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BI-METALLIC TUBE STEAM GENERATOR FOR APPR-1 SPECIFICATIONS

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BI-METALLIC TUBE STEAM GENERATOR

FOR

APPR-1

VOLUME I

SPECIFICATIONS

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BI-METALLIC TUBE STEAM GENERATOR

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J. O. No. AE 12-PE

SPECIFICATION

FOR

BI-METALLIC TUBE STEAM GENERATOR

FOR APPR-1

Scope: This specification complete with its applicable drawings constitute all pertinent design data for a bi-metallic tube Steam Generator replacement of an existing unit at Fort Belvoir, Virginia.

This specification with drawings presents physial size limitations, shell side water volume, limitation, type of exchanger, materials of construction, conditions of service, required performance and weight limitation.

Sections:

I EQUIPMENT AND SERVICES FURNISHED BY MANUFACTURER:

The manufacturer shall furnish one complete unit f.o.b. purchasers plant site including:

Shell, "U" Bend Tube Bundle; Channel, Channel cover; internal baffles; internally mounted steam separators, all necessary internal and external connections; supports as specified; bolting and gaskets with one spare set suitably identified; and thermocouples as required.

II EQUIPMENT FURNISHED BY OTHERS

Erection labor, support foundation, necessary external piping, and insulatiom will be furnished by others.

III PERFORMANCE GUARANTEE:

The manufacturer shall guarantee the equipment to be suitable for continuous operation under the specified design conditions of temperature and pressure. Manufacturer guarantees that all material furnished and work performed hereunder shall meet in all respects, the applicable drawings and specifications. Unless otherwise specified, all equipment, materials and articles furnished hereunder are to be new and of the most suitable grade of their respective kinds for the purpose and all workmanship shall be first class. Manufacturer shall repair without charge or replace without charge, any material, equipment, parts or accessories which are defective as to design, workmanship or material; or which failed to operate in a normal or proper manner due to any defects within one year after initial operation of the system in which the unit is installed.

IV PERFORMANCE TEST:

The performance test of the unit after installation shall be performed by the purchasers personnel or representatives after installation. This test may be witnessed by the manufacturers representative at his expense. Notification of such an official test will be given to the manufacturer at least two weeks prior to test date, but the test date shall be within 120 days after installation of the unit.

V STEAM GENERATOR DATA:

Design Requirements - Unit must be capable of meeting continuous design load at steady state conditions. In addition the design shall be such that consideration is given to transient operation. In evaluating the unit operation during transients use a change of 30% of design load over a 5 second period. This analysis should indicate surge in water level, steam separation volume above this new water level, and increased pressure drop across the purifiers. Assume the operating conditions will change from 70% design flow at 270 psia to 170 psia. Estimate low pressure steam flow developed by superheated water volume and increased boiling rate due to increased wall to bulk water temperature, when inlet temperature on tube side remains 447.2°F for calculation purposes. This should produce the estimated maximum flow for purifiers.

STEADY STATE DESIGN OPERATING CONDITIONS

	Shell Side	Tube Side
Total Fluid Entering	34,200 #/HR	4000 gpm
Fluid Vaporized and Superheated	34,000 #/HR	-
Boiler Blowdown	200 #/HR	-
Temperature, In	250°F	450°F
Temperature, Out	407°F	431.1°F

*Original unit utilize 304 L SS tubing. Due to the decreased tube metal resistance of the bi-metal tubes, it will be necessary to proportion surfaces to maintain 200 psia pressure and as a result degrees of superheat may increase.

STEADY STATE DESIGN OPERATION CONDITIONS CONTINUED

	Shell Side	Tube Side
Pressure	200 psia	1200 psia
Duty	34,097,000 BTU/HR	
Maximum Pressure Drop (Nozzle to Nozzle)		7 psi
DESIGN CONDITIONS		
Temperature	650°F	650°F
Pressure	500 psia	1600 psia
Maximum Length (Overall)	18'-0"	
Maximum Width (Overall)	**	

CODE REQUIREMENTS: ASME (1956) with latest revisions and applicable local laws and regulations.

VI SUPPLEMENTARY DESIGN DATA:

This unit must replace an existing unit in the primary system of the APPR-1. This requirement places many restrictions on the design and physical arrangement of the unit.

