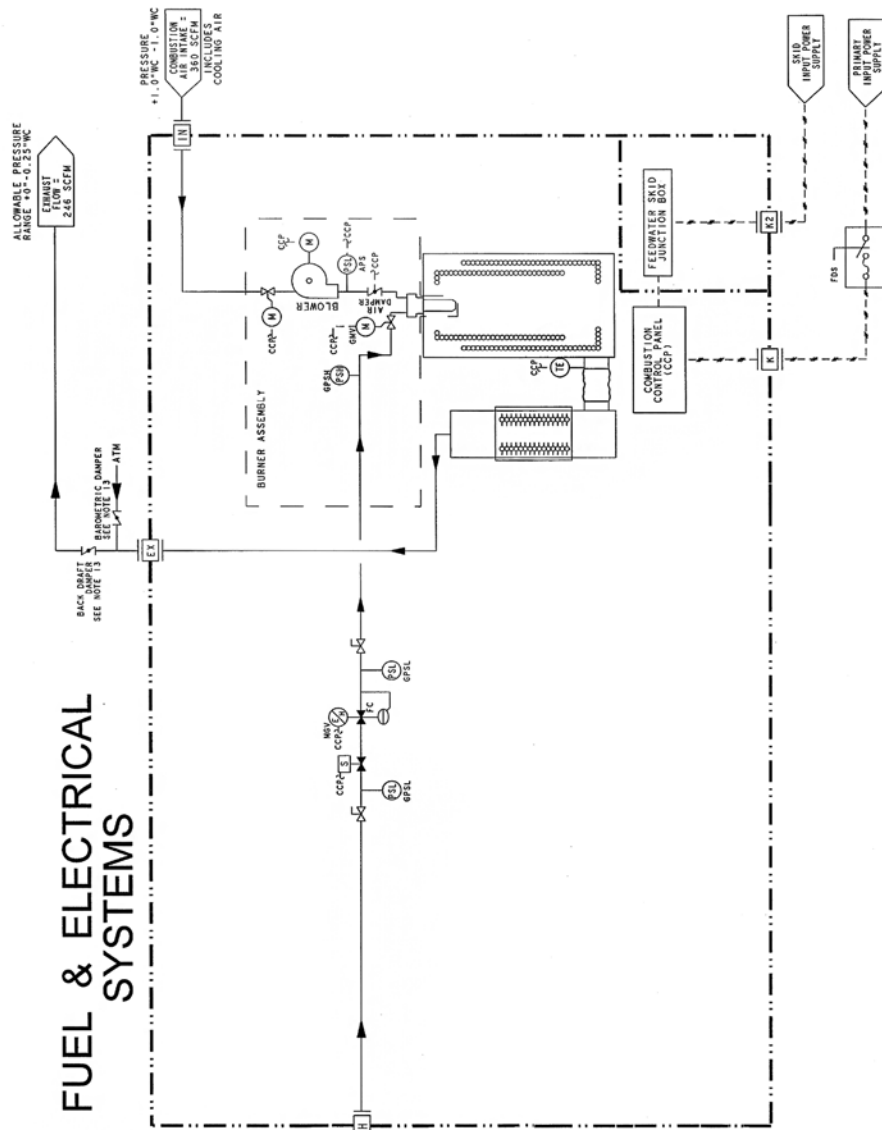






## FUEL & ELECTRICAL SYSTEMS

W/O SE: INPUT = 1.2 MMBTU/HR  
FLOW = 1240 SCFH @  
-10 PSIG

[illegible]

	VALVE	SOLENOID VALVE (NORM. OPEN)		SOLENOID VALVE (NORM. OPEN)		SOLENOID VALVE (NORM. CLOSED)		SOLENOID VALVE (NORM. CLOSED)		MOTOR ACTUATOR		BALL VALVE		ELECTRIC / HYDRAULIC ACTUATED VALVE (NORM. CLOSED)		ELECTRIC / PNEUMATIC ACTUATED VALVE (NORM. OPEN)		VACUUM BREAKER		SAFETY RELIEF VALVE		STRAINER		FILTER		ORIFICE/ RESTRICTOR		FURNEL DRAIN		DROP LEG / CAP		TURBINE FLOW METER		FLEX COUPLING (2 FT MIN)		SPARK PLUG		PUMP		STEAM TRAP		CURRENT / PNEUMATIC POSITIONER		ELECTRIC MOTOR / ACTUATOR		INSTRUMENT - NON-ACCESSIBLE		INSTRUMENT - FIELD MOUNTED		INSTRUMENT - PANEL MOUNTED		ELECTRICAL SIGNAL		MECHANICAL LINK		THREE-PHASE ELECTRICAL		CLAYTON EQUIPMENT BOUNDARY		ALTERNATE EQUIPMENT
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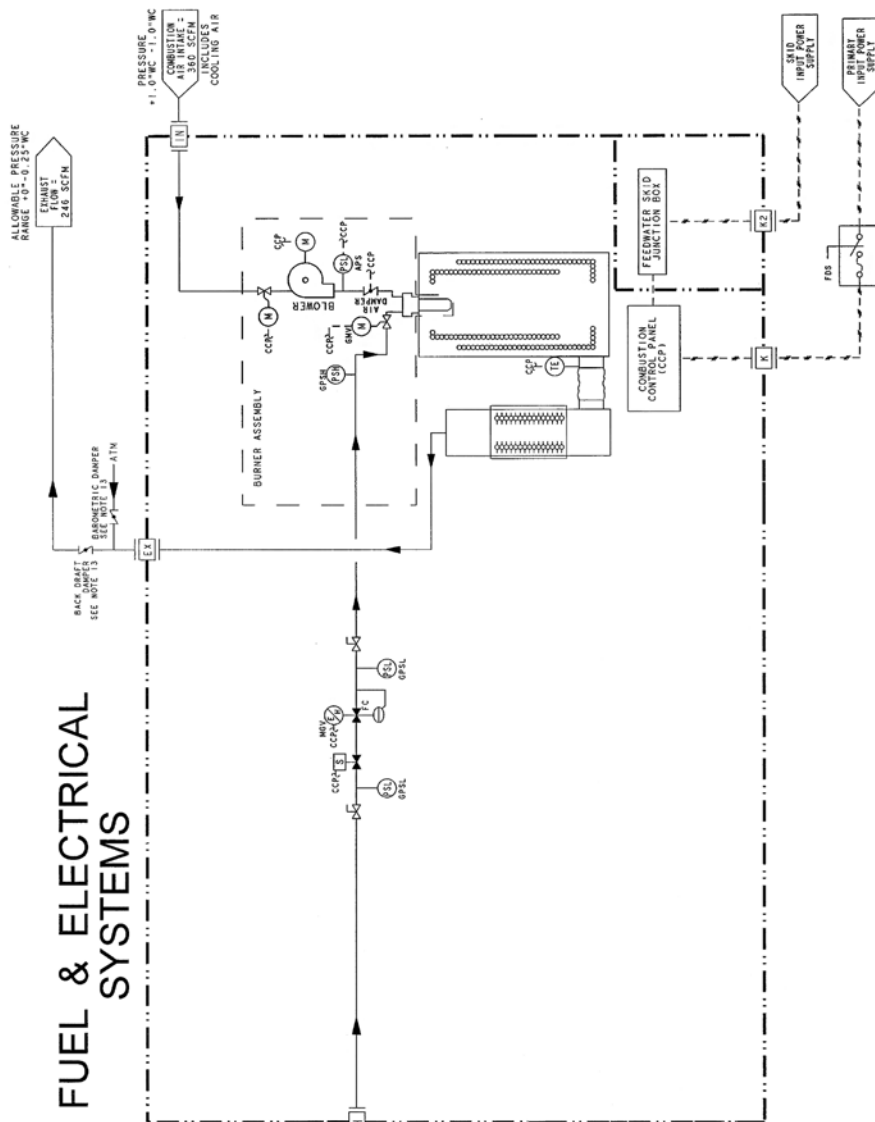
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LEGEND (NOT ALL DEVICES ARE USED)

