



APAE-112(Vol. IV)

30 MEGAWATT HEAT EXCHANGER AND STEAM  
GENERATOR FOR SODIUM COOLED REACTOR  
SYSTEM

Volume IV. Operation and Maintenance Procedures

May 15, 1962

Alco Products, Inc.  
Schenectady, New York

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Printed in USA. Price \$1.50. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

30 MEGAWATT  
HEAT EXCHANGER AND STEAM GENERATOR  
FOR SODIUM COOLED REACTOR SYSTEM

Volume I Thermal & Mechanical Final Design  
Volume II Chemical and Stress Analysis  
Volume III Material and Welding Specifications  
Volume IV Operation and Maintenance Procedures

Submitted to:  
United States Atomic Energy Commission  
Chicago Operations Office  
9800 South Cass Ave.  
Argonne, Illinois

Contract No. AT(11-1)-666

May 15, 1962

ALCO PRODUCTS, INC.  
Research & Development  
Schenectady, New York

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SECTION 1  
GENERAL INFORMATION

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## 1. GENERAL INFORMATION

### A. TYPE OF EQUIPMENT

1. The intermediate heat exchanger is a vertical shell and tube type of unit designed for operation in a nuclear power plant using liquid sodium as the primary and secondary coolant. It is an integral part of the primary and secondary sodium piping systems having the primary sodium flowing on the shell-side and secondary sodium flowing inside the tubes.
2. The design characteristics of the intermediate heat exchanger are listed in Table 1-1 of this report. The applicable design drawings are included in the Appendix. In brief, the basic design includes a fixed type of tube bundle with sine wave tubes. Each sine wave tube can lengthen or shorten according to the surrounding temperature independently of the shell or adjacent tubes. The vertical shell, with close overlapped disc and doughnut baffles, minimizes rapid temperature stratification prior to the primary sodium going isothermal. The channel ends are hemispherical in shape, and each includes a manway to provide access to the tubesheets for inspection and maintenance.
3. The steam generator is a once-through type, designed to produce superheated steam and for operation in a nuclear power plant using liquid sodium as the reactor coolant. It is an integral part of the secondary sodium piping system, receiving sodium from the intermediate heat exchanger and having the sodium flowing on the shell-side and downward through the unit. High pressure, superheated steam is generated from one pass inside the tubes and is supplied to the turbine driven electrical generator of the power conversion system.
4. The design characteristics of the steam generator are listed in Table 1-2 of this report. The applicable design drawings are included in the Appendix. In brief, the basic design can be classed as shell and tube construction which is very similar to the intermediate heat exchanger incorporating a fixed tube bundle, sine wave tubes, and disc and doughnut baffles. The unbaffled portion of the steam generator is used to provide for a sodium gas blanket and rupture disc. The channel ends are hemispherical in shape, and each includes a manway to provide access to the tubesheets for inspection and maintenance.

### B. PURPOSE OF EQUIPMENT

1. The intermediate heat exchanger is used to transfer heat from the primary loop containing radioactive sodium to the secondary loop containing

nonradioactive sodium. The heat is extracted from the secondary loop by the steam generator.

2. The primary sodium is pumped through the coolant passages of the reactor core, and it then flows through the shell-side of the intermediate heat exchanger countercurrent to the tube-side flow. The secondary sodium is pumped through the tube-side of the intermediate heat exchanger countercurrent to the shell-side flow, and it then flows through the shell-side of the steam generator.
3. The feedwater enters the steam generator through the lower channel. It is preheated to a saturated liquid, evaporated to a saturated vapor, and superheated on a once-through vertical pass through the tubes countercurrent to the shell-side sodium flow. High quality superheated vapor is supplied to the turbine inlet control valve from the upper channel.

### C. DESIGN CHARACTERISTICS

1. The design characteristics of the intermediate heat exchanger are listed in Table 1-1.
2. The design characteristics of the steam generator are listed in Table 1-2.

TABLE 1-1  
DESIGN CHARACTERISTICS OF INTERMEDIATE HEAT EXCHANGER

	<u>SHELL-SIDE</u>	<u>TUBE-SIDE</u>
Fluid Circulated	Primary Sodium	Secondary Sodium
Flow	1,140,000 lb/hr	855,000 lb/hr
Temperature In	1200°F	777°F
Temperature Out	900°F	1175°F
Number of Passes	One	One
Velocity	Axial-Flow 2.22 fps Cross-Flow 2.7-4.9 fps	9.92 fps
Pressure Drop	9.0 psi	7.4 psi
Design Pressure	100 psi	150 psi
Test Pressure	413 psi	620 psi
Design Temperature	1200°F	1200°F
Normal Operation	Startup 1000 cycles Operating 1,000,000 cycles	
Heat Transfer Surface (Effective)	1340 sq ft	
Duty (Full Load)	102,400,000 BTU/hr	
Log Mean Temp. Difference	61.5°F	
Heat Transfer Rate	Service 1240 BTU/ft <sup>2</sup> hr°F Clean 1390 BTU/ft <sup>2</sup> hr°F	

TABLE 1-2  
DESIGN CHARACTERISTICS OF STEAM GENERATOR

	<u>SHELL-SIDE</u>	<u>TUBE-SIDE</u>
Fluid Circulated	Secondary Sodium	Water-Steam*
Flow	855,000 lb/hr	116,000 lb/hr
Temperature In	1175°F	600°F*
Temperature Out	777°F	1050°F*
Flow Arrangement	Cross-Counter	Once-through
Velocity Minimum	2.70 ft/sec	4.95 ft/sec
Maximum	4.22 ft/sec	79.0 ft/sec
Pressure Drop	12.3 psi	35.3 psi
Design Pressure	150 psi	2500 psi
Test Pressure	620 psi	6220 psi
Design Temperature	1200°F	1200°F**
Normal Operation	Startup 1000 cycles Operating 1,000,000 cycles	
Heat Transfer Surface (Effective)	1260 sq ft	
Duty (Full Load)	102,400,000 BTU/hr	
Overall Heat Transfer Rates	Superheating 278 Boiling 495 Preheating 395	BTU/ft <sup>2</sup> hr <sup>0</sup> F BTU/ft <sup>2</sup> hr <sup>0</sup> F BTU/ft <sup>2</sup> hr <sup>0</sup> F

\* Feedwater Inlet at 600°F  
Saturation at 650°F (approximately)  
Superheat to 1050°F

\*\* Except channels which are designed to 1075°F

SECTION 2  
SHIPPING AND INSTALLATION



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## 2. SHIPPING AND INSTALLATION

### A. PREPARATION FOR SHIPMENT

The following shipment preparations are applicable to the intermediate heat exchanger and steam generator.

1. After approval of cleanliness, each unit is to be thoroughly flushed with an inert gas and openings are to be sealed or plugged and capable of maintaining an internal gas pressure of 2 to 4 psig.
2. The sealed unit is to be filled with an inert gas to a pressure of 2 psig.
3. Pipe or nozzle openings which have been prepared for welding shall be protected from damage by end caps securely fastened.
4. A means of introducing inert gas into the vessel shall be provided.
5. All equipment shall be prepared with the necessary fixtures for shipment.

### B. HANDLING

Lift the units by means of rope slings or protected metal slings to avoid damaging the surfaces of the exchangers. Slings should be placed just inside of the tubesheets for handling of the intermediate heat exchanger. Slings should be placed just inside both steam generator tubesheets, and approximately 14 feet from each tubesheet. No compressive or tensile loads should be transmitted to the tubes.

Weights: Dry weight of the intermediate heat exchanger is 17,500 pounds.

Dry weight of the steam generator is 33,000 pounds.

CAUTION: Extreme care must be taken to avoid damage to pipe ends which have been prepared for welding.

### C. MOUNTING

The intermediate heat exchanger and steam generator will be supported on the lip of the bottom tubesheet. Guide brackets shall be included in conjunction with the support design near the top of both the steam generator and intermediate heat exchanger. Provisions for thermal expansion of the shells must be included in both support structures.

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SECTION 3  
OPERATION PROCEDURES

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### 3. OPERATION PROCEDURES

The operating instructions given herein must be treated as general principles which cannot be made more specific without consideration of design characteristics of the plant in which the units are to be installed. Such consideration is not practical, since the units are to be suited for installation in various sodium-cooled nuclear reactor plants with varying characteristics.

The physical characteristics of the once-through steam generator impose limitations on the operation. Since the water level cannot be independently controlled, care must be exercised to avoid flooding the unit with water, or allowing it to boil dry, either of which will result in severe thermal stresses. Furthermore, since there is no steam separator in the upper drum, any drops of water carried with the steam can result in erosion damage to the turbine blades and the seats of any safety valves, pressure relief valves, or throttling valves, so that they will not reseat properly, requiring the plant to be shut down while valve seats are reground or replaced. A minimum of 50°F of superheat is tentatively suggested while outlet steam is being routed through system components which are susceptible to erosion damage.

There is no provision for cooling the system during a shutdown, except by generating steam. The feedwater rate must be carefully controlled and regulated to avoid cooling the system too rapidly, which would introduce severe stresses on the units.

Consideration must be given to techniques of preheating equipment to avoid high stresses during sodium fill and start-up.

A feedwater shut-off valve should be located in the feedwater inlet line close to the steam generator, so as to allow isolation of most of the high pressure feedwater from the unit. A water dump valve should be located between this shut-off valve and the vessel.

Danger points as regard to thermal stresses are:

1. The metal in and adjacent to the primary sodium inlet nozzle of the intermediate heat exchanger may be subject to large and rapid changes in the temperature of the sodium coming from the reactor. Shielding has been provided to control the size of the resulting stresses.
2. Large temperature differentials between the sodium above and below the lower tubesheet of the intermediate heat exchanger will cause severe bending stresses. These large differentials must be avoided, being limited to the steady-state differential under normal conditions.

3. The upper face of the lower tubesheet in the steam generator has been shielded with stainless steel plates. These plates guard the tubesheet against rapid changes in sodium temperature, but they will not be adequate if the existing sodium temperature remains high while the barrel walls remain relatively cool. Within a few minutes after a rise in sodium outlet temperature, the tubesheet will begin to feel a change.
4. The thick-walled upper head of the steam generator is very slow to respond to changes in temperature. The first 150°F change in temperature of steam passing through the head establishes a temperature gradient of permissible magnitude and can occur fairly rapidly. Further temperature changes in the steam are limited to 100°F per hour, except under emergency conditions.

The stainless steel in these units will withstand a surprising amount of thermal overstress, if not too often repeated, but it is bad policy to make full use of this property under normal operating, or regularly expected emergency conditions. It should be reserved as a safety factor to come into play when imperatively needed.

#### A. FILL AND START-UP

The units shall be clean, dry and free of air prior to filling with sodium. Inert cover gas at some low positive pressure shall be sealed in the secondary sodium loop. The sequence of operations shall be as follows:

1. Preheat the intermediate heat exchanger by means of external shell and channel heaters to a minimum of 350°F. Enough soaking time should be allowed to bring all tubes and internal parts to above 300°F. Heating rates and temperature differentials are not to be in excess of values recommended in this procedure. Circulation of hot inert gas through the tubes may be necessary or desirable to supplement the external heaters.
2. Charge the primary sodium preheated to a temperature approximating the maximum metal temperature in the intermediate heat exchanger. Bleed off gas through an upper tubesheet vent hole until the heat exchanger is full, as indicated by sodium flow through the vent.
3. Maintain the sodium temperature by circulation through a heat source external to the heat exchanger, until the secondary system has been charged and operation can proceed.
4. Preheat the steam generator to bring all metal temperatures to a minimum of 350°F. The source for preheat may be external heaters applied to the shell and channels and high purity steam or hot pressurized water circulated through the tubes, either or both, with

capacity to reach the required metal temperature in all sections of the unit in the desired heating time. Attention must be given to recommended maximum heating rates and temperature differentials.

5. Charge secondary system sodium at a preheat temperature approximating the maximum steam generator metal temperature. If the secondary side of the heat exchanger is to be filled at the same time, the primary sodium temperature should be made to approximate the secondary sodium charge temperature.
6. When inert cover gas pressure in the steam generator rises to the desired pressure, due to displacement by sodium bleed gas to maintain this pressure. When the sodium level approaches the normal fill level, approximately intermediate between the high and low levels specified for the liquid level detection system, gas venting and sodium fill shall be stopped. Recommended operating pressure at the gas blanket is 100 psig, in order to minimize level fluctuation.
7. The system is now filled and ready for start-up. The following limitations apply to this procedure and to other controlled transient operations.
  - a. Sodium circulation is to be at a low flow rate consistent with maintaining good temperature control.
  - b. Temperature is to be controlled by regulation of the output from the primary heat source.
  - c. The change in temperature of the heat transfer fluids is not to exceed 100°F per hour. However, an exception can be made, if the metal temperatures have stabilized at some steady state level; then a 150°F temperature change at a uniform rate in fifteen minutes or longer is permissible.
  - d. Fluid temperature differentials across the tubesheets are not to exceed their steady state values, which are as follows:
    - (1) Steam Generator,  
Lower Tubesheet: 175°F.
    - (2) Intermediate Heat Exchanger,  
Lower Tubesheet: 125°F.
    - (3) Intermediate Heat Exchanger,  
Upper Tubesheet: 25°F.  
(This limit may be as high as 75°F during start-up)



- e. The sodium level is to be maintained within the readout range of the liquid level detector in the steam generator. The sodium is to be in contact with the upper tubesheet in the intermediate heat exchanger.
8. Regulate the reactor, or other primary heat source, to increase the system temperature within stated limitations. At this point, feed-water flow and steam pressure should be regulated to obtain a minimum of 50°F of superheat, with superheat maintained between 50 and 150°F until full operating pressure of 2200 psig is reached.
9. Attention must be given to the start-up instructions for the turbine when detailing procedures for bringing the plant feedwater and steam system to normal operation. For most turbines, the following practice would be permissible:
  - a. At an operating pressure of 600 psig with a superheated steam temperature of 550°F, start bleeding steam to the turbine to warm up the turbine in accordance with procedures recommended by the turbine manufacturer.
  - b. After the turbine has been warmed and the steam and feedwater system are in normal operation, increase the pressure in steps to 2200 psig, while maintaining the recommended superheat.
  - c. Continue to increase the system temperature until 1050°F superheated steam is attained, with attention given to limitations for the heat exchanger, steam generator and turbine during start-up.
10. When operating conditions are attained, make final corrections to sodium level and gas pressure in the steam generator.