1. The support for the vessel must remain as shown in drawing D-AES-234. (The supporting criteria and structure as well as certain approved Hazards Criteria under which the plant operates requires that this be mandatory.)
2. The water volume of the shell side and primary side must not be increased due to the vapor container design.
3. Two resistance bulbs shall be installed in the outlet nozzles as indicated in drawing D-AES-235. These resistance bulbs meet the following specifications:

** All dimensions must meet requirements as shown in drawings listed under Section VII.

A. Range 0-500°F

B. 100 ohm platinum element

C. Accuracy ± 0.25°F

D. Thermowell - 304 S.S., to be welded in 12" nominal line and withstand 2400 psig test pressure.

4. Internal Steam Separator(s) shall be installed, which will guarantee minimum steam purity of 99.75% from 25% of load to the overload condition estimated for previously stated consideration in transient load change, or 120%, whichever is greater. Calculation of pressure drop at maximum estimated transient condition or 120% design load, whichever is greater, shall be supplied the purchaser along with the separator manufacturers certification that the unit will meet these requirements.

5. All external connections shall match existing connections exactly as shown on drawings supplied with this specification.

6. Four lifting lugs shall be provided by manufacturer.

7. Calculations of the tube side pressure drop shall be supplied the purchaser.

8. A 16" blind flanged access shall be supplied at the top of the unit.

9. Attention must be paid to the weight of vessel since authorization to exceed 20,000# max. shipping weight must be approved in writing by the purchaser.

10. Unit shall be "U" tube construction consisting of superheater and boiling section.

11. Design operating conditions shall be met or bettered. However this must be accomplished with improved superheat rather than pressure (secondary side) since existing boiler feed pumps will not be changed.

VII GENERAL REQUIREMENTS

A. Definitions:

Manufacturer - Person or firm entering into a contract to design and fabricate the unit described in these specifications.

Purchaser: United States Atomic Energy Commission and or its established representatives.

B. Deviations from Specifications:

There shall be no deviations from these specifications and/or drawings without prior written approval of the purchaser or his representatives.

C. Manufacturers Schedules and Drawings:

1. Schedules - Manufacturer shall supply the purchaser an engineering and manufacturering schedule not later than 30 days after approval of outline drawings.

2. Outline Drawings - These drawings shall be submitted for approval within 2 weeks after award of contract.

3. Approved Drawings: Drawings approved by the purchaser shall be construed to apply only to the general arrangement and shall not relieve the manufacturer from the entire responsibility for correctness of design, details and dimensions, codes, calculations and etc.

4. Applicable Drawing:

D-AES-234 Steam Generator Supports

D-AES-235 Steam Generator.

VIII MATERIALS OF CONSTRUCTION

A. Stainless and Carbon Steel:

Type 304 stainless steel shall be used for any surface exposed to the primary fluid. Type 304L may be used in place of Type 304 if all code requirements are met. All surfaces exposed to the secondary fluid shall be composed of carbon steel. Materials shall conform to the following ASTM specifications:

1. Cladding - Clad plate, i.e., Type 304 stainless steel integrally bonded to carbon steel, shall be equivalent to that manufactured by Lukens Steel Company to Specification SA 264, Grade 3. The carbon steel portion shall be equivalent to SA 212, Grade B (Firebox Quality). Cladding by weld metal deposition shall not be used unless approved in advance of fabrication by the purchaser. A welding procedure for cladding by weld metal deposition shall be submitted in triplicate by the manufacturer to the purchaser. If approved or approved as amended, one copy shall be returned to the manufacturer. A minimum stainless steel thickness of 1/8 inch shall be required for all cladding and cladding weld joints, but shall not be applicable to the composite tubing.

   Where carbon steel is clad with austentic stainless steel by overlaying with weld metal, the carbon content of the carbon steel shall not exceed 0.30%. The composition of the welding wire, and coating or flux if used, and the technique and procedures used in overlaying shall be such that the carbon and chromium content of the deposited weld metal at the final

finished surface of the machined, ground, etc., weld deposit and to a minimum depth of 0.10 inch, shall not exceed 0.08% carbon and not be less than 18.0% chromium, with no other significant difference from a Type 304 stainless steel analysis.