LEGEND	(NOT ALL DEVICES ARE USED)
	VALVE
	GLOBE VALVE
	NEEDLE VALVE
	GAS COCK VALVE
	VALVE WITH HANDWHEEL
	MODULATING VALVE
	DAMPER
	STOP CHECK STRAIGHT VALVE
	SPRING LOADED CHECK VALVE
	CHECK VALVE
	PNEUMATIC CONTROL VALVE
	PRESSURE REGULATOR
	BACK PRESSURE REGULATOR
	DIFFERENTIAL REGULATOR
	SOLENOID VALVE (NORM. OPEN)
	SOLENOID VALVE (NORM. CLOSED)
	MOTOR ACTUATOR
	BALL VALVE
	ELECTRIC / HYDRAULIC ACTUATED VALVE (NORM. CLOSED)
	ELECTRIC / PNEUMATIC ACTUATED VALVE (NORM. OPEN)
	VACUUM BREAKER
	SAFETY RELIEF VALVE
	STRAINER
	FILTER
	ORIFICE / RESTRICTOR
	FUNNEL DRAIN
	DROP LEG / CAP
	TURBINE FLOW METER
	FLEX COUPLING (2 FT MIN)
	SPARK PLUG
	PUMP
	STEAM TRAP
	CURRENT / PNEUMATIC POSITIONING
	ELECTRIC MOTOR / ACTUATOR
	INSTRUMENT - NON-ACCESSIBLE
	INSTRUMENT - FIELD MOUNTED
	INSTRUMENT - PANEL MOUNTED
	ELECTRICAL SIGNAL
	CAPILLARY LINK
	INSTRUMENT TO DO PSIG
	THREE-PHASE ELECTRICAL
	CLAYTON EQUIPMENT BOUNDARY
	ALTERNATE EQUIPMENT



HL	HOTWELL LEVEL TEMPERATURE
HS	SEMI-TEMPERATURE SWITCH
LC	LEVEL CONTROL
LL	LEVEL ELEMENT
LI	LEVEL INDICATOR
LPS	LOW PRESSURE SWITCH
MV	MAIN GAS VALVE
MW	MAKE-UP WATER VALVE
PPI	PRESSURE INDICATOR
PS	PRESSURE SWITCH
PSH	PRESSURE SWITCH HIGH
PSL	PRESSURE SWITCH LOW
PSV	PRESSURE SAFETY VALVE
SSOV	SAFETY SHUTOFF OIL VALVE
TC	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TS	TEMPERATURE SWITCH
TV	TEMPERATURE VALVE

[illegible]



CUSTOMER CONNECTIONS		REF. 13
SA	1/2" FPT	HOTWELL FEEDWATER OUTLET
SB	3" FPT	HOTWELL VENT
SC	1/2" FPT	HOTWELL STEAM SUPPLY
SD	1" FPT	TRAP RETURN
SE	1" FPT	CONDENSATE RETURN
SF	1" FPT	SOFTENER INLET
SG	1" FPT	SOFTENER DRAIN
SH	1/2" FPT	BLOWDOWN TANK INLET
SI	1/2" FPT	BLOWDOWN TANK DISCHARGE
SJ	2" FPT	BLOWDOWN TANK VENT
SK	1/2" BSP R/F LG	2" FPT (GLAYTON)
SL	2" FPT	BACK PRESSURE REGULATOR
SM	3" 500H F/LG (OTHER)	