## B. STEADY STATE OPERATION

Operation may now proceed at any load desired. Detailed instructions are dependent on plant characteristics which will affect the design of control instrumentation and choice of auxiliary equipment. In general, the following operating principles will be adhered to:

1. The steam generator will be operated to give constant pressure at the turbine inlet.
2. Power changes in the operating range will be accomplished by varying sodium flow. The sodium flow rates will vary approximately linearly with load. (Reference Volume I, APAE 112, p. 2-12.)

3. The steam temperature at the steam generator exit must not be allowed to exceed 1075°F, which is the design metal temperature of the upper tubesheet and channel. However, accidental transients of short duration could peak as high as 1100°F without being hazardous.

C. NORMAL SHUTDOWN TO 700°F

The same limitations apply on rate of temperature change for normal shutdown as for normal start-up. The procedure shall be as follows:

1. Lower the reactor power level while slowing the sodium and corresponding feedwater flow to reach a minimum feasible operating load.
2. Continue to lower the reactor power level, maintaining the reduced sodium flow rate, and adhering to specified limitations for temperature change and temperature differentials. Draw off steam as desired to heat feedwater, to operate auxiliaries, and to cool the turbine in accordance with manufacturer's instructions.
3. Unless a complete shutdown is intended, steam temperature at the steam generator outlet will not normally be dropped below 700°F. Steam pressure should be maintained at 2200 psig.

D. NORMAL SHUTDOWN BELOW 700°F

1. Continue to reduce the power level of the primary heat source to maintain a cooling rate within specified limitations. Reduce the feedwater flow and pressure to maintain superheat, reversing the start-up procedure.
2. At some reduced steam temperature, steam should be drawn off through an auxiliary system so as to avoid passage through valves or equipment in the operating system which may be damaged by wet steam. The steam temperature may then be dropped to saturation temperature.
3. The units may be drained after reaching an appropriate temperature.

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SECTION 4

SCRAM AND CASUALTY CONDITIONS

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#### 4. SCRAM AND CASUALTY CONDITIONS

##### A. SCRAM SHUTDOWN

The recommended procedure following a reactor scram is as follows:

1. Slow the sodium and feedwater flows to the minimum feasible sodium flow rate and corresponding feedwater flow rate.
2. Stop the sodium and feedwater flows when outlet steam temperatures has dropped to 850°F. Maintain steam pressure at 2200 psig.
3. Unless a complete shutdown is intended, the units may be allowed to come to equilibrium at this condition.
4. If a complete shutdown is desired, sodium and feedwater may be circulated slowly, with intermittent feedwater operation, if necessary, to stay within recommended cooling rates. Instructions for normal shutdown below 700°F otherwise apply.

##### B. STOPPAGE OF PRIMARY SODIUM CIRCULATING PUMP

Scram the reactor, and thereafter follow the scram shutdown procedure.

##### C. STOPPAGE OF BOTH SODIUM PUMPS OR OF SECONDARY SODIUM PUMP

In either event, scram the reactor, and follow the scram shutdown procedure.

##### D. STOPPAGE OF FEEDWATER PUMP

1. Immediately scram the reactor and slow primary and secondary sodium flow rates to minimum feasible operation.
2. Reduce steam pressure as required to boil water in the lower head of the steam generator and high pressure feed system until the steam outlet temperature has dropped to 850°F.
3. Stop sodium flow and allow the units to come to temperature equilibrium until start-up or shut-down can be accomplished in accordance with given procedures.

E. POWER FAILURE CAUSING STOPPAGE OF ALL PUMPS

Scram the reactor and follow the procedure given for stoppage of feed-water pump (paragraph 4-D).

SECTION 5

LEAKS



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## 5. LEAKS

### A. WEEP

A weep is defined as an extremely small leak of steam into sodium, such as would occur through a pin hole size pore in a tube-to-tubesheet weld area. Such a leak might continue indefinitely without noticeable pressure and temperature effects. The major harmful effect, other than the possibility of the leak growing larger, would be contamination of the sodium with sodium oxide and hydroxide. This would result in an overload of the continuous sodium purification system and would greatly accelerate corrosion of system materials.

Leak detection provisions will allow the system to be shut down by normal procedures in the event of a weep. The leak can then be repaired before it becomes hazardous, and extended operation under corrosive conditions will be avoided. Recommended detection equipment for initial indication of the leak is as follows, in probable order of sensitivity:

#### 1. Hydrogen Detector

A device to monitor the presence of hydrogen gas over a concentration range of 0 to 30 parts per million is presently under development at Atomics International. Hydrogen evolved from the sodium-water reaction is likely to give the initial indication of a weep.

#### 2. Plugging Indicator

This device may be operated at a temperature corresponding to oxide saturation at the recommended maximum sodium oxide concentration for system operation (50 parts per million). The device will then promptly plug when the oxide level rises, because of a weep. High oxide concentration will be indicated by a flow meter which can be made to give an alarm when sodium flow slows.

#### 3. Condensate pH and Conductivity

Enough sodium may contaminate the steam to be evident as sodium hydroxide in the steam condensate, in the event of a weep. Conductivity and pH of the condensate should be monitored continuously.

If the weep continues until a considerable quantity of steam has reacted with the sodium, operating instability may be encountered, due to hydrogen gas generation.

After the existence of a weep has been definitely established, the steam generator shall be shut down by normal procedures described elsewhere in this operation guide, and drained for inspection.

The unit shall be inspected where possible before cleaning to search for evidence of reaction products which might indicate the location of the leak. Such evidence may be particularly obvious for a leak occurring at one of the tube-to-tubesheet joints. If the leak cannot be located by initial inspection, the system shall be cleaned and thoroughly leak tested by conventional techniques, such as:

1. Ionization-Type Halogen Detector (chloroform, freon, etc.)
2. Infra-Red Gas Analyzer, with nitrous oxide tracer.
3. Palladium-Type Ionization Gage.
4. Helium Mass-Spectrometer.

#### B. SMALL LEAK

A small leak is defined as a leak which will actuate the sodium-side pressure relief valve without bursting the large rupture disc. Gas generation can be continuously relieved through the relief valve line and no automatic rapid dump of sodium will occur.

A cover gas pressure of 100 psig in the steam generator under full flow has been chosen as the basis for relief system design. A steam leak into the sodium will cause a pressure excursion to 140 psig, the relief valve set pressure. If the leak has grown from a weep, it will probably have been detected and shut down operations will be underway before the pressure excursion occurs. If shutdown of the reactor is not completed, the reactor shall be scrammed on indication of a rapid pressure rise in the steam generator shell. The sodium and feedwater flows shall be slowed, as for normal scram procedure. When the exit steam temperature drops to 850°F, the sodium and feedwater flow shall be stopped and a valve located in the feedwater line close to the feedwater inlet shall be closed. A dump valve located between the feedwater shutoff valve and feedwater inlet shall then be cracked to allow dumping of water and steam until the steam pressure is approximately equivalent to shell-side pressure. The sodium and metal temperatures may then be allowed to subside until an appropriate draining temperature is reached.

The steam generator must be cleaned, inspected, and repaired prior to putting the unit back in service.

### C. LARGE LEAK

A large leak is defined as a leak which generates a rapid pressure rise in the sodium system not controllable by the sodium-side pressure relief valves. Design pressure of the shell will be exceeded, and the rupture disc will blow out. Sodium and gas will be exhausted through the twelve inch line leading from the rupture disc. This line should lead to some type of separator, such as employed by Atomic Power Development Associates, in the Enrico Fermi plant, where gases can be safely exhausted and sodium will be retained. The exhaust system must be kept free of air at all times.

In the event of a large leak, which will be easily detected, the reactor shall be scrammed as quickly as possible. The sodium pumps shall be stopped, the feedwater pump stopped, and the feedwater valve closed. A remotely controlled dump valve located between the feedwater shut-off valve and the lower head of the steam generator shall be opened and steam released through it to rapidly reduce pressure.

A large leak may possibly damage the steam generating equipment beyond repair. The only consideration in shutdown will be to dissipate the water supply as rapidly as possible, so as to minimize the quantity of water which can contact sodium. This hazard will be somewhat greater than normal power plant operation, because of the properties of the heat exchange fluids involved. Careful consideration should be given to possible operating malfunctions when designing safety provisions of the plant.

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SECTION 6  
MAINTENANCE

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## 6. MAINTENANCE

### A. INTERMEDIATE HEAT EXCHANGER

#### 1. Inspection

The intermediate heat exchanger is of all-welded design. Corrosion of the stainless steel construction material by the primary and secondary liquid sodium heat exchange fluid will be negligible. Internal inspection of the unit after it has been in service should be avoided, unless operating difficulties indicate that maintenance work is necessary. If the unit is opened for repairs, inspection shall be as follows:

- a. All tube-side surfaces of the tubesheets, including tube welds and rises, shall be visually inspected for cracks or other defects. The shielding within the channel and vent and drain openings shall also be inspected.
- b. External inspection will include vessel supports, insulation and the general condition of the vessel.
- c. Internal inspection is not required, or considered necessary, on the shell-side of this unit.

Repairs required as a result of this inspection shall be of first quality workmanship and, where necessary, according to acceptable practices under Section VIII of the ASME Boiler and Pressure Vessel Code and in accordance with applicable NA-666-30 MW specifications. Complete data of inspection and repairs shall be filed as permanent records.

#### 2. Draining and Cleaning

In order to gain access to the unit, primary and secondary sodium must be drained, and the tube-side of the unit must be subjected to steam cleaning, or equivalent. Steam cleaning of the shell-side of the unit should not be necessary, since it can be kept under a satisfactory inert cover gas atmosphere while work is being performed from the tube-side. Thorough cleaning of the shell-side would be difficult, because of the complicated internal structure which introduces points where pockets of sodium oxide and hydroxide might accumulate during steam cleaning. These oxide pockets could cause serious localized corrosion. In case of extenuating circumstances which may necessitate cleaning of the shell-side, design provisions have been made to facilitate the operation as much as possible.



Cover gas can be charged through vent holes provided in the upper tubesheet of the intermediate heat exchanger to speed the draining of the primary sodium. Draining of primary and secondary sodium shall be accomplished through the main piping systems as completely as possible. Drain holes are provided through the upper shroud support ring and lower tube sheet for complete sodium draining. In addition, two, 2 inch auxiliary annulus drains are provided, one in the upper shell section and one in the lower shell section. These auxiliary drains are sealed with welding caps which can be cut off, if the drains are to be used.

Access to the intermediate heat exchanger is further complicated because the unit will be inside the vapor container when utilized in a nuclear power plant. After it has been completely drained, it must be monitored for radioactive contamination to determine if the activity level is low enough to allow access for maintenance. Contamination may be from residual primary sodium and/or corrosion products which have been carried through the reactor and deposited in the intermediate heat exchanger. If the activity level is so high that a down period is necessary to allow decay of short-lived radioactive nuclides, no further cleaning shall be performed until the decay period is complete. Corrosion will be minimized, if residual sodium is not oxidized prior to an idle period.

Prior to removing the manway covers for purpose of entry, the tube-side of the vessel shall be flushed thoroughly with low pressure steam. The shell-side shall be maintained under inert gas pressure great enough to prevent entry of steam through any leaks. Alcohol and liquid ammonia have also been used successfully as cleaning fluids and either may be substituted for steam, if plant facilities are available. A mixture of ammonia and ammonium chloride solution is useful for removal of oxide sludges.

In the event cleaning of the shell-side becomes necessary, some difficulty may be encountered in complete cleaning of the annulus behind the shell thermal shields. If the normal drains or shield annulus should become plugged with oxide sludge during cleaning operations, it will be necessary to remove the welding caps from the auxiliary annulus drains. Unplugging of the shield annulus may then be accomplished by application of pressure to the auxiliary drains. The bottom tube sheet drains can also be pressurized to clear oxide sludge. Caution must be exercised to avoid excessive application of pressure in the annulus, since a differential pressure of greater than 10 psi across the shield may damage the shield. The aforementioned ammonia and ammonium chloride solution may also prove useful in removal of oxide sludge from the drains and annulus.

After the vessel is satisfactorily free of sodium, as determined by alkalinity of the steam condensate, it should immediately be flushed generously with clean hot water until all hydroxides and chlorides are removed. All possible precautions shall be taken to prevent entry of rinse water from the tube-side to the shell-side, if cleaning of the shell-side is to be avoided. After water flushing and drying, the unit will be accessible for necessary maintenance.

It must be recognized that any residue remaining in the vessel after cleaning operations can be the source of severe corrosion. For this reason, the life of the unit may be curtailed if cleaning solutions come in contact with the shell-side crevices.

### 3. Maintenance

In the event there is evidence of a leak between the primary and secondary fluids, the unit shall be shut down and isolated. It shall then be drained and cleaned in accordance with Section 6, A-2.

After the unit is accessible, the following procedures shall be followed:

- a. Remove upper channel manway cover nuts and open cover.
- b. Using a cutting tool, cut seal weld and remove seal and backing ring.

**CAUTION:** If it is necessary to remove the lower manway cover, retain the seal and backing ring in position while cutting the seal weld.

- c. Pressurize the shell side of the unit with an inert gas, and check for the leak by sound, feel, bubble test, or helium sniffer. The shell-side must be pressurized with helium, if a helium sniffer is to be used. Pressure is not to exceed 150 psig.
- d. If gas is escaping from the shell through a tube, the leak may be in a tube between tubesheets or at the tube joints in the lower tubesheet. To determine the exact location of the leak in this instance, it will be necessary to remove the lower manway cover and seal. After location of the leak and prior to rewelding, reduce the gas pressure to atmospheric on the shell-side.
- e. If the leak is at a tube weld, repair the weld as follows:
  - (1) Coverings shall be used to protect surrounding area from foreign matter.