2. Other Stainless Steel -

Plate:	SA 240, Grade S
Forgings:	SA 182, F 304
Seamless pipe:	SA 312, TP 304
Welding electrode: (tube to tube sheet weld joints)	SA 298, type 308 E1C-15

3. Carbon Steel -

Plate:	SA 212, Grade B (Firebox Quality)
Forgings:	SA 105, Grade II
Seamless pipe:	SA 106, Grade B
Studs:	SA 193, Grade B7
Nuts	SA 194, Grade 2-H
Welding electrodes: (tube to tube sheet weld joints)	SA 316, Type E7016

4. Carbon Steel Weld Metal - Carbon steel weld metal shall have a tensile strength at least equal to the tensile strength of the base metal. The elongation of the weld metal in the as-welded condition shall not be less than 90% of the base metal elongation. If the weld is stress relieved, the weld material shall be equal to or better than the base metal in regard to tensile strength and elongation.

5. Bi-metallic Tubing - Bi-metallic tubing shall be defined as two seamless concentric metal tubes composed of differing material, inseparably and metallurgically bonded together. The tubing shall be made from two concentric pipes that are hot extruded to form the bond. The resulting bi-metallic tube shall be cold drawn and processed to size by normal commercial methods. Bi-metallic tubing shall be as made by the Allegheny Ludlum Steel Corporation, or equivalent.

The inside portion of the tube shall be Type 304 stainless steel, while the outside shall be AISI 1015 carbon steel made to fine grain melting practice. The tubing shall comform to ASTM cladding specification SA 264, Grade 3, including the optional shear test. The bi-metallic tubing shall also meet all requirements of specification SA 213 except for modifications as follows:

Tensile strength:	65,000 psi
Yield strength:	30,000 psi
Percent elongation:	35%
Material analysis:	Stainless steel - Type 304 Carbon steel-AISI 1015
Flattening Test:	As stated, using 0.09 as the deformation per unit length
Flaring test:	As stated, using the carbon steel minimum data for the complete tube.
Hydrostatic Test:	As stated, using S=15,000 psi

Ovality and eccentricity of the entire tube, and of the stainless steel and carbon steel portions of the tube, shall not exceed the requirements of SA 213 for plain stainless or carbon steel tubing of the same type, diameter and wall thickness.

Tubing shall be 100% ultrasonically tested as performed by the Sperry Corporation, or equivalent. Tubing as examined longitudinally and in two directions circumferentially shall have no bond discontinuity and no defect in excess of 0.004 inch or 3% of the wall thickness, whichever is greater, or more than 3/8 inch long.

6. General Requirements - Reinforcing pads shall be made of the same material as that being reinforced.

Vendor certification for all materials used in the steam generator shall be required. The manufacturer shall make a check analysis for each batch or lot of material to be used in contact with the primary fluid. The manufacturer shall further make such analyses of material used elsewhere in the system as may be specifically required by the purchaser. Concise records of all components and analyses shall be maintained by the manufacturer. Two copies of all such records possessed by the manufacturer shall be furnished to the purchaser prior to testing of the steam generator.

All scrap or overage material exceeding 8 square inches in area and having a minimum width of 1 inch, used in pressure containing members in the vessel, shall be legibly identified as to manufacturer, melt, slab and heat number and to location from which it was scrap or overage in the vessel. All such material shall be furnished to the purchaser prior to vessel testing.

Sufficient integral excess shall be procured for any piece or pieces or material for pressure-containing members that are to be subjected to a heat treatment other than stress relief to allow determination of compliance with specification requirements after heat treatment. Such excess material shall be removed from the piece or pieces prior to fabrication, but shall be heat-treated as part of the furnace charge with the piece or pieces being fabricated.

IX FABRICATION PROCEDURES

A. General:

All fabrication, processing and inspection except that dealing with composite tube-to-tube sheet fabrication, processing and inspection shall be in strict accord with the latest edition of Section VIII of the Boiler and Pressure Vessel Code.

Three copies of welding procedures shall be submitted by the manufacturer to the purchaser before welding is actually begun for each procedure covered by Code. One copy, approved or approved as amended, shall be returned to the manufacturer prior to commencement of fabrication.

Stainless steel shall not be pickled unless in the completely annealed condition.