SG CUSTOMER CONNECTIONS	
1-1/2" FPT	STEAM OUTLET
150 PSI, 1" FPT	Safety Valve Outlet
1-1/2" FPT	FEEDWATER INLET
3/4" FPT	STEAM TRAP OUTLET
3/4" FPT	SEPARATOR/BLOWDOWN DRAIN
1" FPT	ECONOMIZER COIL DRAIN

[illegible]

**ABBREVIATIONS**  
(NOT ALL DEVICES ARE USED)

[illegible]

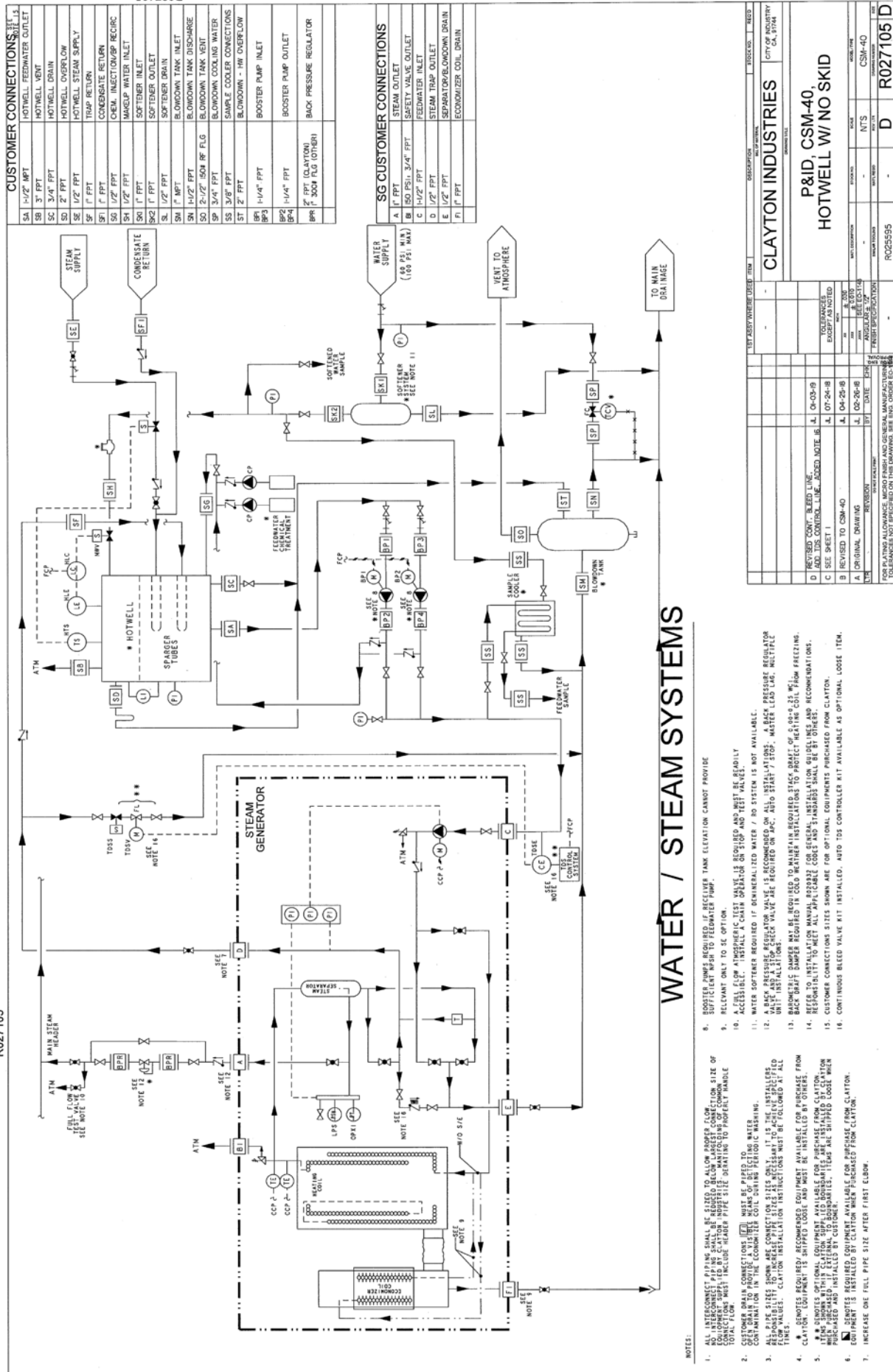
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R027105



R027105

SHEET 2 OF 2

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ADD TDS CONTROL LINE, ADD NOTE 11		07-24-08				
SEE SHEET 1		04-25-08				
ORIGINAL DRAWING		02-26-08				
REVISION		DATE	BY	CHKD	APP'D	REV
FOR PLANT ALLOWANCE, MFG/PMI AND GENERAL MANUFACTURING						
TOLERANCES NOT SPECIFIED ON THIS DRAWING, SEE ENG. ORDER EC-						
CLAYTON INDUSTRIES						
CSM-40						
NTS						
D						
R027105						

## ABBREVIATIONS

ASV	AIR PRESSURE SWITCH - HIGH
ATV	AIR PRESSURE SWITCH - LOW
ATM	ATMOSPHERE
BPM	BOOSTER PUMP
BPR	BACK PRESSURE REGULATOR
CCP	CARBON CAP
CCP	COMBUSTION CONTROL PANEL
CP	CHEMICAL PUMP
CS	CUT-OUT SWITCH
DCS	DISCONNECT SWITCH
FC	FUEL CONTROL VALVE
FCPS	FUELED DISCONNECT SWITCH
FPO	FALL OPEN
FPP	FULL OPEN PUMP
GV	GAS MODULATING VALVE
GVW	GAS MODULATING VALVE - LOW
GVH	GAS MODULATING VALVE - HIGH
GPS	GAS PRESSURE SWITCH - LOW
GPS	GAS PRESSURE SWITCH - HIGH
HV	HIGH FLOW VALVE