- (2) Using a tube end cutter, remove the existing weld.
  - (3) Reweld tube to riser with a two pass weld, using inert gas shielded tungsten-arc process with filler rod addition. Minimum depth of weld to be  $1.5T$  ( $T$  = tube wall thickness).
  - (4) After the reweld is completed, pressurize the shell-side with helium and check the weld for leakage with a helium sniffer.
  - (5) After the weld has been checked for leakage, remove the lower manway cover (if not already removed) and run a lint-free cloth through the repaired tube. After the tube is clean, remove all tools and covering from channels. Using a vacuum cleaner with soft brush on hose, clean both channels and close the unit.
  - (6) Completely dry and purge the unit with inert gas prior to sodium refill.
- f. If a defective tube is found, it will be necessary to plug the tube at the upper and lower tubesheet welds as follows:
- (1) Coverings shall be used to protect surrounding area from foreign matter.
  - (2) Cut off the end of the tube and the tube-to-tubesheet weld approximately  $1/16$  inch above the tubesheet face. Prepare a stepped plug (Type 316) with the large collar diameter being  $1/2$  inch for a distance of  $1/8$  inch from one end. Drill out a hollow in this end using a  $5/16$  inch drill for a depth of  $1/4$  inch. The remainder of the plug length shall have a diameter suitable for a drive fit into the tube. The small diameter end of the plug shall be well rounded (bull point) to minimize galling when driving the plug. The plug length should correspond to the tubesheet thickness, plus  $3/16$  inch and the length of the bull point. Drive fit the stepped stainless steel plug into the tube at each tubesheet so that the collar rests on the tube end.
  - (3) Plugs shall be welded using the inert gas shielded tungsten-arc process with filler rod addition. Two weld passes shall be required.
  - (4) Check welds with a helium sniffer after pressurizing the shell-side with helium.

- (5) After the weld has been leak tested, clean the entire upper and lower channel areas using a vacuum cleaner with soft brush on hose.
  - (6) Completely dry and purge the unit with inert gas prior to sodium refill.
- g. In the event of a defect in a welded joint or shell material, the defect will be repaired in accordance with Section VIII, of the ASME Boiler and Pressure Vessel Code, Paragraph UA-821 and applicable NA-666-30MW specifications.

#### Tools and Accessories

1. Wrenches for manway cover nuts.
2. Manway cover gasket (four spares each manway).
3. Cutting tool for manway seals.
4. Tube end cutter.
5. Vacuum cleaner with hose and soft brush.
6. Welding equipment recommended:  
  
AC-DC rectifier, with high frequency unit and current slope control,  
300 amp capacity.
7. Electric Drill - 1/2 inch chuck.
8. 1/2 inch tube puncture tool.
9. Manway cover studs and nuts (10 per cent extra for spares).
10. Leak detection instruments.
11. Type 316 stainless steel material for plugging tubes, say 5/8 inch diameter rod.
12. For other available tools and accessories see steam generator list.

## B. STEAM GENERATOR

### 1. Inspection

The steam generator is of integral all-welded design with sodium in the shell-side and water and/or steam in the tube-side. Materials have been chosen such that corrosion by sodium on the shell side will be negligible.

It is recommended that internal inspection of the steam-side of the unit be performed when there is evidence of a leak or malfunction, and during shutdown after extended periods of operation without inspection. For example, it is suggested that the initial inspection be performed during the first plant shutdown after one year of steam generator operation, unless there is good cause for an earlier inspection.

Internal inspection shall include the following:

- a. Visual inspection of the tube welds for cracking and/or other defects exposing stainless steel.
- b. Boroscope examination of the Inconel tube lining of a few selected tubes for evaluation of general condition.
- c. Visual examination of steam inlet and outlet channels for extent of oxidation, scaling and corrosion.

External inspection will include vessel supports, insulation, and the general condition of the vessel.

Internal inspections are not required or considered necessary on the shell-side of the unit.

Repairs required as a result of inspections shall be of first quality workmanship, and, where required, in accordance with acceptable practice under Section VIII of the ASME Boiler and Pressure Vessel Code and applicable NA-666-30MW specifications. Complete data of inspection and repairs shall be filed as permanent records.

### 2. Draining and Cleaning

Internal access is provided through manways in the tube-side channel ends. Since this is the steam-side of the unit, it can easily be opened for inspection during a plant shutdown without any complicated cleaning operations. The sodium-side of the unit should normally be drained, but not cleaned, and kept under inert gas during the inspection or maintenance period.

In the event of a steam leak which causes considerable oxide contamination of the shell-side of the unit, it may be necessary to steam clean the shell-side. Even then, renewed operation of the unit with removal of the oxide by continuous cold trapping may be more desirable. If maintenance work necessitates a long period of downtime before the unit can be put in operation, it is recommended that the unit be thoroughly drained on the shell-side, including sodium pockets behind the thermal shields. Corrosion damage will thus be minimized by removal of stagnant sodium which may be oxidized or become oxidized during the down period.

Drainage provisions of the steam generator are similar to the intermediate heat exchanger. Four one inch drain holes are provided in the lower tubesheet for drainage of sodium trapped above the tubesheet. Auxiliary annulus drains are provided on the shell to aid in draining the pockets behind the shield, if necessary. Slots are provided at the bottom of the shield, and may allow complete draining of the annulus without use of the auxiliary drains. Gas can be charged through vent holes in the upper tubesheet to speed draining operations. Initial draining should be through the main piping outlet. Cleaning operations, if necessary, will be the same as described for the intermediate heat exchanger.

### 3. Maintenance

In the event of leaks between fluids, the control system is set, as far as possible, to take care of shutdown either by indicating a manual shutdown of the plant or an emergency scram of the system. The steam generator shall be isolated and drained in accordance with Section 6, B-2. After the unit is accessible, the following procedures shall be followed:

- a. Remove the manway covers from the steam generator.
- b. Pressurize the shell-side of the unit with inert gas, and check for the leak by sound, feel, bubble test, visual evidence, or helium sniffer. The gas pressure is not to exceed 150 psig. The inert gas must be partially helium, if a helium sniffer is to be used for leak detection.
- c. After location of the leak, reduce the shell-side gas pressure to atmospheric prior to any welding.
- d. If the leak is at a tube-to-tubesheet weld, the weld shall be repaired as follows:
  - (1) Coverings shall be used to keep the surrounding areas clean of foreign matter.

- (2) Remove the existing weld with a tube end cutter.
  - (3) The Inconel cover pass on the end of the bimetallic tube may be removed, if it will facilitate the repair of the weld.
  - (4) Reweld the tube and cover pass, if the cover pass has been removed, in accordance with Sodium Component Welding Specification Number NA-666-30MW-16.
  - (5) After the reweld is completed, pressurize the shell-side with helium and check the repair weld for leakage with a helium sniffer.
  - (6) After repair is completed, clean the entire upper and lower channel areas using a vacuum cleaner with soft brush on hose.
  - (7) Install a new manway cover gasket and bolt on the cover.
- e. If a defective tube is found, the tube shall be plugged at the upper and lower tubesheet welds as follows:

- (1) Coverings shall be used to protect surrounding area from foreign matter.
- (2) Drill the tube so as to reduce the wall thickness to approximately 0.025 inch to a point below the tubesheet. Using a puncture tool, puncture the tube just inside the upper and lower tubesheet surface on the shell-side. Then cut off the end of tube and the tube-to-tubesheet weld approximately  $3/32$  inch above the tubesheet overlay.

Prepare a stepped plug (Inconel, SB-166) with the large collar diameter being  $17/32$  inch for a distance of  $5/16$  inch from one end. Drill out a hollow in this end using a  $5/16$  inch drill for a depth of  $5/16$  inch. The remainder of the plug length shall have a diameter suitable for a drive fit into the tube. The small diameter end of the plug shall be well rounded (bull point) to minimize galling when driving the plug. The plug length should correspond to the tubesheet thickness, including the overlay, plus  $5/16$  inch, plus the bull point.

- (3) Drive fit the Inconel metal plug into the tube at each tubesheet, so that the collar rests on the tube end.
- (4) Plugs shall be welded using the inert gas shielded tungsten-arc process with filler rod addition. Two weld passes shall be required with throat dimension of  $3/16$  inch minimum.

- (5) Pressurize the shell-side of the vessel with helium and leak check the weld with a helium sniffer.
  - (6) After repair is completed, clean the entire upper and lower channel areas using a vacuum cleaner with soft brush on hose.
  - (7) Install a new manway cover gasket and bolt on the cover.
- f. In the event of a defect in a welded joint or shell material, the defect will be repaired in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, Paragraph UA-821 and applicable NA-666-30MW specifications.

### Tools and Accessories

1. Wrenches for manway cover nuts.
2. Manway cover gasket (four spares each manway).
3. Tube end cutter.
4. 15/32 inch drill with a leading end approximately 2 inches long, with a diameter suitable for centering drill inside of the tube. (Provide with a 6 inch drill extension.)
5. Tube puncture tool.
6. Manway cover studs and nuts (10 per cent extra for spares).
7. 5/16 inch drill.
8. Inconel bar stock suitable for machining of plugs.
9. Jack for removal of bottom manway cover.
10. For other available tools and accessories see heat exchanger list.



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SECTION 7

APPENDIX A

WATER CHEMISTRY RECOMMENDATIONS

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A. WATER CHEMISTRY RECOMMENDATIONS

The chemistry of feedwater to the steam generator shall comply with normal limitations for subcritical nonblowable, once-through units, which are as follows:

Total Solids ----- 0.5 ppm maximum

pH ----- 8.8 to 9.4

Dissolved Oxygen ----- 0.007 ppm maximum

Hydrazine ----- Slight Excess

The dissolved oxygen content shall be controlled by mechanical deaeration, plus chemical scavenging by addition of enough hydrazine to maintain a slight excess. The hydrazine will also serve to raise the feedwater pH to the required level for minimum corrosion.

Addition of ammonia is permissible to supplement the hydrazine for pH control. Proper selection of the ion exchange resins for make-up and feedwater purification will probably eliminate the necessity for such pH adjustment.