Design and fabrication shall be such that crevices on the tube side are held to an absolute minimum. Peening shall not be permitted.

Weld defects shall be removed by chipping, grinding or Air-Arc by a competent operator to the satisfaction of a qualified inspector. Repaired areas shall be re-radiographed, dye penetrant checked, or otherwise inspected as mutually agreed upon prior to welding.

Surfaces exposed to the primary fluid shall be machined, ground or polished to a 250 RMS surface finish. Exception shall be made for weld deposits that cannot be so finished feasibly. Such weld material shall meet the best commercial practice requirements, consistent with the particular application, as to smoothness of ripples and absence of surface irregularities.

B. Tube to Tube Sheet Weld Joints:

The outlined procedure for fabrication of composite tube to tube sheet weld joints shall be used for procedure and performance

qualification and for actual fabrication. Absolute integrity following deposit of the carbon steel weld metal shall be required to prevent the secondary water from "seeing" stainless steel, which could cause chloride stress corrosion.

1. Mill scale and rust shall be removed to clean metal for approximately 4 inches from the ends of each tube. The carbon steel outer wall of the tube shall be removed from the tube ends by machining or other suitable means for a nominal distance of 1/2 inch, with the face of the remaining carbon steel perpendicular to the tube axis with a bottom radius not to exceed 0.008 inch. An ammonium persulphate solution shall be applied to the exposed stainless steel tube ends. Any residual carbon steel, as indicated by the test solution, shall be removed. The tube ends shall be retested until there is no indication of carbon steel. The tubing shall be washed with water to remove the test solution and dried. If oil or grease has come into contact with the tube ends, they shall be degreased with trichlorethylene.

2. The tube sheet face shall be machined or otherwise finished to clean metal to remove all mill scale, rust and other removable surface defects. The tube holes shall be drilled and reamed to the specified dimensions and tolerances. The tube sheet shall be thoroughly cleaned of oil, grease and other materials deleterious to welding.

3. The tubes shall be inserted through the tube sheet so that the remaining carbon steel portion of the composite tubing protudes 3/32 inch $\pm$ 1/64 inch. The tubing shall be

rolled to contact over the full depth of the tube sheet by using a Wilson Torq-Air-Matic Model A-124 controlled torque expander drive with Wilson Models 44-D-13 and 44-C-13 tube expanders, or equivalent. No rolling lubricant shall be used.

4. A copper plug, machined to a close fit with the inside of the rolled tube, shall be inserted approximately 2 inches into the tube prior to welding around the tube periphery to minimize the possibility of tube collapse or burn through. The plug shall be sufficiently long to permit removal after welding.

5. The temperature of the tube sheet during welding shall not be less than 60°F. or more than 300°F. Preheating of the tube sheet ordinarily shall not be required. All weld deposits shall be free of cracks, incomplete fusion and foreign matter, and shall have satisfactory root penetration. Care shall be taken to prevent tube collapse and burn through during all welding. No weld metal shall be deposited over or through solidified slag. Slag shall be completely removed prior to the deposition of any succeeding pass. The position used in qualification shall be used on welding tube to tube sheet joints.

6. One layer of carbon steel weld metal shall be deposited as a fillet weld around each tube to tube sheet joint between the outer tube wall and the tube sheet. This layer shall be deposited with a minimum of two circumferential passes per tube using 3/32 inch diameter E7016 electrode

at 65-75 amps DCRP and 21-22 arc volts. Care shall be exercised to insure that weld metal is not deposited on the stainless steel portion of the tube and that there is no tube collapse or burn through. Following this first layer, a pressure test shall be applied (see section on Inprocess Inspection). If carbon steel fillet weld metal overlap is removed from between the tubes to assure adequate stainless steel penetration, it shall be done prior to pressure testing. Subsequent to the carbon steel fillet weld pass and fillet grinding, the tube sheet shall be completely cleaned of all metal chips, slag and oil.

7. The entire tube sheet face shall be overlayed with one layer of stainless steel weld metal using 5/32 inch diameter type E 308-15 electrode at 130-150 DCRP and 25-27 arc volts. This layer shall be deposited between the fillet welds on the tube sheet face to the approximate depth of the fillet weld. Overlapping carbon steel fillet weld metal shall be removed as required to assure complete penetration of the stainless steel weld metal. A rounded burr or similar means shall be used to remove weld metal (carbon steel). Fillet size and shape shall not be materially affected by carbon steel weld metal removal. The cladding shall be applied starting at the periphery of the tube sheet and shall proceed in a roughly circular manner toward the center.