**ABBREVIATIONS**  
(NOT ALL DEVICES ARE USED)

[illegible]



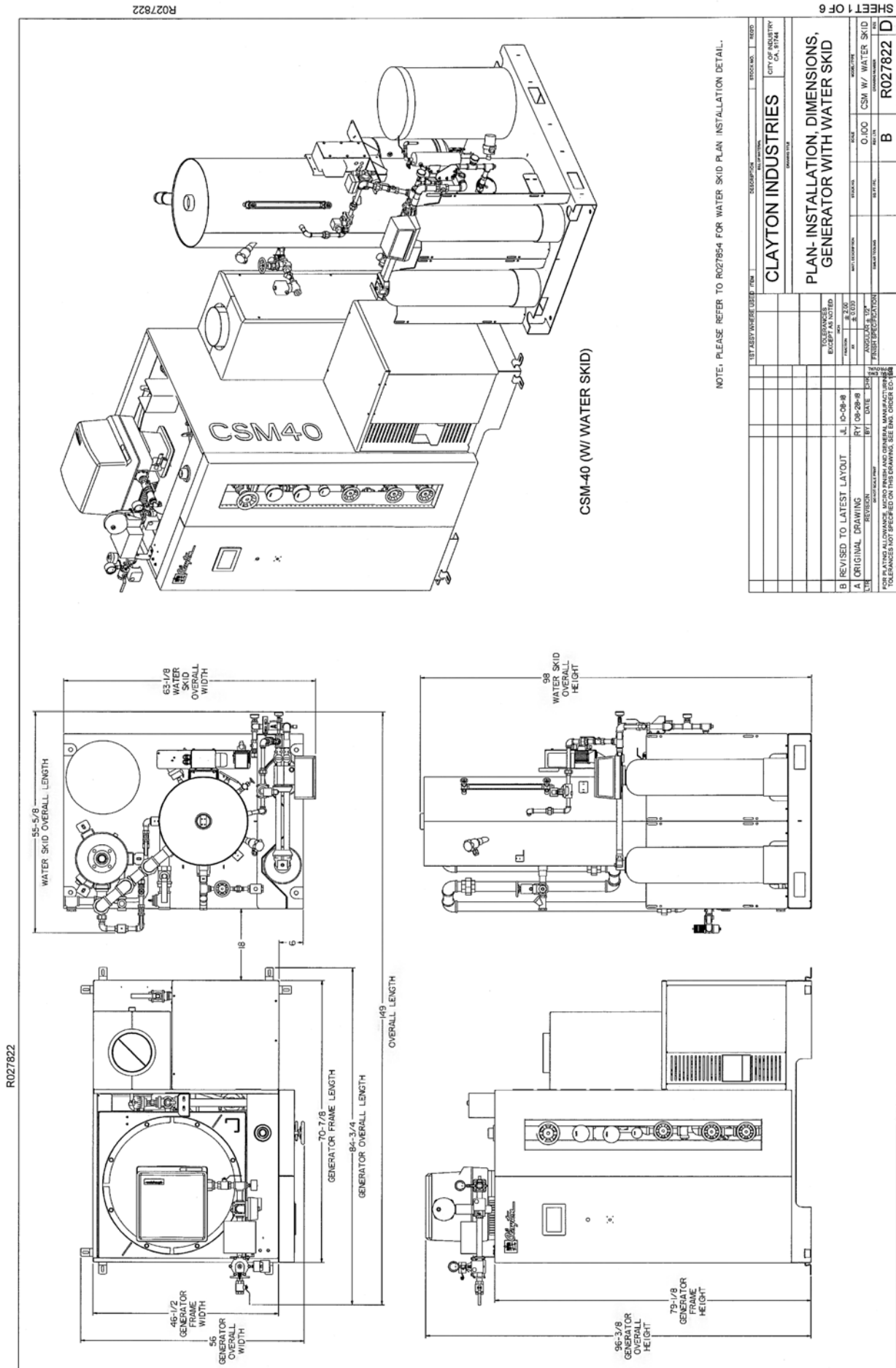
# **Appendix D**

## Plan Installation Layout Diagrams

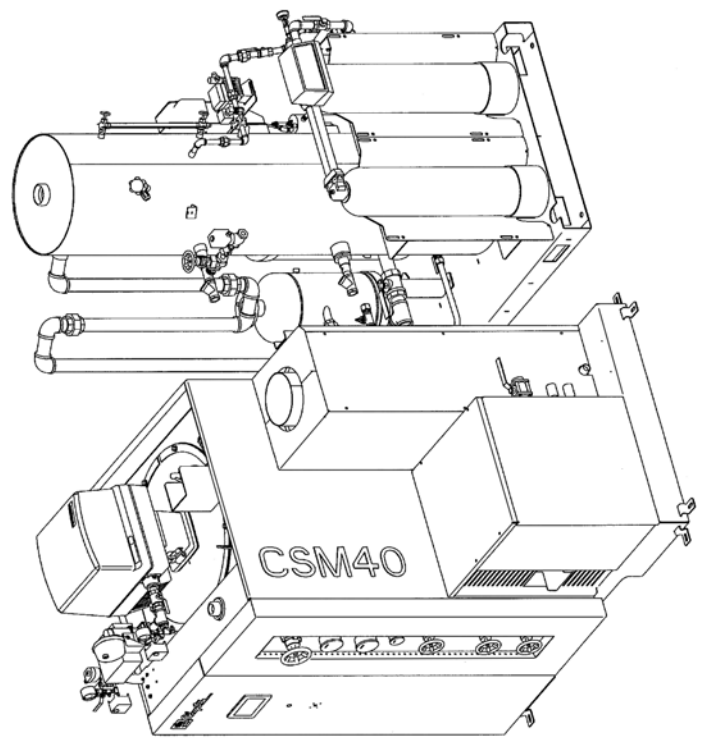
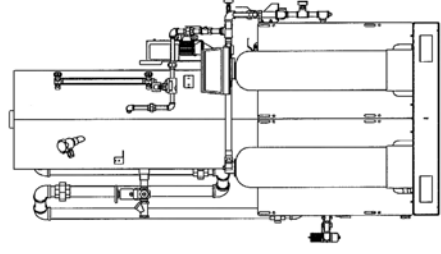