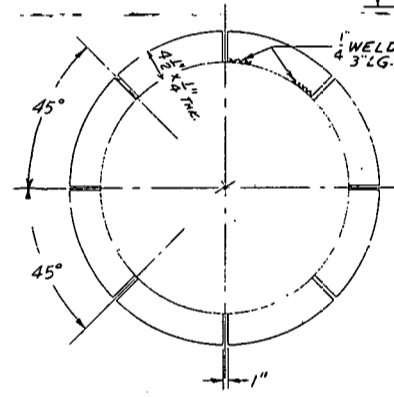
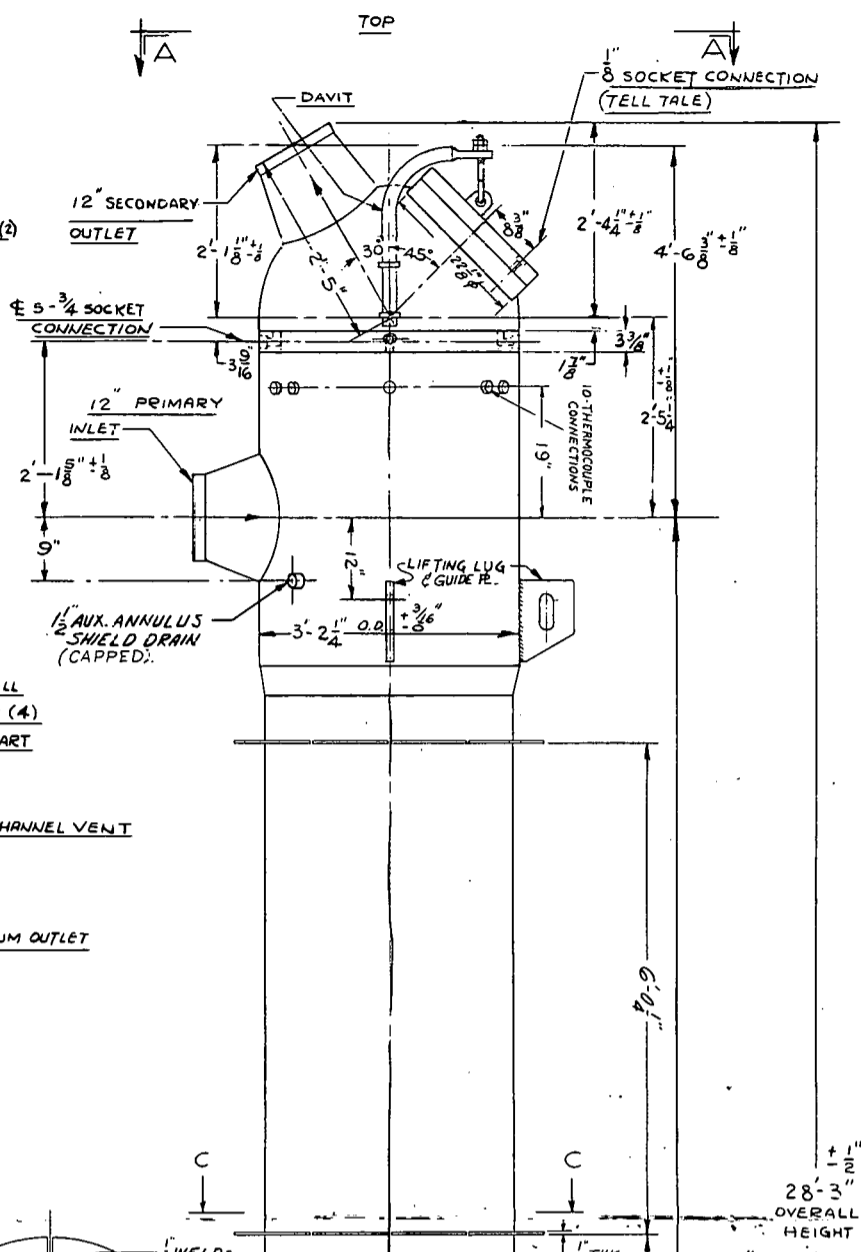
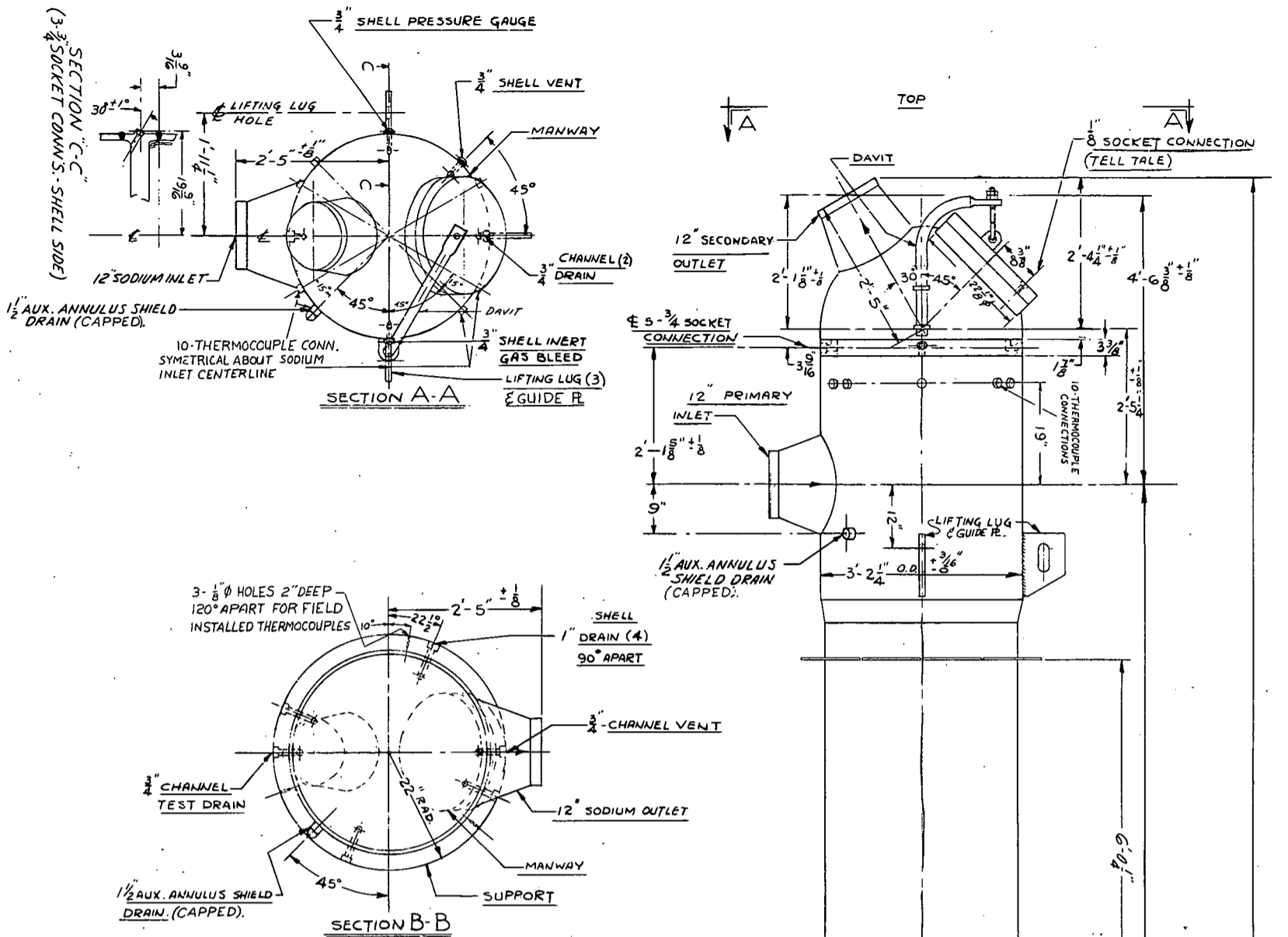
Continuous demineralization of a portion of the feedwater flow will be necessary to maintain the required water purity. It is recommended that the purification system be designed to care for abnormal temporary emergencies, such as gross impurities introduced by condenser leakage. In addition, all make-up water must be demineralized.

In spite of the high purity requirements on steam generator feedwater, there may be a tendency for solids deposition in the tubes during extended periods of operation. In addition to permissible impurities in the entering feedwater, the water can pick up corrosion products as it enters the tubes and deposit most of the solids further up the tubes. If this occurs to an extent which is detrimental to steam generator operation, the unit should be back flushed with hot water of high purity in an attempt to redissolve any soluble solids. If this operation does not sufficiently clean the tubes, consideration should be given to flushing with a chemical cleaning agent.

In view of the low corrosion rate of iron-nickel-chromium alloy in high purity water, it is anticipated that solids deposition will not be a problem so long as feedwater specifications are met.

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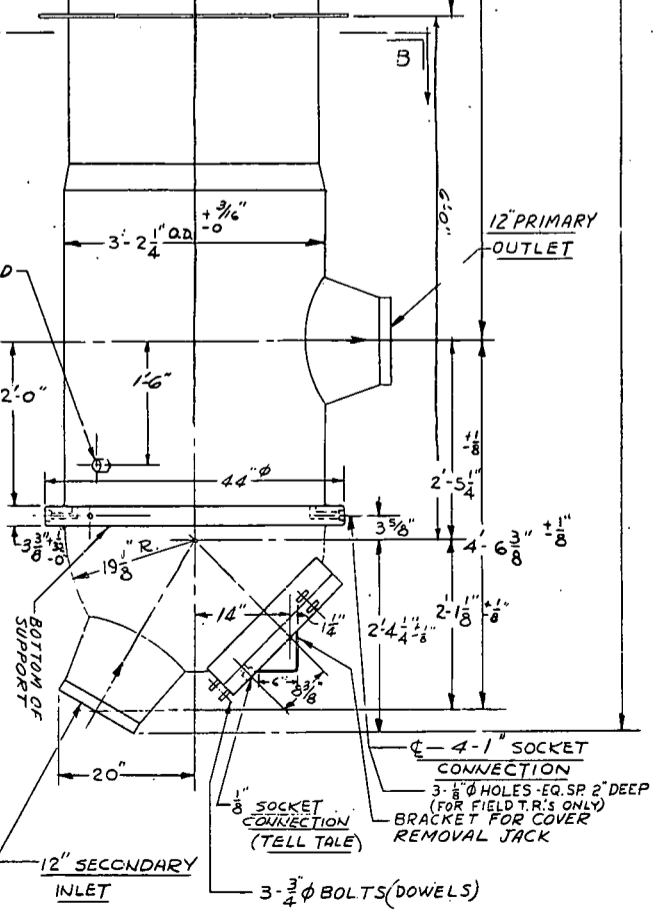
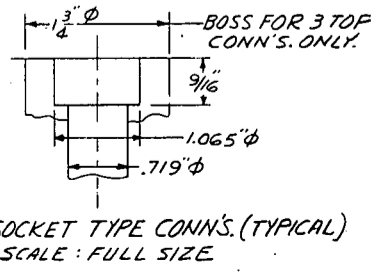
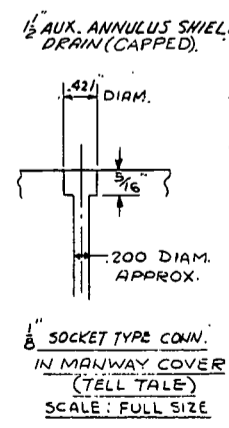
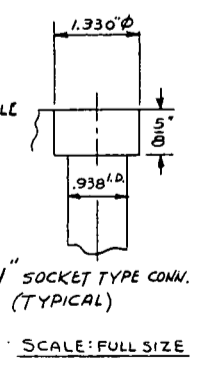
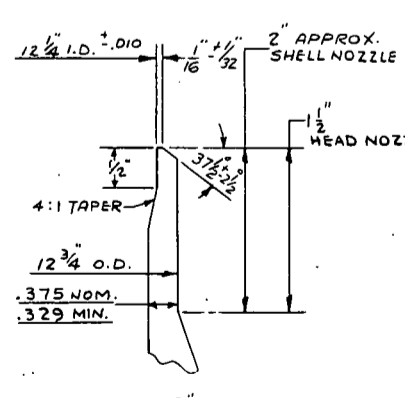
SECTION 7  
APPENDIX B  
DESIGN DRAWINGS



CALCULATED WEIGHTS (LBS.)	
ENTIRE UNIT (DRY)	17,500
ENTIRE UNIT (OPERATING)	27,000
ENTIRE UNIT (WITH WATER)	28,200
MANHOLE COVER EACH	210

	DESIGN PRESS.	DESIGN TEMP.	TEST PRESS.
SHELL SIDE	100 P.S.I.	1200° F	413 P.S.I.
TUBE SIDE	150 P.S.I.	1200° F	620 P.S.I.

REFERENCE DRAWINGS	
TUBE STUDY	D666-3-2
X-SECTION	D666-3-4
NOZZLE CONN'S.	B666-3-5
DETAILS	C666-3-6



97

D 666-3-3

ALCO PRODUCTS, INCORPORATED  
 RESEARCH & DEVELOPMENT  
 SCHENECTADY, NEW YORK

INTERMEDIATE HEAT EXCHANGER  
 OUTLINE (30 M.W.)  
 DRAWING NO. D 666-3-3  
 ORDER NO. 3  
 DATE 3-1-53

REVISIONS

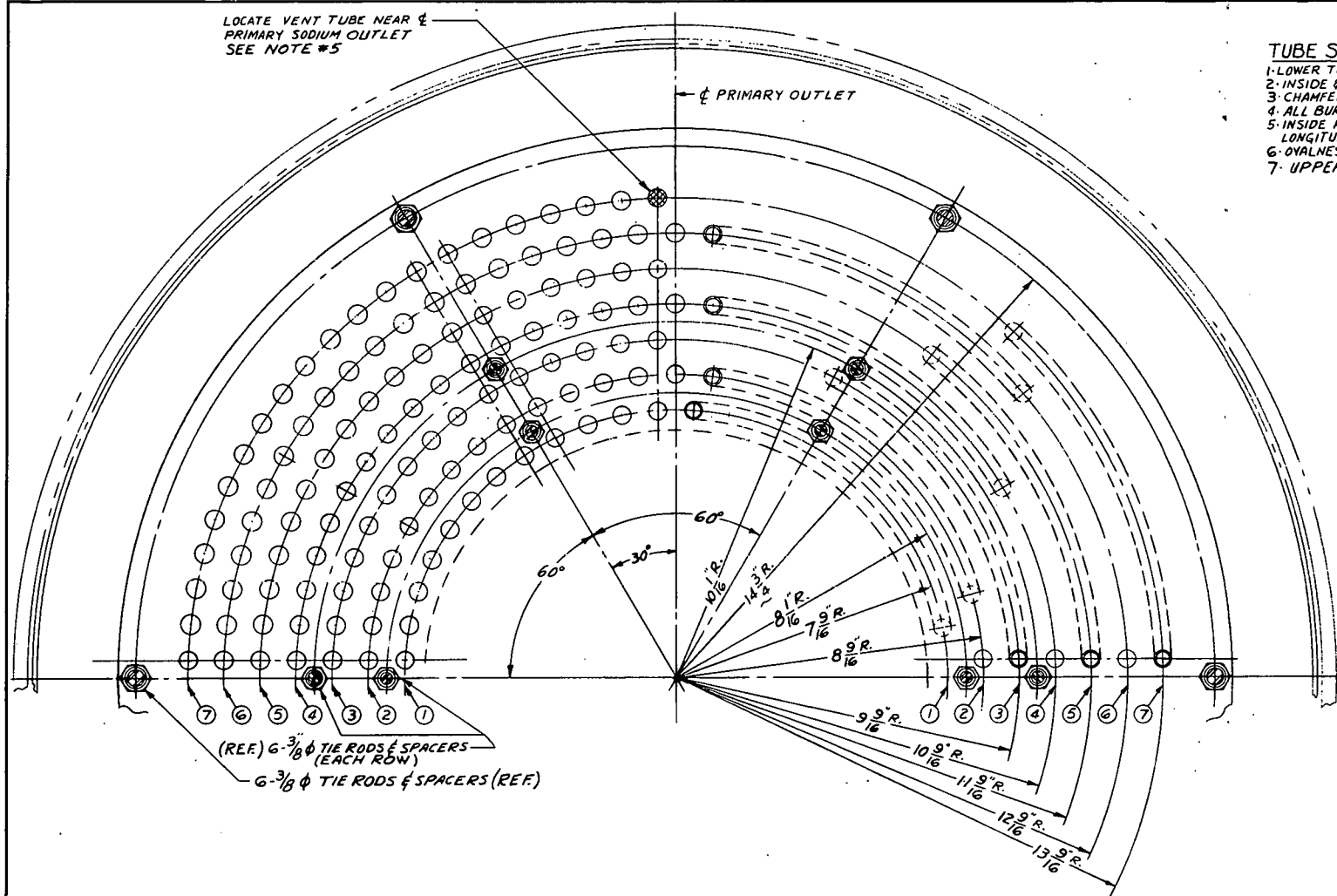
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2	3/1/53	REVISED TO SHOW REVISIONS
3	3/1/53	REVISED TO SHOW REVISIONS