8. A second pass fillet weld, deposited around the tube and joining the inner stainless steel tube to the first weld layer, shall be made using 5/64 inch diameter type E 308-15 electrodes at 55-65 amps DCRP and 23-25 arc volts.

9. The second cladding layer shall be deposited over the entire tube sheet face between the stainless steel fillet welds in the same manner that the first layer was deposited between the carbon steel fillet welds. For cladding, 5/32 inch diameter type E 308-15 electrodes at 130-150 amps DCRP and 25-27 arc volts shall be used.

10. Approximately three more fillet welds and three more cladding layers of stainless steel shall be applied, using the procedure outlined above. A minimum clad depth of 5/16 inch shall be required.

11. Subsequent to cladding, the tube ends and the entire tube sheet face shall be machined to a surface having a 250 RMS finish. The total cladding thickness subsequent to machining shall be no less than 1/4 inch.

12. Each tube hole shall be chamfered 45° to a maximum depth of 3/32 inch subsequent to tube sheet machining.

13. Tube burn through shall be cause for rejection.

X QUALIFICATION, TUBE TO TUBE SHEET WELD JOINTS

21 Tube to tube sheet weld joints shall be made using the fabrication procedure, tube size and configuration used in production. The 21 joints shall be arranged in a 7 x 3 configuration, i. e., 7 rows containing 3 joints per row. The rows, (numbered 1 through 7), shall show a progression in the application of successive weld metal passes. A 1/4 inch high retaining lip shall be attached completely around the sample tube sheet at a distance of 1/4 inch - 1/2 inch from the outside tube periphery.

The carbon steel fillet weld shall be made around each tube to tube sheet joint. The entire sample tube sheet shall be overlayed with the first stainless steel cladding layer.

The second fillet weld (first stainless steel fillet), shall be made around rows 2 through 7. The second clad layer shall start at the approximate centerline of row 2 and shall be deposited over the rest of the tube sheet (rows 3 through 7) between the fillet welds.

The third fillet weld shall be made around rows 3 through 7. The third clad layer shall start at the approximate centerline of row 3 and shall be deposited over the rest of the tube sheet (rows 4 through 7) between the fillet welds.

The fourth fillet weld shall be made around rows 4 through 7. The fourth clad layer shall start at the approximate centerline of row 4 and shall be deposited over the rest of the tube sheet (rows 5, 6 and 7) between the fillet welds.

The fifth (final) fillet weld shall be made around rows 5, 6, and 7. The fifth (final) clad layer shall start at the approximate centerline of row 5 and shall be deposited over the rest of the tube sheet (rows 6 and 7) between the fillet welds.

All clad layers shall be carried out to the lip of the sides and end of the sample tube sheet specified.

The sample tube sheet shall be sectioned in planes perpendicular to the tube sheet. The first section shall be cut through the centerline of the three tubes of row 6. The second section shall be cut through the centerline of the middle tube of all seven rows. Another cut shall be made, exposing the clad layers only in at least two places. All joints cut through tubes shall be capable of fitting with any other cut joint with no more than 1/8 inch gap.

Both sides of all joints sectioned and both sides of the clad layer section shall be etched and macroscopically examined. Macroscopic examination of sample tube to tube sheet joints shall be based on joint requirements and shall encompass the following:

The legs of the carbon steel fillet weld shall be approximately equal in length and equal to the height of the carbon steel outside portion of the tube above the tube sheet (3/32 inch).

Complete root penetration shall be obtained on carbon steel fillet welds.

The stainless steel fillets shall have adequate root penetration so as to leave no voids. The first stainless steel fillet weld shall penetrate at least to the radius at the base of the carbon steel removal cut.

Each clad layer shall be approximately equal in depth to the fillet height. The clad layers shall penetrate the tube sheet or previous weld metal so as to leave no voids.

All weld metal shall be free of cracks, voids, and inclusions.