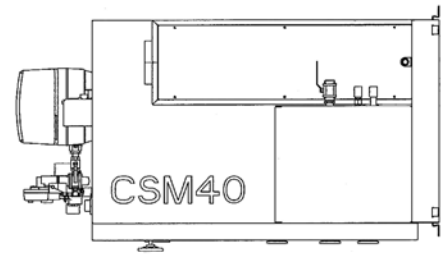
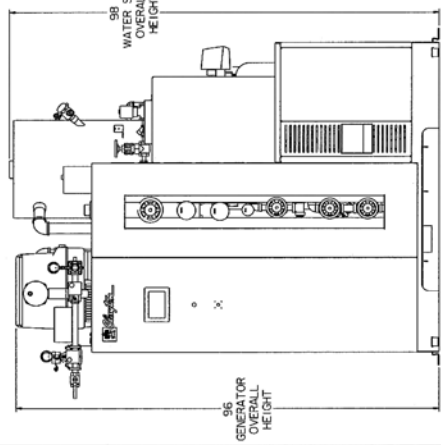
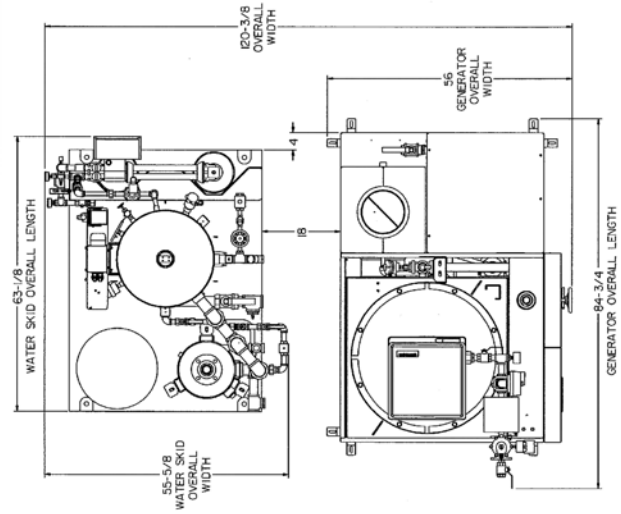
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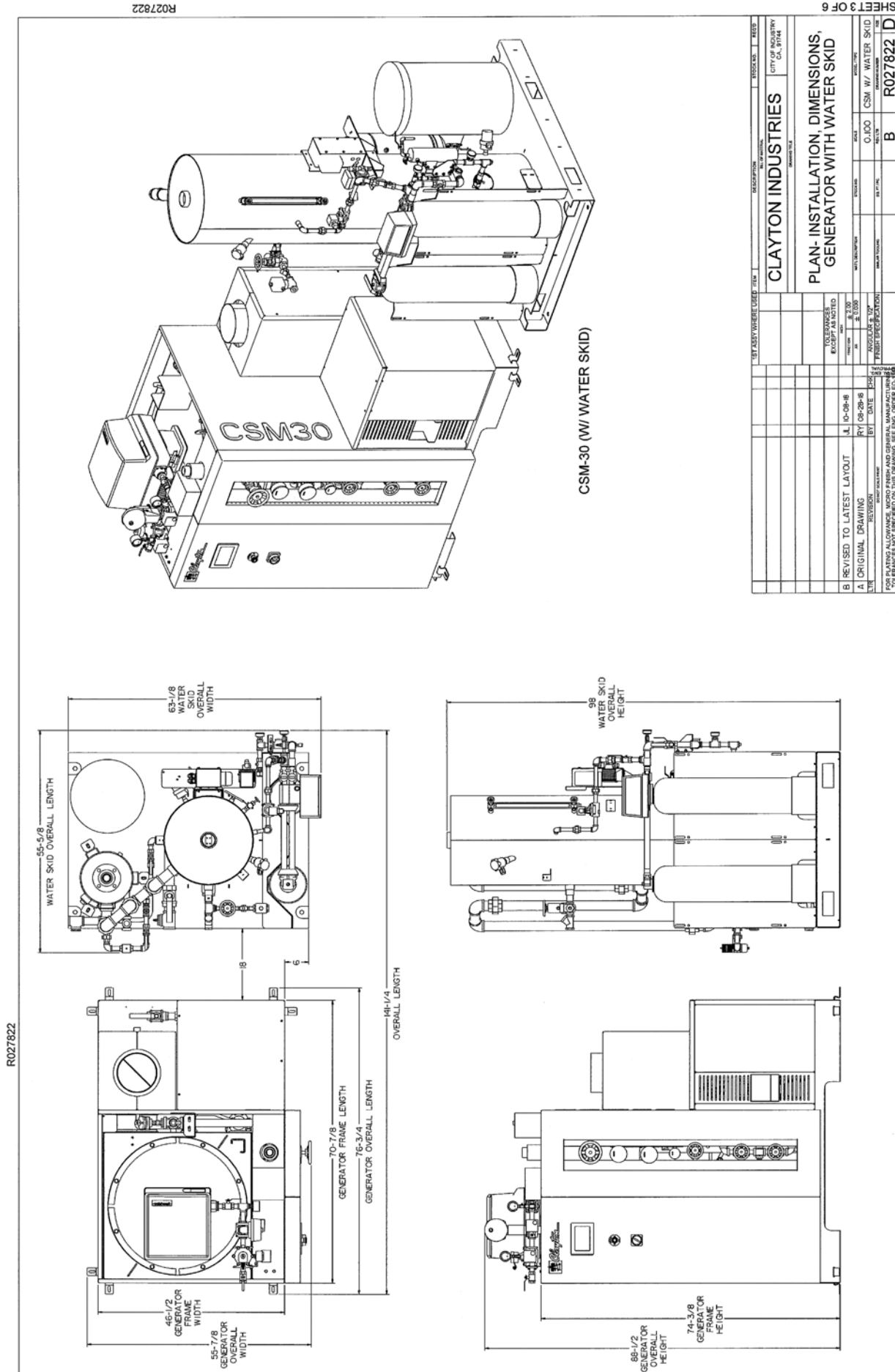