B-1



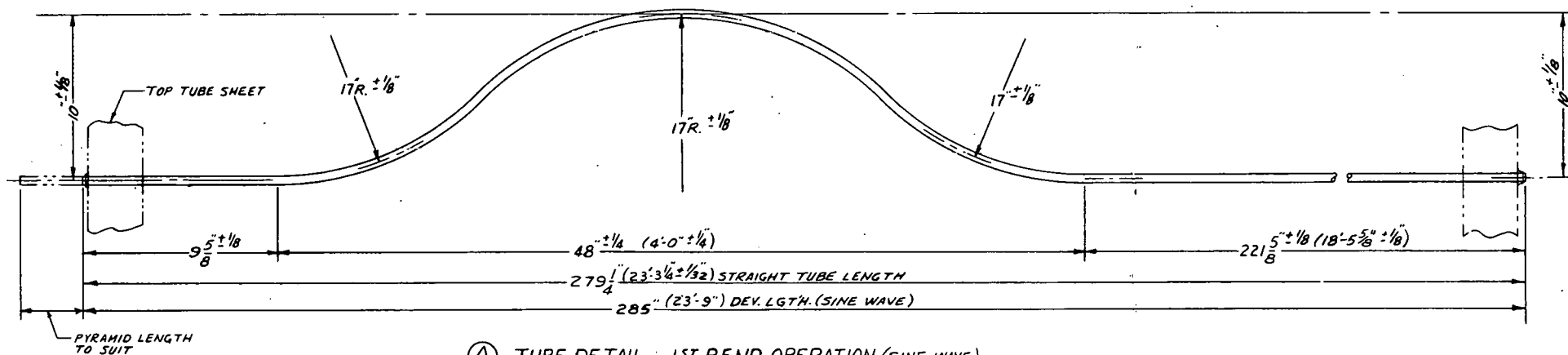


LOCATE VENT TUBE NEAR & PRIMARY SODIUM OUTLET SEE NOTE #5



VIEW OF TUBE & TIE ROD ARR'G'T.  
SCALE: 6"=1'-0"

VIEW FROM TOP END AFTER 2ND. BENDING OPERATION



(A) TUBE DETAIL - 1ST BEND OPERATION (SINE WAVE)  
SCALE: 3"=1'-0"

**TUBE SHEET FACING & DRILLING**

1. LOWER TUBE SHEET ONLY. TUBE HOLE DIAMETER SHALL BE  $.508 \pm .002$ "
2. INSIDE & OUTSIDE FACE OF TUBE SHEETS -  $12\frac{1}{2}$ " FINISH OR BETTER.
3. CHAMFER HOLES ON INSIDE FACE OF TUBE SHEETS ONLY.
4. ALL BURRS REMOVED FROM EDGES OF HOLES.
5. INSIDE HOLE SURFACE TO BE  $6\frac{3}{4}$ " OR BETTER FINISH & BE FREE OF LONGITUDINAL SCRATCHES, NOTICEABLE SPIRAL GROOVES, INDENTATIONS & NOTCHES.
6. OVALNESS IN HOLES SHALL BE LIMITED SPECIFICATION 17A SHEET 3 - ALCO STD'S.
7. UPPER TUBE SHEET ONLY. TUBE HOLE DIAMETER SHALL BE  $.517 \pm .002$ "

**BAFFLE PLATE TOLERANCE**

1. HOLE DIA. - MAX. OF  $1/32$  LARGER THAN NOM. TUBE SIZE.
2. ALL BURRS & SHARP CORNERS REMOVED FROM EDGES OF HOLES.
3. HOLE SURFACE -  $6\frac{3}{4}$ " OR BETTER & BE FREE OF LONGITUDINAL SCRATCHES, NOTICEABLE SPIRAL GROOVES, INDENTATIONS & NOTCHES.
4. OVALNESS IN HOLES SHALL BE LIMITED BY THE MAJOR DIAMETER NOT EXCEEDING THE MINIMUM AXIS DIAMETER BY MORE THAN  $1/64$ .
5. HOLE PITCH & DRILL DRIFT SHALL HAVE A TOLERANCE BY MEASURING OF THE LIGMENT WHICH SHALL HAVE A VARIATION OF  $\pm 1/32$ .

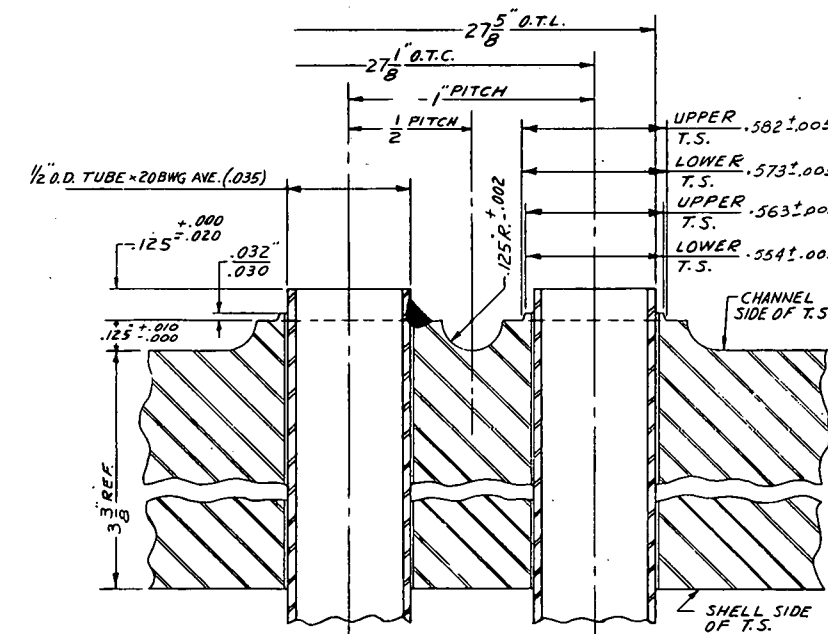
**NOTES:**

1. ROWS #1, 2, 4 & 6 SINE WAVE CLOCKWISE.
2. ROWS #3, 5 & 7 SINE WAVE COUNTER CLOCKWISE.
3. BETWEEN ROWS #1 & 2 AT  $16\frac{1}{8}$ " DIA.,  $6\frac{3}{8}$ " DIA. TIE RODS & SPACERS AS SHOWN.
4. TOTAL NO. OF TUBES - 462, DRILL & REAM TUBE SHEET FOR 461 -  $1/2$  O.D. TUBES ON  $1$ " CIR. &  $1$ " RAD. PITCH AS SHOWN.
5. ONE TUBE MARKED THUS  $\otimes$  TO BE USED AS INERT GAS VENT PIPE, DO NOT DRILL TUBE SHEETS, SEE DETAILS "A & H" OF DWG. D666-3-4
6. BETWEEN ROWS #3 & #4 AT  $20\frac{1}{8}$ "  $\phi$ ,  $6\frac{3}{8}$ "  $\phi$  TIE RODS & SPACERS AS SHOWN.
7. AT  $29\frac{1}{2}$ " DIA.,  $6\frac{3}{8}$ "  $\phi$  TIE RODS & SPACERS AS SHOWN.

**TUBE SHEET DRILLING**

ROW NO.	CIRCLE DIA.	EQUAL SPAC.	CIR. $\phi$	NO. OF PITCHES	NO. OF TUBES
1	15 <sup>1</sup> / <sub>8</sub>	.9899	47.517	48	48
2	17 <sup>1</sup> / <sub>8</sub>	.9963	53.800	54	54
3	19 <sup>1</sup> / <sub>8</sub>	1.001	60.083	60	60
4	21 <sup>1</sup> / <sub>8</sub>	1.005	66.366	66	66
5	23 <sup>1</sup> / <sub>8</sub>	1.009	72.649	72	72
6	25 <sup>1</sup> / <sub>8</sub>	1.012	78.933	78	78
7	27 <sup>1</sup> / <sub>8</sub>	1.014	85.216	84	83 + 1 VENT TUBE

461 + 1 VENT = 462 TOTAL



(A) TUBE WELDING ARR'G'T. - TUBE SHEETS  
SCALE: 3"=1"

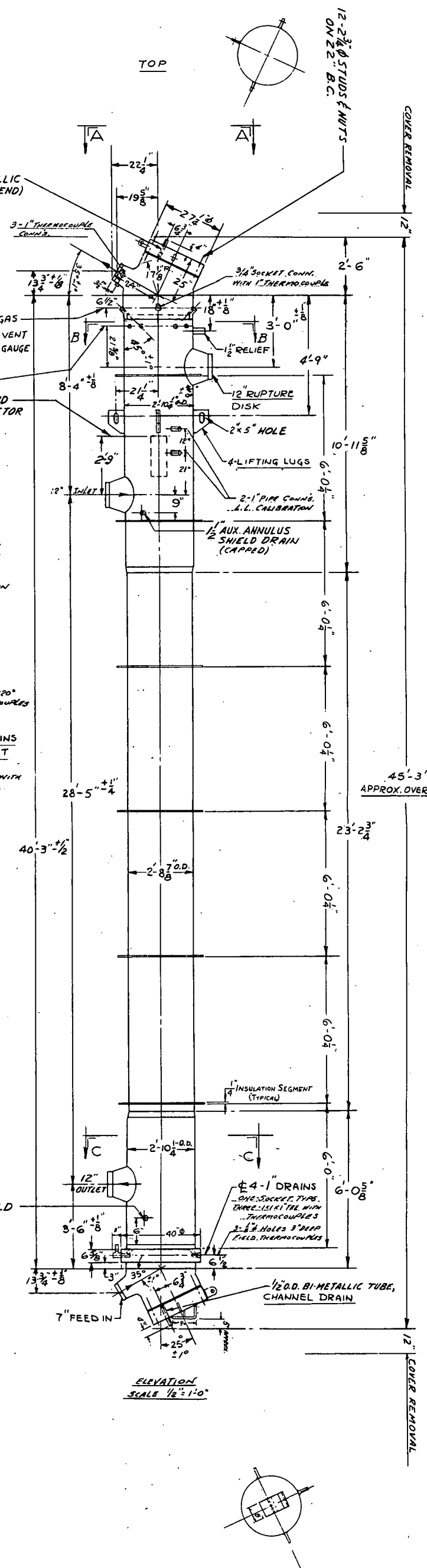
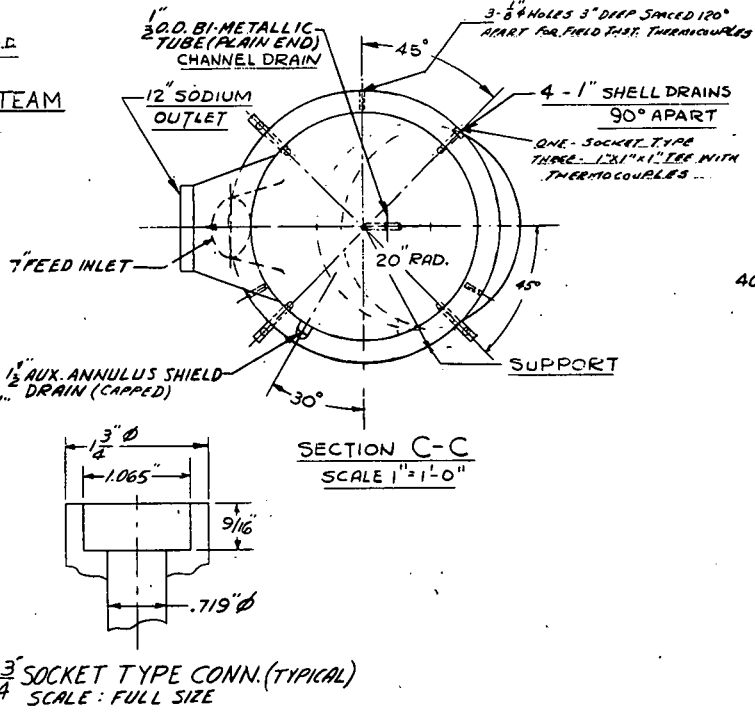
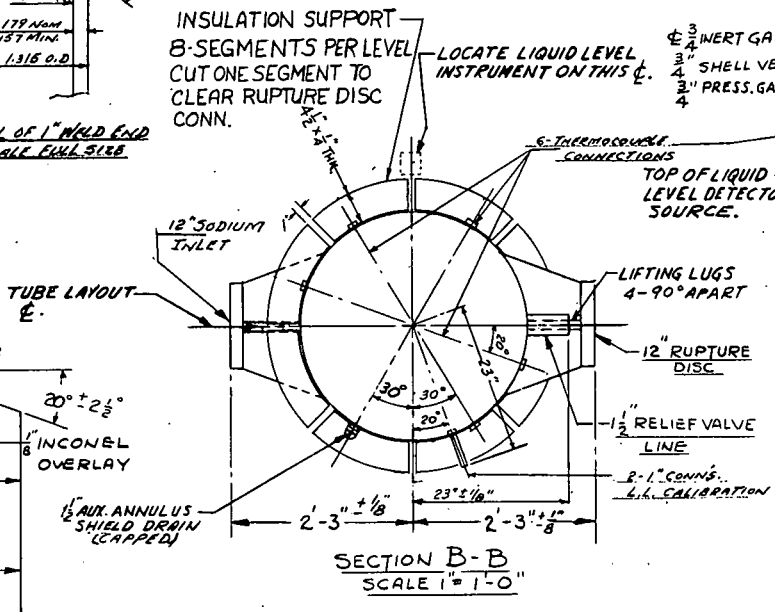
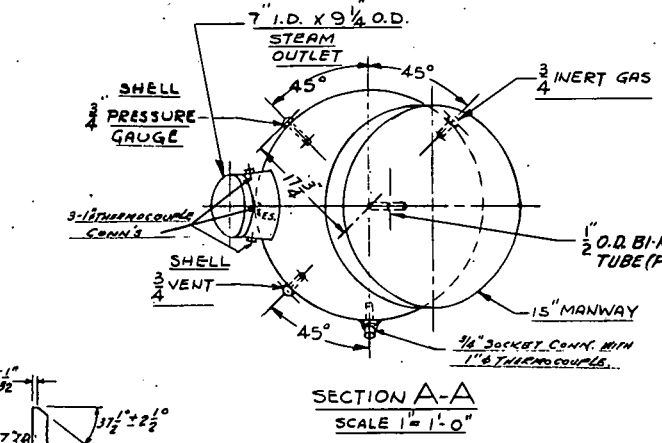
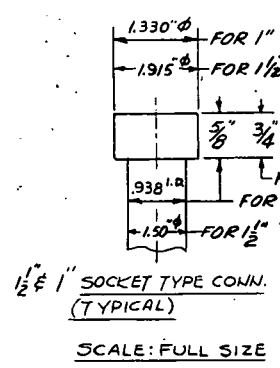
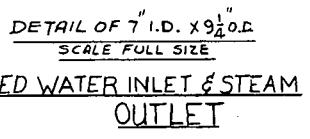
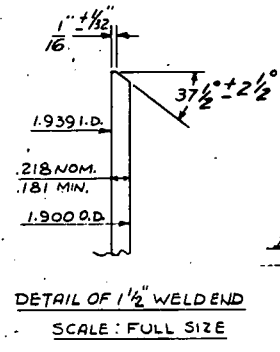
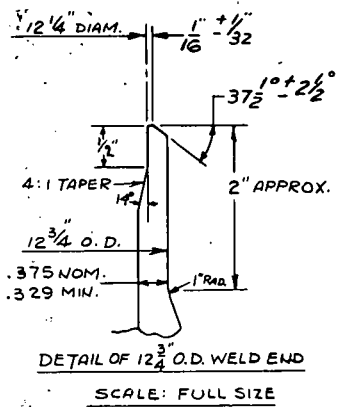
REF. DWG: D666-3-4 - INT. HEAT X-CHR. (X-SECTION)

