1.0 Purpose

The purpose of this specification is to establish the minimum quality assurance requirements for the shop fabrication of superheater, reheater, and economizer assemblies supplied to NRG Energy Inc.

2.0 Scope

2.1 This specification applies to the fabrication and assembly of boiler pressure parts using carbon steel, low-alloy steel, and stainless steel tubular products in accordance with the ASME Boiler & Pressure Vessel Code, Section I.

2.2 This specification shall be used in conjunction with a project specification that contains the material, quantity, bid, contract, schedule, transportation, delivery, and other job, plant and site-specific requirements.

3.0 Definitions

3.1 ANSI – American National Standards Institute

3.2 ASME – American Society of Mechanical Engineers

3.3 ASME B&PV Code – ASME Boiler and Pressure Vessel Code

3.4 ASNT - American Society for Nondestructive Testing

3.5 NRG - The NRG individual responsible for the overall management of the project

3.6 ISO – International Organization for Standardization

3.7 Manufacturer – The organization providing the raw materials (e.g., tubing, lugs, plates, etc.) for the superheater, reheater, or economizer assemblies

3.8 Supplier – The organization providing the superheater, reheater, or economizer assemblies

4.0 References

4.1 ASME Boiler & Pressure Vessel Code, Section I, “Rules for Construction of Power Boilers”

4.2 ASME Boiler & Pressure Vessel Code, Section II, Parts A and B, “Ferrous and Nonferrous Material Specifications”

4.3 ASME Boiler & Pressure Vessel Code, Section II, Part C, “Specifications for Welding Rods, Electrodes, and Filler Metals”

4.4 ASME Boiler & Pressure Vessel Code, Section V, “Nondestructive Testing”

4.5 ASME Boiler & Pressure Vessel Code, Section IX, “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators”

4.6 SNT TC-1A, “Personnel Qualification and Certification in Nondestructive Testing"

The latest edition of the above codes, standards, and specifications shall apply. In the event of conflicts between this specification and the references cited above, the Supplier shall notify NRG, who will make the final judgment and interpretation.

5.0 Responsibility

5.1 The Supplier shall be responsible for fulfilling the requirements as set forth in this specification including all required inspection and testing and the submission of all required documentation. Exceptions to and deviations from this specification shall be clearly delineated in the Supplier’s bid for disposition by NRG.

5.2 The Supplier shall hold a valid “S” Stamp issued by the ASME.

5.3 The Supplier shall provide a Manufacturers Partial Data Report (ASME Form P-4).

5.4 The material or tube Manufacturer shall have a Quality Program in compliance with and certified to ISO 9001.

5.5 If the Supplier is not the Manufacturer, the Supplier must have a formal program for qualifying their manufacturers and must have evidence of periodically monitoring their performance.

5.6 The Supplier shall identify clearly in their proposal any and all subcontractors intended to be used. All subcontractors must be approved by NRG prior to the issuance of a purchase order.

5.7 If the project specification requires in-kind assembly replacements, NRG is responsible for providing detailed design information.

5.8 If the project specification requires re-designed assemblies, NRG is responsible for providing the available boiler dimensions and design criteria for the re-designed assemblies. The project specification shall also indicate if any of the tubing shall be clad or overlayed.

6.0 Material

6.1 Tube materials, fabrication and testing procedures shall comply with ASME SA-450 or ASME SB-829 and the applicable ASME B&PV Code, Section II material specifications.

6.2 Supplier to furnish either cold-finished or hot-finished tubing. If hot-finished tubing is furnished, the Manufacturer shall meet the applicable ASME SA-450 or ASME SB-829 Code tolerances for cold-finished tubing.

6.3 All tubing shall be seamless.

6.4 Tubing shall be furnished in standard mill lengths. Use of shorter than mill length sections to make up longer tube lengths is prohibited.

6.5 The Supplier shall provide certified material test reports (CMTR) for all tubing and welding electrodes (typical deposit analysis is adequate for electrodes). CMTRs shall report chemical and mechanical test data as required by the applicable ASME B&PV Code, Section II material specification. CMTRs shall be prepared in English units or in metric units with conversions to English units.