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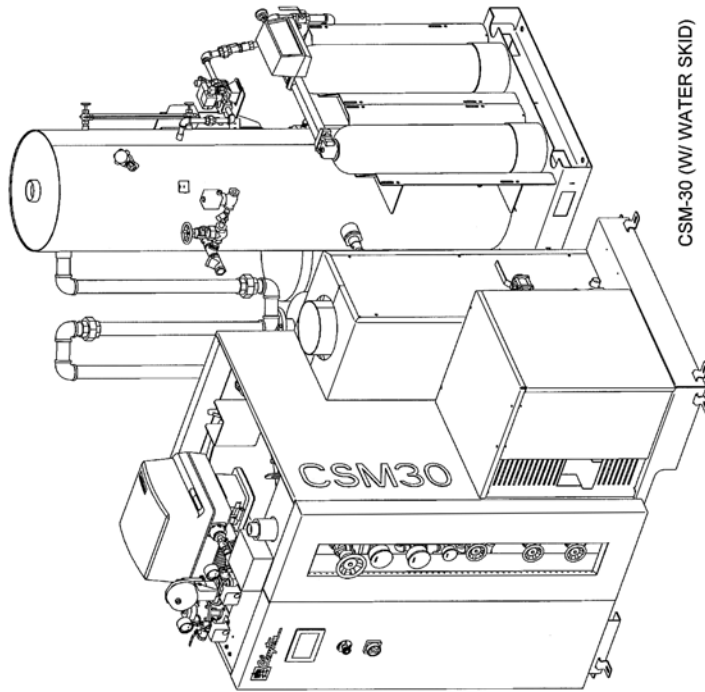
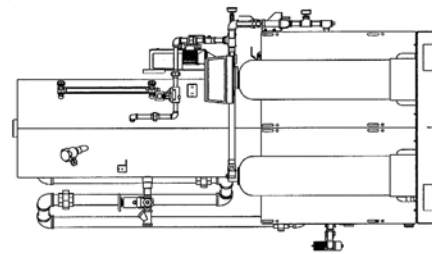
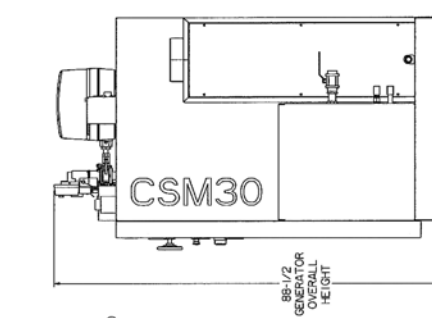
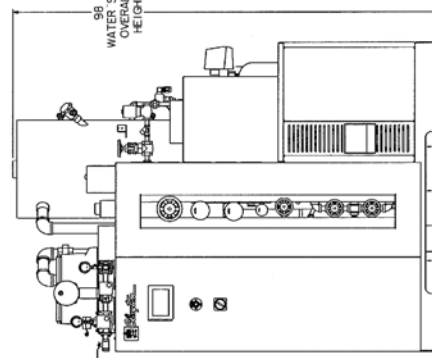
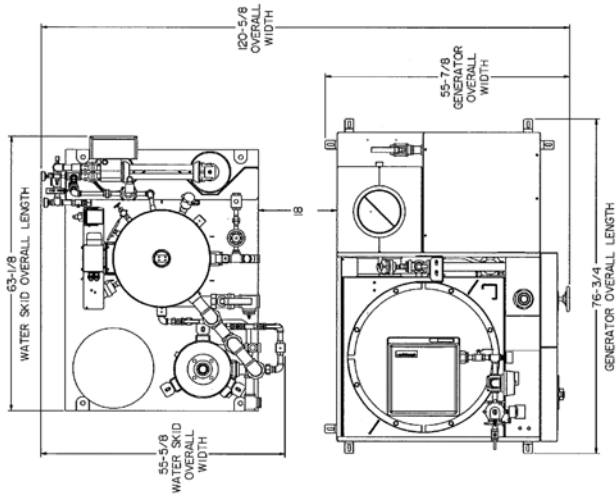


CSM-40 (W/ WATER SKID)

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86	REVISION	RY 08-28-18				
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96	REVISION	RY 08-28-18				
97	REVISION	RY 08-28-18				
98	REVISION	RY 08-28-18				
99	REVISION	RY 08-28-18				
100	REVISION	RY 08-28-18				



R027822



CSM-30 (W/ WATER SKID)

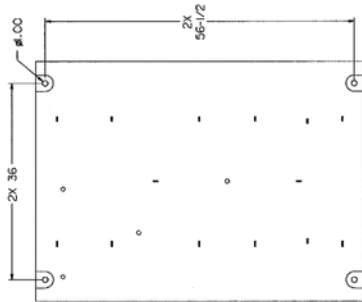
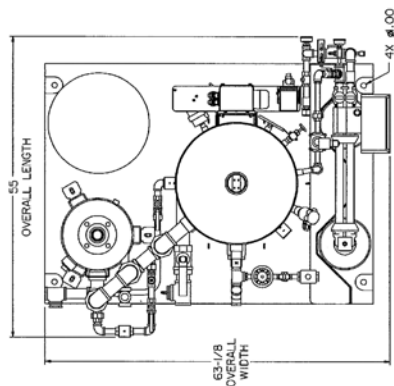
																				ST. ASST. WHERE USED		ITEM		DESCRIPTION		STOCK NO.		REVISED			