D-666-3-2

ALCO PRODUCTS, INCORPORATED RESEARCH & DEVELOPMENT SCHENECTADY, NEW YORK		ALCO		TUBES-ARR'G'T, WELDING & BENDING INTER. HEAT X-CHR. (30MW)-CONTRACT AT(11-1)666	
SCALE: MADE	CHK'D	DATE	ORDER NO.	ITEM NO.	IDENT. NO.
1/4"	MM	11/16	D 666	3	2
REVISIONS					







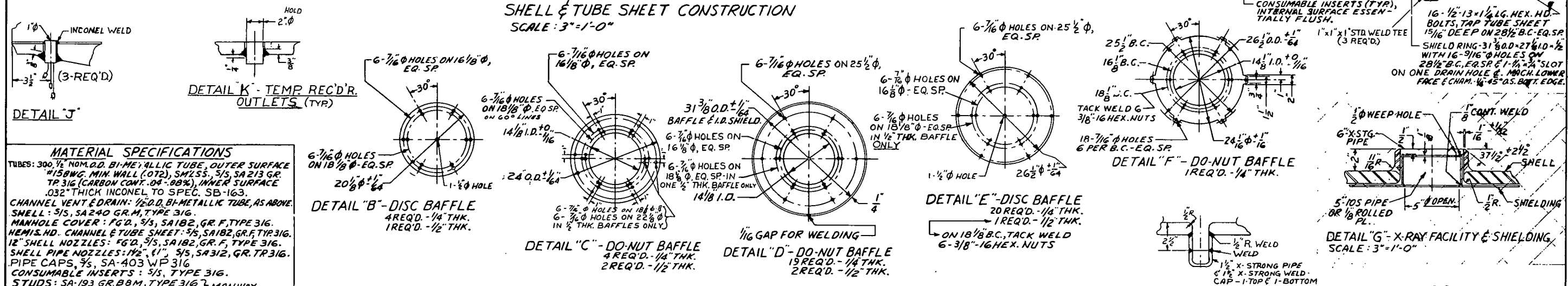
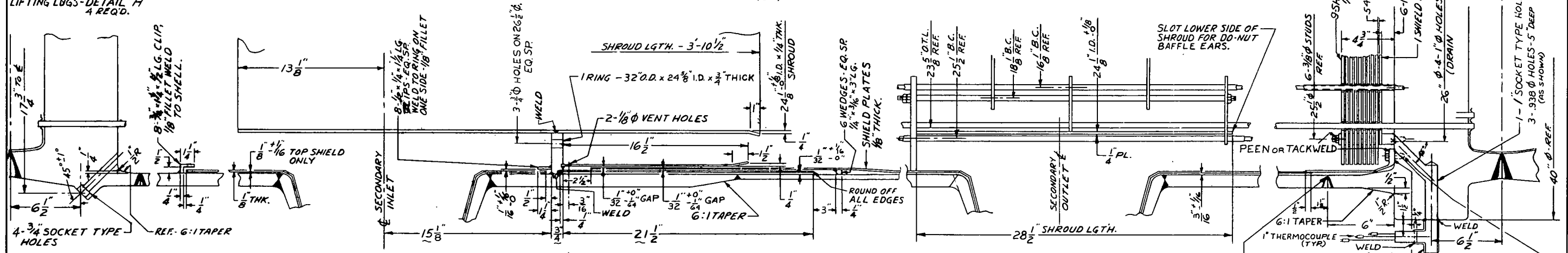
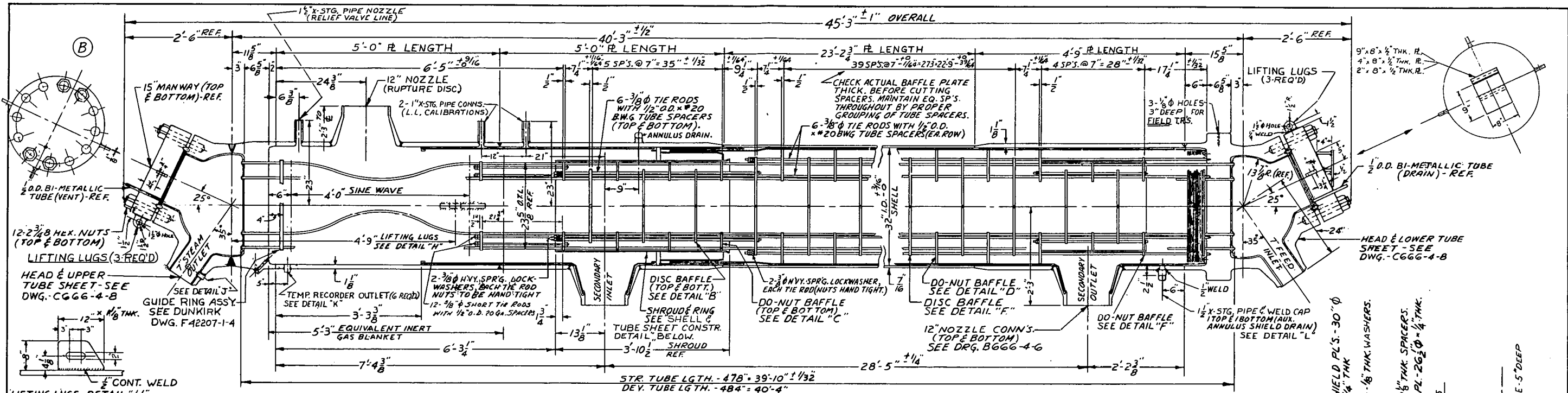
CALCULATED WEIGHTS (LBS.)	
ENTIRE UNIT (DRY)	33,000
ENTIRE UNIT (OPERATING)	42,000
ENTIRE UNIT (WITH WATER)	46,500
MANHOLE COVER EACH	960

	DESIGN PRESS.	DESIGN TEMP.	TEST PRESS.
SHELL SIDE	150 P.S.I.	1200° F.	620 P.S.I.
CHANNELS	2500 P.S.I.	1075° F.	6220 P.S.I.
TUBES ONLY INTERNAL	2500 P.S.I.	1200° F.	6220 P.S.I.

REFERENCE DRAWINGS	
TUBE STUDY	D666-4-4
X-SECTION	D666-4-5
NOZZLE CONN.	B666-4-6
NOZZLE (RUPTURE DISC) DETAILS	B666-4-7
	C666-4-8

REVISIONS	NO.	DATE	BY	CHKD.	DESCRIPTION

D. 666-4-3  
 ALCO PRODUCTS, INCORPORATED  
 RESEARCH & DEVELOPMENT  
 STEAM GENERATOR OUTLINE (30MW)  
 SCHENECTADY, NEW YORK



**MATERIAL SPECIFICATIONS**

TUBES: 300 1/2" NOM. O.D. BI-METALLIC TUBE, OUTER SURFACE #15 BWG. MIN. WALL (.072), SMLSS, 5/5, SA 213 GR. TP 316 (CARBON CONT. .04-.08%), INNER SURFACE .032" THICK DRINCON: 1/2" O.D. BI-METALLIC TUBE, AS ABOVE.

SHELL: 5/5, SA 240 GR. M, TYPE 316.

MANWAY COVER: FG D, 5/5, SA 182, GR. F, TYPE 316.

HEMIS. HD. CHANNEL & TUBE SHEET: 5/5, SA 182, GR. F, TYPE 316.

12" SHELL NOZZLES: FG D, 5/5, SA 182, GR. F, TYPE 316.

SHELL PIPE NOZZLES: 1/2", 1", 5/5, SA 312, GR. TP 316.

PIPE CAPS, 5/5, SA-403 WP 316.

CONSUMABLE INSERTS: 5/5, TYPE 316.

STUDS: SA-193 GR. B8M, TYPE 316 - MANWAY NUTS: SA-194 GR. B.C., TYPE 347.

GASKET: R.T.J. SOLID INCONEL, ANN'L.D. (OCTAGONAL)

SPACERS: TUBING, TIE RODS: BAR, 5/5, TYPE 304

INSUL. SUPPTS. & LIFTING LUGS, 5/5, TYPE 304

SHIELD, SHROUDS, BAFFLES, INT. SUPPT. RINGS & SHIELD BACK-UP STRIP: 5/5 PL., TYPE 304.

INTERNAL BOLTS & NUTS: 5/5, TYPE 304.

SPRING LOCKWASHERS: 5/5, TYPE 304 (HEAVY)

GENERAL NOTES		CALCULATED WGT'S (LBS.)		DESIGN CONDITIONS			REFERENCE DRAWINGS	
CONSTRUCT. & WELD. SHALL BE IN ACCORDANCE WITH ASME CODE SECTION VIII, 1959 EDITION & T.E.M. CLASS R STDS. WHERE APPLICABLE.		ENTIRE UNIT (DRY)	33,000	DES. PRESS.	DES. TEMP.	TEST PRESS.	OUTLINE	D666-4-3
STRESS RELIEVE - NO.		ENTIRE UNIT (OPERATING)	42,000	SHELL SIDE	150 P.S.I.	1200 °F	TUBE STUDY	D666-4-4
CORROSION ALLOWANCE - NONE.		ENTIRE UNIT (WITH WATER)	46,500	TUBE SIDE	2500 P.S.I.	1075 °F	NOZZLE CONN.	B666-4-6
RADIOGRAPH - YES.		MANHOLE COVER EA.	960	TUBES ONLY INTERNAL	2500 P.S.I.	1200 °F	NOZZLE (RUPTURE DISC)	B666-4-7
CODE STAMP APPLIED.							DETAILS	C666-4-8
TOLERANCES AS NOTED & ALL MACHINED SURFACES 125 FINISH UNLESS OTHERWISE NOTED.								

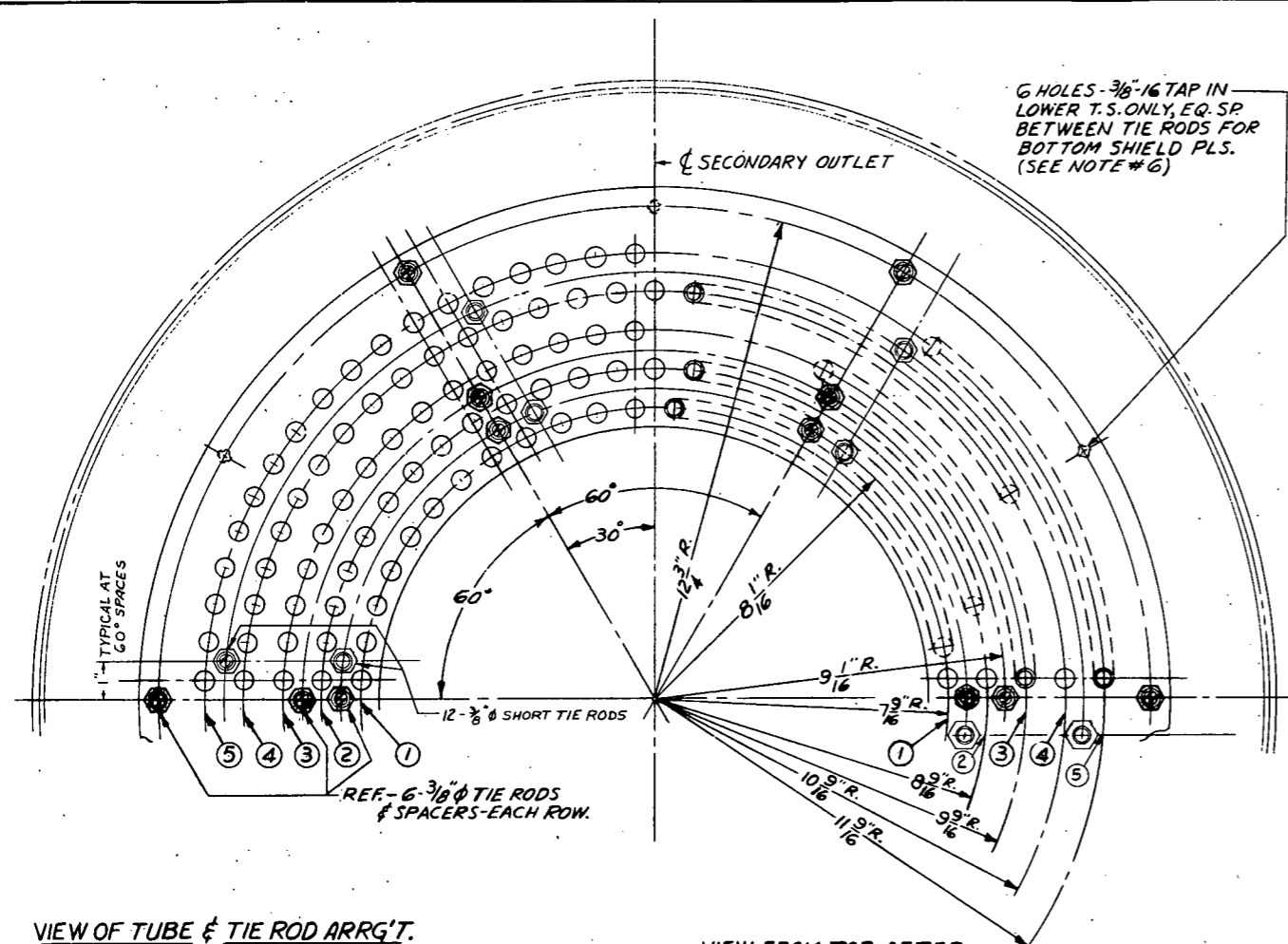
**D666-4-5**

ALCO PRODUCTS, INCORPORATED  
RESEARCH & DEVELOPMENT SCHENECTADY, NEW YORK

**STEAM GENERATOR (X-SECTION)**  
30 M. W. - CONTRACT AT (11-1) 666

SCALE: 1" = 1'-0"    DRAWING NO. 666-4-5

ALCO



VIEW OF TUBE & TIE ROD ARR'G'T.