All tube to tube sheet joints, both sectioned for macroscopy and unsectioned, shall be checked for indications of tube collapse, burn through and cladding separation.

If the manufacturer employes both vertical and horizontal welding for tube to tube sheet joints, all qualification shall be in the vertical position.

A minimum of 2/3 of the original carbon steel fillet weld dimensions shall remain after subsequent stainless steel weld metal has been deposited.

XI NOZZLES

The free ends, i.e., ends protruding from the vessel, shall allow

steel, while secondary piping shall allow carbon steel to carbon steel welding. The free ends of stainless steel nozzles shall be suitably finished to allow welding by the Tungsten-Inert Gas Method using EB inserts.

XII IN PROCESS INSPECTION

A. Tube to Tube Sheet Welds:

Following the initial carbon steel weld around each tube, the welds shall be checked by applying a pressure of approximately 100 psi to the shell side. Inspection for leaks in the tube to tube sheet weld joints shall be made on the tube side by immersing in water or other suitable fluid. Any defects shall be removed, rewelded and again ins-inspected. Any substance, including water, used as an aid in inspection, shall be completely removed prior to further welding. Any alternate inspection procedure proposed by the manufacturer shall be evaluated by the purchaser and approved or disapproved prior to welding.

B. Code Specification Weld Joints:

Complete radiographic inspection shall be required for all welds made in conformance to code requirements. Dye penetrant examination shall be performed on all pressure containing joints that cannot feasibly be x-rayed. Single bevel welds shall be examined after the first pass, at the halfway point, and on the finished weld. Double bevel weld joints shall be examined after back cleaning the root pass and after completion of welding. A minimum of three dye penetrant examinations shall be made on each weld.

XIII INSPECTION AND TESTING The vessel is subject to the purchaser's representative inspection but an authorized outside inspection agency shall be allowed to inspect for compliance with applicable codes and these specifications at mutually agreed upon stages of construction and with suitable advance notice to the manufacturer.

The unit shall be subjected to an individual hydrostatic test on the shell side and the tube side. Hydrostatic test shall conform to the latest edition of Section VIII of the ASME Unfired Pressure Vessel Code. Commercial distilled water shall be used for the hydrostatic tests. Upon completion of tests, the vessel shall be dried immediately by hot air blowers or similar means until all traces of water are removed and the dew point of the air inside the vessel is not higher than -40° F. (Refer to Section XIII).

The unit shall be subject to a helium mass spectrometer test prior to the hydrostatic test. This test shall be conducted under the vacuum technique. During the test, the absolute pressure in the vessel section being tested shall not exceed 15 microns of mercury. No leak shall be detected by a Consolidated Engineering Company Detector Model #24-101A or equivalent set at maximum sensitivity.

XIV CLEANING PROCEDURE AND PREPARATION FOR SHIPPING

Within the past year, Military Specification MIL-C-19874 (Ships), "Cleaning Requirements for Nuclear Primary Coolant Equipment Including Piping Systems" has become a generally accepted basis for cleaning primary system components for pressurized water reactors. This specification, MIL-C-19874 (including Amendment 1), is incorporated in, and forms a part of, the fabrication requirements on this bi-metallic tube steam generator.

Inasmuch as MIL-C-19874 is a general specification, the requirements listed therein are to be supplemented by the following procedures specific to this design. The numbers listed refer to the applicable sections of the reference specification.

1.1 Since this steam generator is a heat exchanger, the requirements of this specification shall apply to metal surfaces exposed to both primary and secondary system coolants.

3.1.1.1 Since the inside surfaces of the tubes in this steam generator cannot be adequately inspected by the unaided eye, the wipe technique shall be used to evaluate tube cleanliness. Clean swabs are to be run through each tube by means of snakes. The swabs are to be visually inspected for the presence of foreign material by the unaided eye and are to be examined under ultra violet light for the detection of oil and grease. For a discussion of these techniques, prospective vendors are referred to: "Cleaning Nuclear Reactor Systems" by A. L. Medin and R. J. Clark presented at the Fourth Nuclear Engineering and Science Conference, March 1958.

3.1.4.2 As stated, this heat exchanger is considered a critical item. All contamination, including oils, greases, lubricants, rust, scale, weld spatter, grinding particles, etc., must be removed from the heat transfer surfaces.