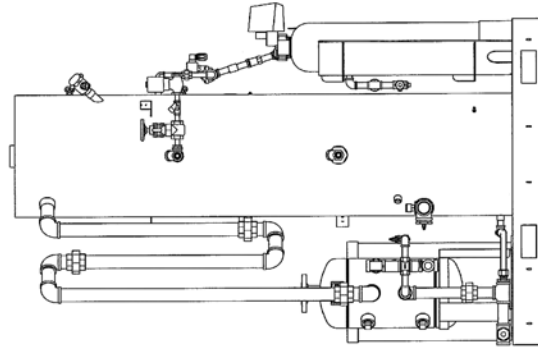
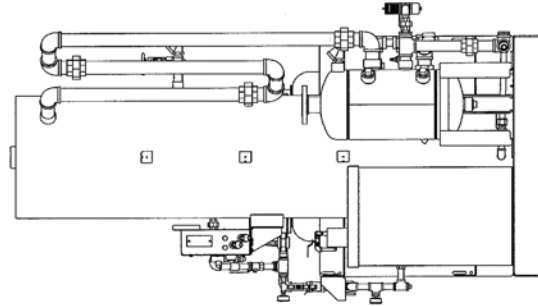
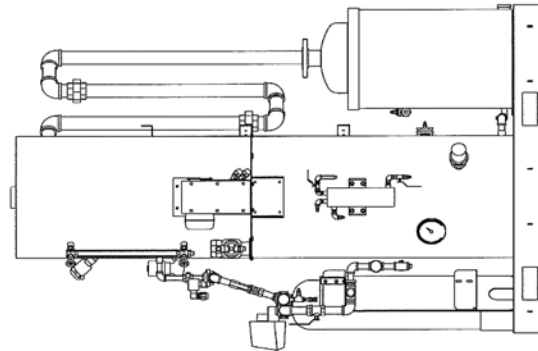
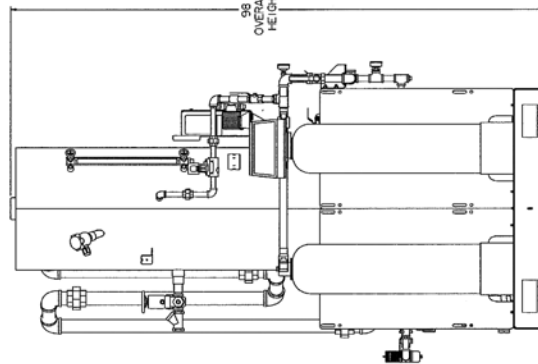
SHEET 5 OF 6

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R027854



FRAME MOUNTING DIMENSIONS



CUSTOMER CONNECTIONS	
5A 1/2" FPT	HOTWELL FEEDWATER OUTLET
5B 3" FPT	HOTWELL VENT
5E 1/2" FPT	HOTWELL STEAM SUPPLY
5F 1" FPT	TRAP RETURN
5G 1" FPT	CONDENSATE RETURN
5K 1" FPT	SOFTENER INLET
5L 1/2" FPT	SOFTENER DRAIN
5M 1" FPT	BLOWDOWN TANK INLET
5N 1/2" FPT	BLOWDOWN TANK DISCHARGE
5O 2-1/2" ISO R F LG	BLOWDOWN TANK VENT

R027854

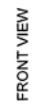
NOTES:

1. RECOMMENDED CLEARANCE:  
A. REAR SIDE = 48" (MINIMUM SUGGESTED)  
B. ALL OTHER SIDES = 36"
2. REFER TO INSTALLATION MANUAL R027849 FOR GENERAL INSTALLATION GUIDELINES.
3. REFER TO R027822 FOR GENERATOR AND WATER SKID OVERALL DIMENSION RECOMMENDED.