6.6 Lug, clip and attachment materials shall comply with the project specification design requirements. The Supplier shall submit a certification of compliance for lugs, clips, and other attachments.

6.7 All materials of construction shall be new. Previously used tubing and scrap use is prohibited.

6.8 All tubing shall be free of injurious mill scale, grit, flaking, and rust prior to fabrication.

7.0 Fabrication

7.1 The Supplier shall submit general arrangement (GA) drawings to NRG for review and approval prior to the start of work. All construction details and dimensions specified in the project specification shall be clearly shown. The GA drawings shall include the following as a minimum:

7.1.1 A material diagram showing the OD, wall thickness, and material specification/grade of all tubing

7.1.2 A weld map showing all joint numbers with the weld procedure and filler metal identified

7.1.3 Design and weld details for all tube attachments including, but not limited to, clips, lugs, spacers, and ties

7.1.4 The weight of an individual assembly/tube section

7.1.5 Individual assembly/tube section lifting and handling requirements

7.1.6 Identification of load-carrying attachment welds

7.2 If the project specification requires re-designed assemblies, the design shall account for the corrosive and erosive environment in which the assemblies and tube sections will operate (e.g., high temperature, high velocity ash impingement, etc.). The tube wall thickness shall be established to account for these conditions.

7.3 The following shall apply to the tube ends of fabricated assemblies unless specified otherwise:

7.3.1 Tube end preparation (bevel) shall be 37½° ± 2½°

7.3.2 Tube end preparation shall be free from injurious defects such as pits or scratches greater than 0.010” deep

7.4 At wall thickness transitions, the thinner tube shall be worked (swaged or upset) to match the inside diameter of the thicker tube.

7.5 The filler metal for tube attachments including, but not limited to, clips, lugs, spacers, and ties shall match the tube alloy. Attachments shall be secured with the smallest weld necessary.

7.6 Safe ends shall be installed on stainless steel assemblies that will be welded to ferritic tubing in the field. Safe ends shall not be less than 6” long, match the OD, wall thickness, and alloy of the ferritic tubing, and comply with the requirements of Paragraph 8.10.

7.7 Fabricated workmanship samples shall be submitted to NRG four weeks prior to the start of fabrication for the following:

7.7.1 Each unique type of swage, upset, flare, and bend with a radius equal to or less than two times the tube OD. These samples shall be provided in the heat-treated condition.

7.7.2 Each unique type of welded attachment (clip, lug, spacer, tie, etc.) to tubing that has a specified minimum wall thickness of 0.180” or less. These samples shall be provided using the same procedure and methods proposed for fabrication.

## 8.0 Welding

8.1 Welding shall be performed in accordance with the requirements of the ASME B&PV Code, Section I and the quality control requirements of Paragraph 12.0.

8.2 Welding procedures, welders and welding operators shall be qualified per the Supplier's Quality Program and the ASME B&PV Code, Section IX.

8.3 Weld procedure specifications (WPS) and supporting procedure qualification records (PQR) shall be made available to NRG for review prior to the start of fabrication.

8.4 Copies of all welding operator and welder performance qualifications, along with applicable welder continuity data, shall be made available to NRG for review prior to the start fabrication.

8.5 The following welding practices are prohibited:

8.5.1 Pressure induction welds
8.5.2 Backing rings
8.5.3 Butt welds in the bend area of tubing
8.5.4 The gas metal arc welding process (GMAW) in the short circuiting arc transfer mode.
8.5.5 The Flux Cored Arc Welding process (FCAW) without gas shielding.

8.6 Welding processes employed for applications with a design temperature over 850°F shall limit heat input to 60,000 joules/inch maximum. Heat input shall be determined by the following formula:

$$\frac{\text{volts x amps x 60}}{\text{travel speed (in/min.)}} = \frac{\text{Joules}}{\text{inch}}$$

8.7 All circumferential butt welds shall utilize a gas tungsten arc (GTA) welded root pass unless otherwise approved by NRG.

8.8 A backing gas (argon) purge shall be used for the GTAW process on all austenitic stainless steels and when the base metal contains an excess of 3% chromium for ferritic steels.

8.9 Welding materials utilized for fabrication shall be in accordance with the ASME B&PV Code, Section II, Part C except for the restriction

that low carbon ('L' Grade) filler materials are prohibited when fabrication involves ferritic materials.