3.3 During fabrication, assembly, and testing, it is very important that the carbon steel surfaces be protected from pitting or rusting. Considerable judgment will be necessary during this period to determine exactly

what procedures and precautions should be taken to prevent or inhibit corrosion and contamination. Precautions fall into three general categories:

1. Corrosion may be minimized by supplying sufficient heat to the unit to prevent the condensation of water, by using such items as strip heaters, hot air blowers, etc. Adequate consideration should be given to ill effects which may result from differential thermal expansion.
2. Use of a preservative on certain components where the presence of the preservative does not interfere with the assembly operations or does not contaminate areas which will not be subsequently accessible for cleaning.
3. The same results may be obtained by carrying out the assembly operations in an area which is sufficiently heated to prevent condensation.

3.4 Since lubricating oils will probably be used during various stages of fabrication and assembly, and particularly during final machining of the tube-to-tube sheet welds, the completed steam generator shall be chemically cleaned by vapor degreasing or alkaline immersion, or both. Water used in preparing the alkaline cleaning solution shall have a total solids content of less than 10 ppm. The boiler shall be thoroughly rinsed with water having a pH of 10.5, obtained by adding trisodium phosphate. Excluding additions for pH control, the water shall have a total solids content of less than 10 ppm. The drying procedure shall be started within 30 minutes after the rinsing or draining operation in accrodance with the procedures in 3.5.

Since this boiler will be installed in an existing plant, the unit must be thoroughly clean on both primary and secondary surfaces so as to preclude the necessity of an alkaline boil-out when installed.

3.5 When the surfaces of the assembly or component are in contact with water, such as during cleaning, rinsing, or testing, water is drained from the unit. To prevent pitting of the carbon steel tube surfaces, extreme dryness is required for these components, and procedures shall be in accordance with the following:

A. Small parts with all surfaces accessible shall be dried with clean, lint-free cloths, with filtered hot air, or by heating in an oven. Parts are considered dry when there is no visual evidence of water or moisture when the items have cooled to room temperature.

B. Complicated parts with inaccessible surfaces which cannot be dried as outlined in (A), shall be dried as per procedures (1) and (2) or a combination of (1) and (2), whichever is more suitable from the point of view of time and cost.

(1) Oven Drying - The unit shall be dried in an oven maintained at a temperature between 250 and 300° F. Inlet and outlet pipe or suitable hose attachments shall be provided on the unit so that it may be flushed with an inert gas (-40° F. dew point) such as a nitrogen, after the unit has reached the temperature of the oven. Sufficient gas should be

introduced into the unit in order to completely replace the moisture laden air. Following the completion of the flushing operation, the oven shall be turned off and the unit allowed to remain sealed for eight hours, after which a dew point reading shall be taken on the gas in the unit. If the dew point of the gas in the unit is equal to or less than -40°F., the unit is considered dry. However, if the dew point determined is above -40°F., additional drying shall be employed until this requirement is met. Adequate consideration shall be given to ill effects which may result from thermal expansion.

After approval of cleanliness, unit is to be thoroughly flushed with an inert gas and openings are to be sealed internally with expanding rubber plugs capable of maintaining an internal gas pressure of 2-4 psig. Sealed unit is to be filled with an inert gas to a pressure of 4 psig. Pipe openings which have been prepared for welding shall be protected from damage during shipment by end caps securely fastened. End cap devices shall be subject to approval by buyer's personnel. A means of introducing inert gas into the vessel or pipe, the cap of which shall be removable, shall be included in the plug device.

XV MARKING

The pressure vessel shall be legibly stamped or marked with the steel manufacturer's name or symbol, the melt or slab numbers or other identification marks on the outside of the vessel in locations to afford visability after fabrication.

The name plates shall be attached to the units, giving the

manufacturer's name and serial numbers, maximum working pressure and temperatures, year built, hydrostatic test pressure and temperature if other than cold, mark number, and code symbol.

On exchangers that are to be insulated, name plates shall be supported on brackets away from the shell. The name plates on uninsulated units shall be attached directly to the vessel.

XVI PAINTING

The completed unit shall be given two coats of paint; one prime coat of red lead and one shop coat prior to shipment for protection against rusting of the unit in transit and storage prior to erection.