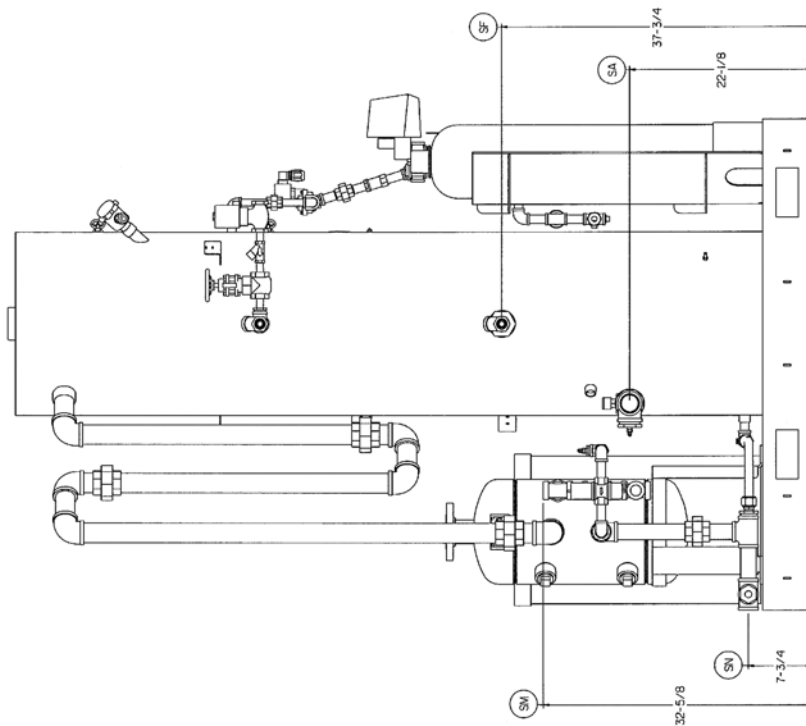
CLAYTON INDUSTRIES		STANDARD SIZE	STOCK NO.	REV
PLAN-INSTALL, DIMENSIONS, WATER SKID, CSM-40 WITH VERTICAL HOTWELL		STANDARD SIZE	STOCK NO.	REV
TOLERANCES EXCEPT AS NOTED		FINISHES	STOCK NO.	REV
FRACTIONS		DECIMALS	STOCK NO.	REV
1/8		0.125	STOCK NO.	REV
1/4		0.250	STOCK NO.	REV
3/8		0.375	STOCK NO.	REV
1/2		0.500	STOCK NO.	REV
3/4		0.750	STOCK NO.	REV
1		1.000	STOCK NO.	REV
1 1/2		1.500	STOCK NO.	REV
2		2.000	STOCK NO.	REV
3		3.000	STOCK NO.	REV
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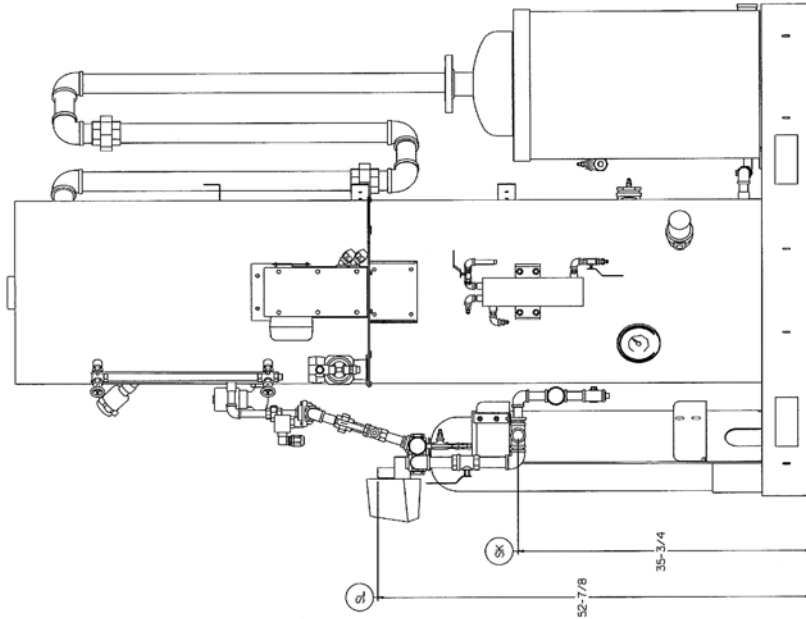


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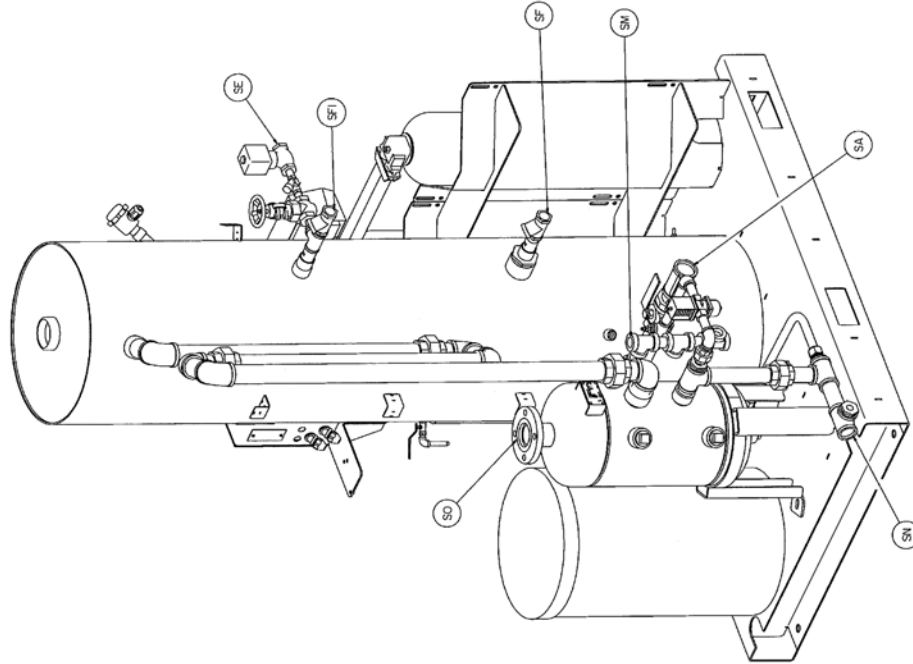
LEFT VIEW



RIGHT VIEW

CLAYTON INDUSTRIES		CITY OF INDUSTRY CA 91744		STOCK NO. 2822	
PLAN- INSTALL, DIMENSIONS, WATER SKID, CSM-40 WITH VERTICAL HOTWELL		REV. 0.60		REV. 0.60	
TOLERANCES EXCEPT AS NOTED		FINISHES UNLESS SPECIFIED		MATERIALS UNLESS SPECIFIED	
A ORIGINAL DRAWING		REV. 09-25-8		DATE 09-25-8	
LTH		REV. 09-25-8		DATE 09-25-8	
FOR PLATING ALLOWANCES, MICRO FINISH AND GENERAL MANUFACTURING TOLERANCES NOT SPECIFIED ON THIS DRAWING, SEE ENR ORDER EC-104					

SHEET 4 OF 5



ISO VIEW

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FOR PLATING ALLOWANCE, MICRO FINISH AND GENERAL MANUFACTURING TOLERANCES NOT SPECIFIED ON THIS DRAWING, SEE ENG. ORDER EO-1562

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## NOTES

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Email: [sales@claytonindustries.com](mailto:sales@claytonindustries.com)