8.10 The following requirements shall apply to dissimilar metal welds:

8.10.1 The filler metal shall be nickel based (Inconel). The filler metals shall be ERNiCr-3 for the root pass and ENiCrFe-2 for the cover passes. An inert gas is required.

8.10.2 Preheat and maximum interpass temperature shall be as stipulated in the approved weld procedure specification.

8.10.3 For tubing with a wall thickness greater than 0.250"**,** the joint preparation on the ferritic material shall consist of a compound bevel as shown in Figure 1.

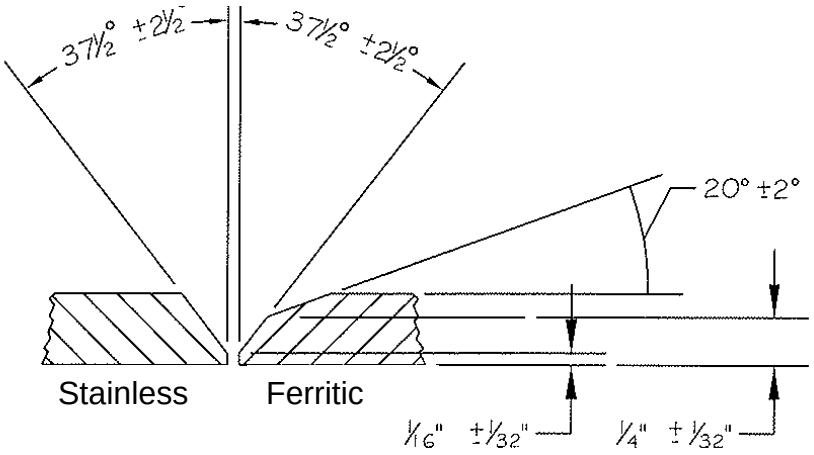



***Figure 1***

9.0 Preheat and Post Weld Heat Treatment

9.1 The maximum interpass temperature shall be 800°F for carbon and low alloy steels and 350°F for manual welding of austenitic stainless steels including dissimilar metal welds and nickel base alloys.

9.2 For austenitic stainless steel and inconel butt welds in tubing made with an automatic welding process, the maximum interpass temperature shall not exceed 500°F unless the weld receives a heat treatment.

9.3 Austenitic stainless steels shall be solution annealed in accordance with the ASME B&PV Code, Section II, SA-213 after forming (i.e., bending, swaging, upsetting, or flaring). Material hardness after heat treatment shall not exceed 90 HRB.

9.4 Ferritic materials covered by the ASME B&PV Code, Section II, SA-213 shall be heat treated after bending, swaging, upsetting, or flaring. Heat treatment and material hardness requirements after heat treatment shall comply with the ASME B&PV Code, Section II, SA-213.

9.5 Dissimilar welds shall not be post-weld heat treated unless NRG approves the Supplier's Weld Procedure Specification that requires post-weld heat treatment.

9.6 The Supplier shall submit the post-weld heat treatment procedure to NRG for review and approval prior to fabrication. Use of localized torch or heating tips is prohibited.

10.0 Inspection and Testing

10.1 Non-destructive examination (NDE) procedures shall be in accordance with the ASME B&PV Code, Section V. The Supplier shall make available all NDE procedures to NRG for review.

10.2 Personnel performing NDE shall have Level II qualifications and be certified in accordance with the requirements of SNT TC-1A. The Supplier shall make available all NDE personnel qualifications to NRG for review. Visual inspections may be performed by an AWS Certified Weld Inspector or designated shop QC Inspector.

10.3 If the specification, codes, laws, ordinances, or any state agency or Authorized Inspector having jurisdiction over the Supplier's shop require any work to be specifically tested or approved, the Supplier shall assume the responsibility and cost thereof and shall give NRG timely notice of its readiness for inspection or testing.

10.4 Tube wall thickness shall be measured prior to fabrication on a sampling of tubes to confirm the tubing meets the minimum wall thickness as described in the purchase order. Sample size is determined by Table 1 below.

10.4.1 Wall thickness measurements shall be made using the Ultrasonic Pulse-Echo Contact Method in accordance with ASME B&PV Code, Section V, Subsection B, Article 23, SE-797.