VIEW FROM TOP AFTER 2ND BENDING OPERATION

**TUBE SHEET FACING & DRILLING**

1. LOWER TUBE SHEET ONLY, TUBE HOLE DIAMETER SHALL BE  $.009 \pm .001$  LARGER THAN THE SMALLEST DIAM. TUBE.
2. INSIDE & OUTSIDE FACE OF TUBE SHEETS - 125 FINISH OR BETTER.
3. CHAMFER HOLES ON INSIDE FACE OF TUBE SHEETS ONLY.
4. REMOVE ALL BURRS FROM EDGES OF HOLES.
5. INSIDE HOLE SURFACE TO BE 63 OR BETTER FINISH & BE FREE OF LONGITUDINAL SCRATCHES, NOTICEABLE SPIRAL GROOVES, INDENTATIONS & NOTCHES.
6. OVALNESS IN HOLES SHALL BE LIMITED TO SPECIFICATION 17A SHEET 3-ALCO STD'S.
7. UPPER TUBE SHEET ONLY, TUBE HOLE DIAMETER SHALL BE  $.512 \pm .001$

**BAFFLE PLATE TOLERANCE**

1. HOLE DIAM. - MAX. OF  $1/32$ " LARGER THAN NOM. TUBE SIZE.
2. ALL BURRS & SHARP CORNERS REMOVED FROM EDGES OF HOLES.
3. HOLE SURFACE - 63 OR BETTER & BE FREE OF LONGITUDINAL SCRATCHES, NOTICEABLE SPIRAL GROOVES, INDENTATIONS & NOTCHES.
4. OVALNESS IN HOLES SHALL BE LIMITED BY THE MAJOR DIAMETER NOT EXCEEDING THE MINIMUM AXIS DIAMETER BY MORE THAN  $1/64$ ".
5. HOLE PITCH & DRILL DRIFT SHALL HAVE A TOLERANCE BY MEASURING OF THE LIGAMENT WHICH SHALL HAVE A MAX. VARIATION OF  $\pm 1/32$ ".

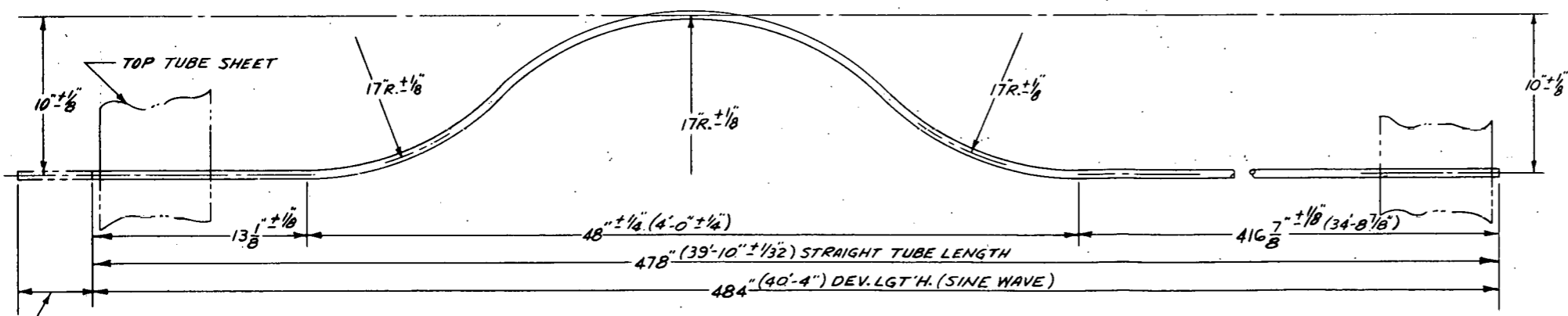
**TUBE SHEET DRILLING**

ROW NO.	CIRCLE DIA.	EQUAL SPAC.	CIR. Ø	NO. OF PITCHES	NO. OF TUBES
1	15 1/8	.9899	47.517	48	48
2	17 1/8	.9963	53.800	54	54
3	19 1/8	1.001	60.083	60	60
4	21 1/8	1.005	66.366	66	66
5	23 1/8	1.009	72.649	72	72

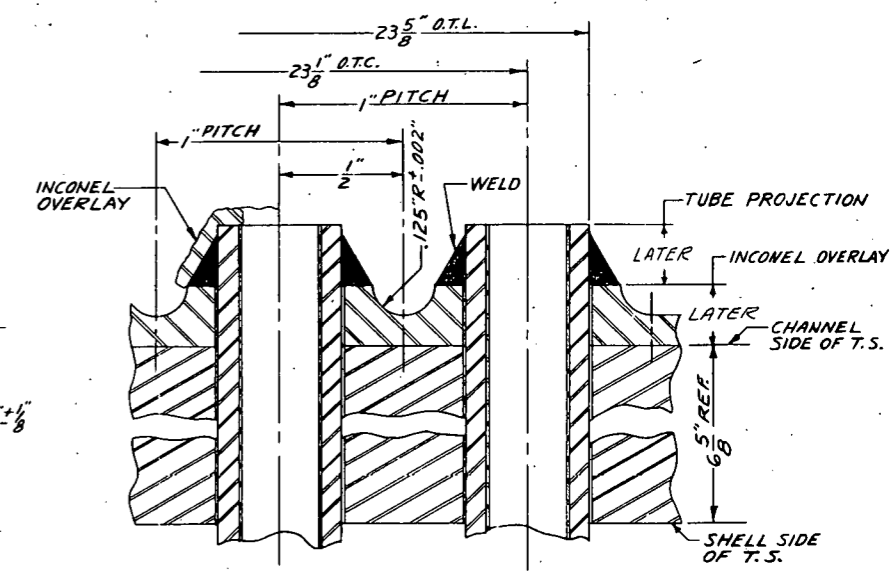
300 TOTAL

**NOTES:**

1. ROWS # 1, 2 & 4 SINE WAVE CLOCKWISE.
2. ROWS # 3 & 5 SINE WAVE COUNTER CLOCKWISE.
3. BETWEEN ROWS # 1 & 2 AT 16 1/8 DIA. - 6-3/8 DIA. TIE RODS & SPACERS AS SHOWN.
4. BETWEEN ROWS # 2 & 3 AT 18 1/8 DIA., 6-3/8 DIA. TIE RODS & SPACERS AS SHOWN.
5. TOTAL NO. OF TUBES - 300, DRILL & REAM TUBE SHEET FOR 300-1/2" DIA. TUBES ON 1" CIR. & 1" RAD. PITCH AS SHOWN.
6. BOTTOM SHIELD PLATES ONLY - ALL TUBE & TIE ROD SPACER TUBE HOLES TO BE 5/8" Ø ± 1/32" (DETAIL ON DWG. D666-4-5)



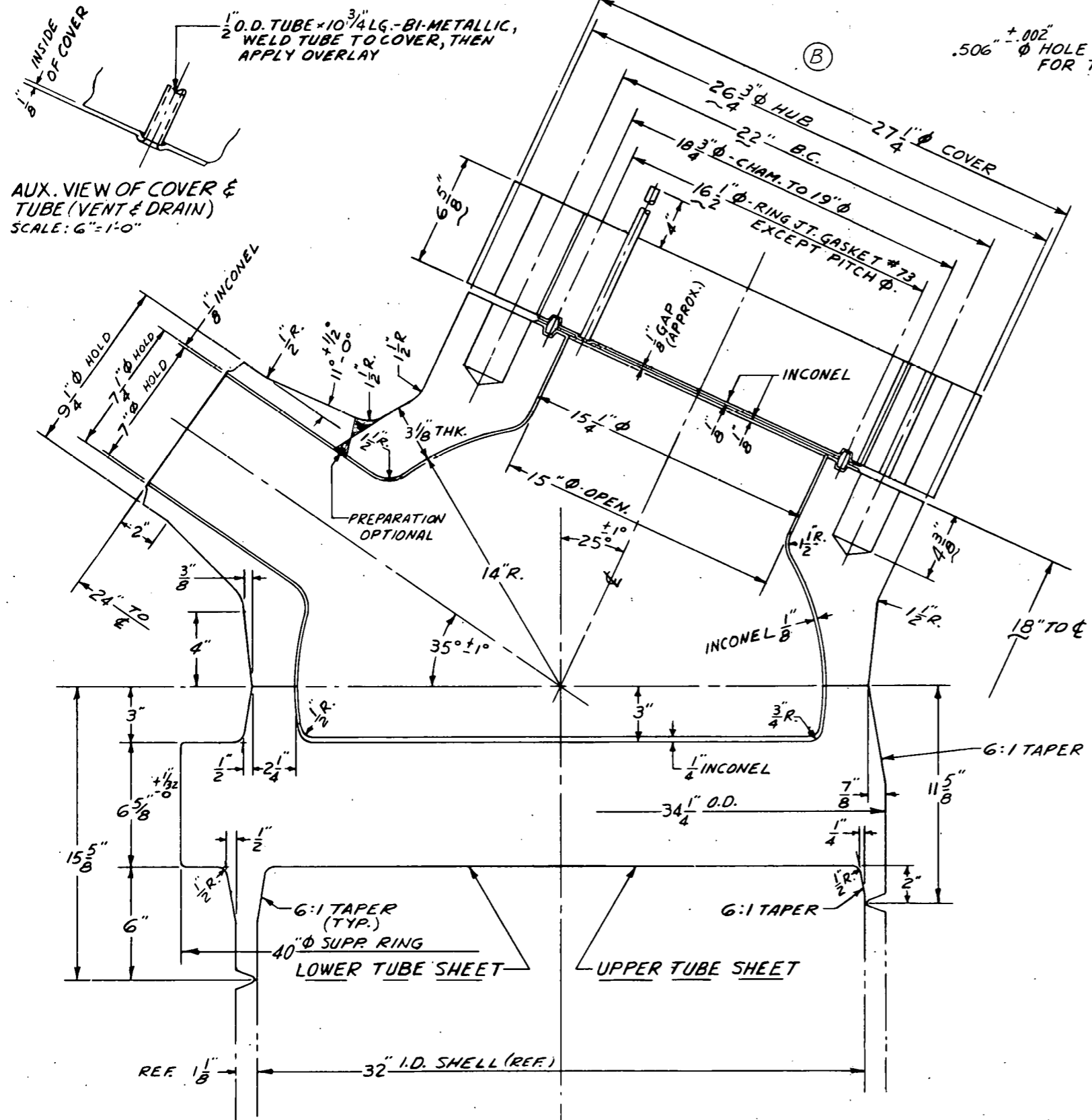
TUBE DETAIL - 1ST BEND OPERATION (SINE WAVE)  
SCALE: 3"=1'-0"



TUBE WELDING ARR'G'T. - TUBE SHEETS  
SCALE: 3"=1"

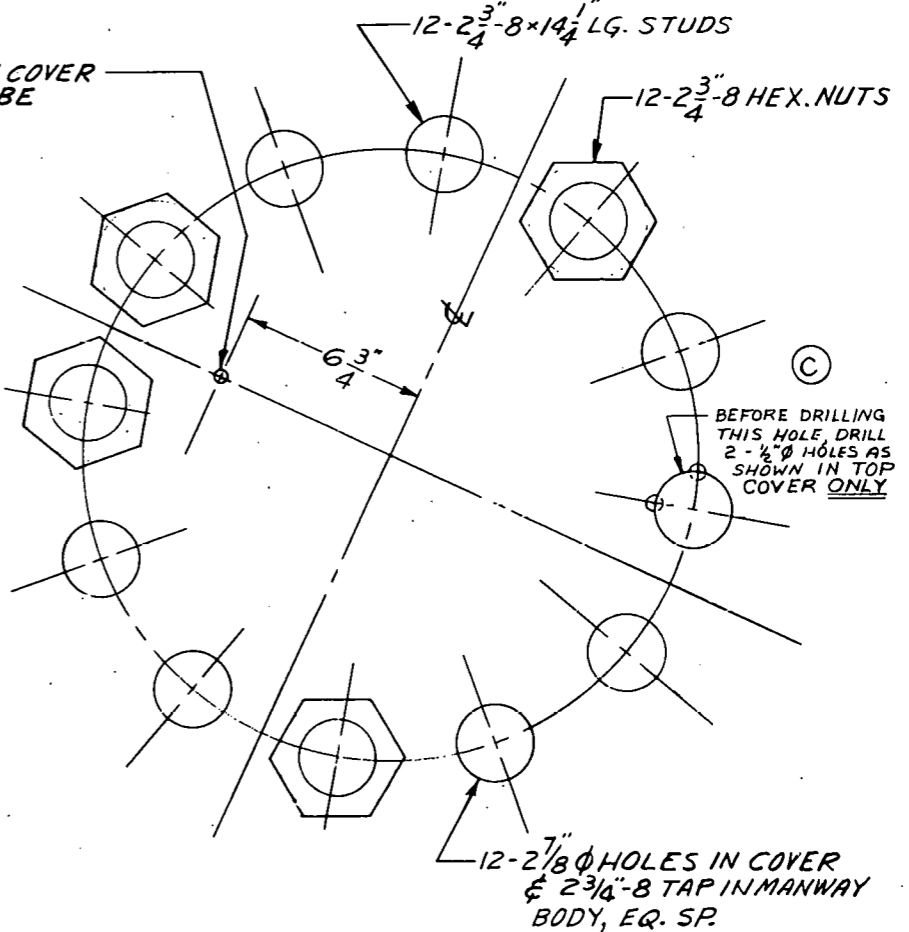
D666-4-4

B 1/4 RDF #111 ADDED 12-3/8\"/>			
A 1/4 RDF #111 GEN. (SEE REV SHEET #1)			
DATE	BY	CHKD	REVISION
ALCO PRODUCTS, INCORPORATED RESEARCH & DEVELOPMENT SCENECTADY, NEW YORK			
TUBES ARR'G'T, WELDING & BENDING STEAM GENERATOR CONTRACT ATU(11-1)666			
SCALE	MADE	CHK'D	CERT. DATE
6-10			
ORDER NO.	ITEM NO.	IDENT. NO.	
D 666	4	4	



AUX. VIEW OF COVER & TUBE (VENT & DRAIN)  
SCALE: 6"=1'-0"

.506"  $\pm$  .002"  $\phi$  HOLE IN COVER FOR TUBE

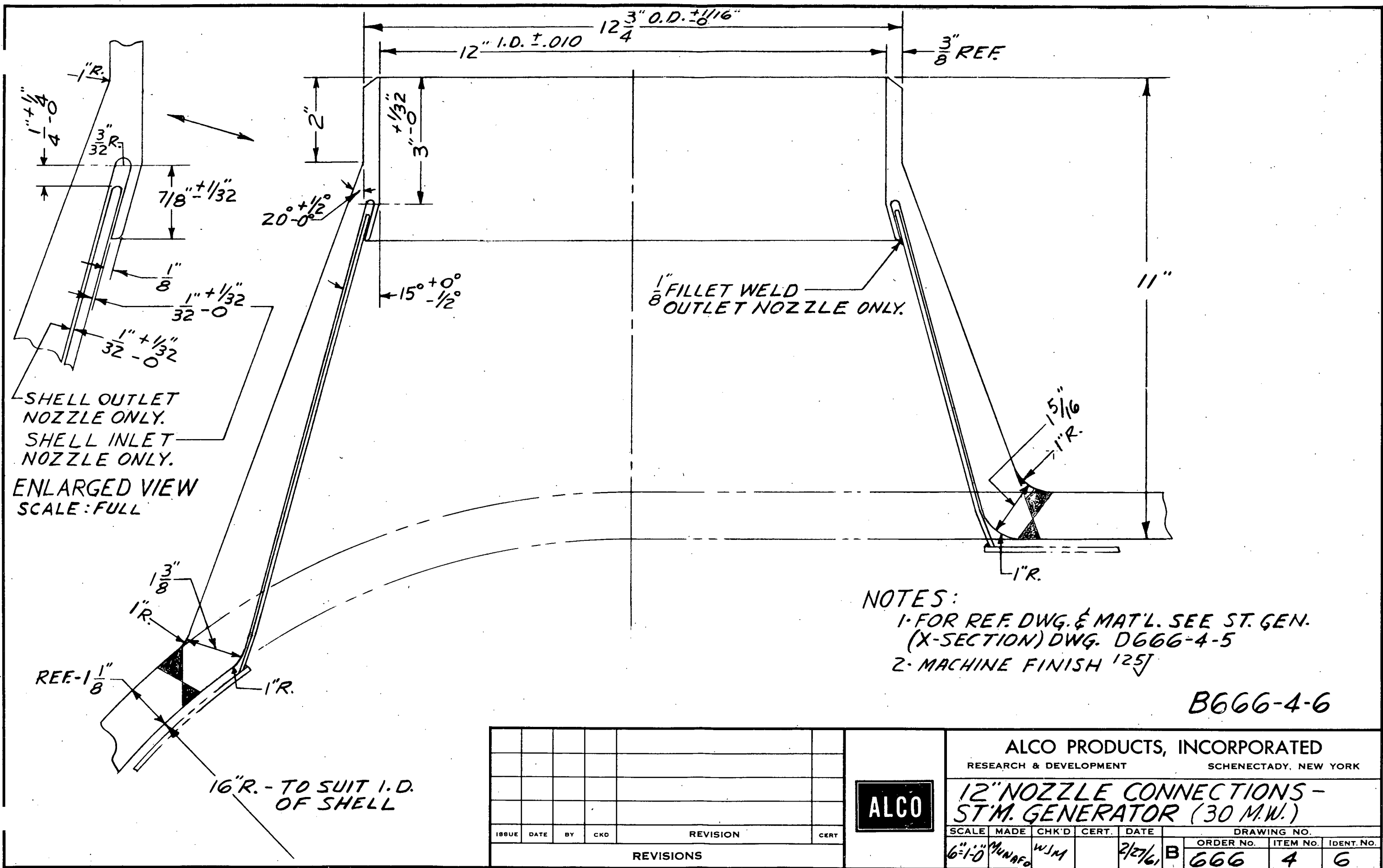


ORIENTATION OF DRILLING-MANWAY & COVER (B)

NOTES:  
1. FOR REF. DWG. & MAT'L. SEE DWG. D666-4-5  
2. FOR TUBE SHEET DRILLING SEE DWG. D666-4-4  
3. ALL MACH. FINISH 125 EXCEPT R.T.J. GASKET GROOVES SHALL HAVE A 63 FINISH OR BETTER.

C666-4-8

ALCO PRODUCTS, INCORPORATED RESEARCH & DEVELOPMENT SCHENECTADY, NEW YORK									
ALCO DETAILS-UPPER & LOWER TUBE SHEETS & HEAD-ST. GEN. (30MW)									
SCALE: 3"=1'-0" MADE: WJ/M CHK'D: WJ/M CERT.: DATE: 3/2/61 DRAWING NO. C666-4-8 ORDER NO. ITEM NO. IDENT NO.									
REVISIONS									



SHELL OUTLET NOZZLE ONLY.  
 SHELL INLET NOZZLE ONLY.  
 ENLARGED VIEW  
 SCALE: FULL

1" FILLET WELD  
 8" OUTLET NOZZLE ONLY.

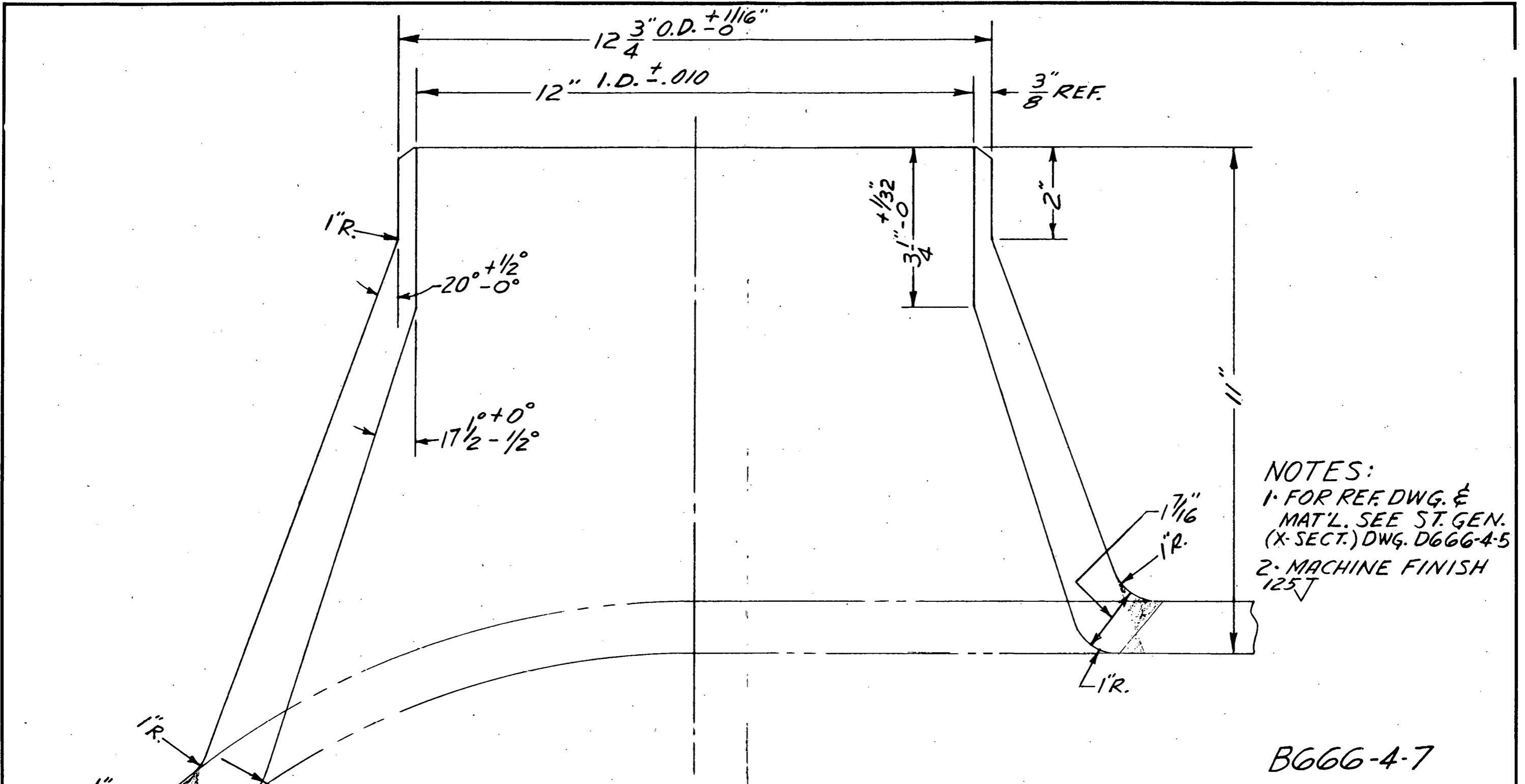
NOTES:  
 1. FOR REF. DWG. & MAT'L. SEE ST. GEN. (X-SECTION) DWG. D666-4-5  
 2. MACHINE FINISH [25]

B666-4-6

ISSUE	DATE	BY	CKD	REVISION	CERT
REVISIONS					

<b>ALCO</b>						ALCO PRODUCTS, INCORPORATED RESEARCH & DEVELOPMENT      SCHENECTADY, NEW YORK					
<b>12" NOZZLE CONNECTIONS - ST. M. GENERATOR (30 M.W.)</b>											
SCALE	MADE	CHK'D	CERT.	DATE	DRAWING NO.						
6"-1-0"	MUNAF	WJM		2/27/61	B	ORDER No.	ITEM No.	IDENT. No.			
						666	4	6			





ISSUE	DATE	BY	CHK'D	REVISION	CERT
A	3/27/61	MAM	WJM	GEN. (SEE REV. SHEET #1)	
REVISIONS					



ALCO PRODUCTS, INCORPORATED					
RESEARCH & DEVELOPMENT			SCHENECTADY, NEW YORK		
12" NOZZLE CONN. - ST. GEN. (RUPTURE DISC) 30 MW					
SCALE	MADE	CHK'D	CERT.	DATE	DRAWING NO.
6"=1'-0"	MUNAF0	WJM		3/27/61	B 666-4-7
		ORDER NO.	ITEM NO.	IDENT. NO.	
		666	4	7	

SECTION 7

APPENDIX C

SODIUM PURITY CONTROL RECOMMENDATIONS

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## C. SODIUM PURITY CONTROL RECOMMENDATIONS

Sodium oxide is the most prevalent impurity in sodium systems. Excessive amounts of this impurity can be troublesome because of danger of precipitation and plugging in cooler portions of the system. In addition, this compound has a well known accelerating effect on sodium corrosion of stainless steel and other structural materials. The detrimental effects of sodium oxide can be combated successfully, if the oxygen level is maintained below fifty parts per million maximum, and preferably at a normal level under twenty-five parts per million. Such control is not uncommon in large scale sodium systems.

Carbon will react with stainless steel in high temperature sodium to give a brittle carburized case which reduces the ductility of the alloy. System sodium in contact with stainless steel should, therefore, be kept free of contact with carbonaceous material in areas where the carbon is likely to go into sodium solution.

Other impurities in commercially available high purity sodium can be held to acceptable concentrations, if the sodium is filtered prior to charging the system, using micro metallic filter elements of five microns pore size, or equivalent.

In summary, the following practices are recommended in regard to primary sodium system purity:

1. Filter the good commercial-grade sodium before charging to the system.
2. Avoid the use of materials which will introduce carbon into the system sodium.
3. Do not expose the unit to sodium with oxygen levels in excess of fifty parts per million for extended periods. Such exposure can cause excessive corrosion of system materials.
4. Removable of oxygen may be accomplished by:
  - a. Cold trapping at  $170^{\circ}\text{C}$  until the oxygen level is down to less than thirty parts per million, and subsequently hot trapping continuously in a zirconium hot trap at  $1200^{\circ}\text{F}$ , or
  - b. Continuous cold trapping at  $145^{\circ}\text{C}$ .

The initial method is preferable, since hot trap walls will also act as a sink for any carbon in the system.

Identical practices are recommended for the secondary sodium system, with the exception of hot trapping procedure. If a hot trap is to be employed, it is recommended that the hot trap temperature be at the maximum secondary sodium temperature (1140°F), in order to avoid auxiliary heating. Calculations based on data in the literature indicate that the purification rate at this temperature will be about seventy-five per cent of the purification rate at 1200°F. (See APAE 41, Volume II, p. 2 D-9).