10.4.2 In lieu of the ultrasonic method described in Paragraph 10.4.1, micrometer measurements taken at each tube end may be taken.

10.4.3 Readings are to be taken at the 0, 90, 180 and 270 degree positions at each end of the tube.

10.4.4 Any tube in the sample group found with readings below minimum wall thickness shall cause the entire lot to be rejected. Disposition of the rejected lot shall be discussed and approved by NRG.

***Table 1***

| Lot Size (# of tubes) | Sample Size |
|---|---|
| 1 to 8 | Entire Lot |
| 9 to 90 | 8 |
| Greater than 90 | 5% |

Notes: 1) Lot size is the entire number of tubes being provided with the Purchase Order.
2) Each heat of steel provided by the tubing manufacturer is to be considered as a separate lot.

10.5 Eddy current examination shall be performed prior to fabrication on a sampling of tubes to confirm the absence of abrupt imperfections. Sample size determined by Table 1 above.

10.5.1 Eddy current testing shall be conducted in accordance with Paragraph 24 of ASME SA-450 for carbon, ferritic, and austenitic stainless tubes and Paragraph 5.3 of ASME SB-829 for nickel alloy tubes.

10.5.2 Any tube in the sample group found with readings below minimum wall shall cause the entire lot to be rejected. Disposition of the rejected lot shall be discussed with and approved by NRG.

10.5.3 If eddy current testing was conducted by the tube Manufacturer and satisfactory results are documented on the tube material CMTR, the eddy current testing of Paragraph 10.5 is not required.

10.6 Visual inspection of tubing shall be performed along the entire length to assure proper surface finish and the absence of any harmful defects, gouges, tears, cracks, flat spots and kinks, the presence of which shall be cause for rejection. All weld spatter, slag, and/or flux shall be removed prior to visual inspection.

10.7 Visual inspection of all welded attachments shall be performed to ensure that the integrity of the adjacent tubing has not been compromised. Any of the following are unacceptable and grounds for rejection:

10.7.1 Cracks

10.7.2 Surface undercut greater than 1/32”deep or 10% of wall thickness, whichever is less

10.7.3 Surface porosity

10.8 Tube bends shall exhibit good workmanship and be free of wrinkles, splits, and surface defects.

10.9 Twenty percent (20%) of all tubes with welded attachments and a specified minimum wall thickness less than 0.180” shall be inspected for weld burn through (as indicated by ID blistering, distortion or other surface imperfections other than discoloration) using a borescope or equivalent device. All burn-through indications observed during borescope examination shall be considered detrimental to the tubing integrity and be rejected. NRG reserves the right to perform borescope examination of additional tube internal surfaces.

10.10 All completed assemblies shall be inspected to assure the absence of any obstruction or constriction inside the tubes. This shall be done by passing steel balls through the inside diameter of the tubes after the assemblies are completely welded. The Supplier shall set up an accountability system to assure recovery of all balls inserted into the tubes.

10.10.1 Ball Size = 0.9 X (Minimum tube OD – 2 X Maximum Wall Thickness) where:

Minimum tube OD = specified OD – SA-450 tolerance
Maximum wall thickness – specified wall + SA-450 tolerance

10.10.2 Balls shall be selected from the next smallest commercial size from the result obtained in Paragraph 10.10.1, but not less than 1/16” of the result obtained in Paragraph 10.10.1

10.11 Wall thickness and ovality measurements shall be obtained from a 20% sample of each unique type of bend. Ultrasonic testing shall be per ASME Section V, Article 23, SE-797. The following are the acceptance criteria for tube bends:

10.11.1 Maximum allowable wall thinning shall be ten percent (10%) of the specified minimum wall thickness.

10.11.2 Maximum ovality, as defined by the following equation, shall be ten percent (10%):

$$\text{Ovality} = \frac{(\text{Major OD} - \text{Minor OD}) \times 100}{\text{Nominal Tube OD}}$$

10.11.3 Necking or OD reduction of the tube at a bend shall not exceed 10% of the specified tube OD.

10.12 Twenty percent (20%) of all tube bends and twenty percent (20%) of all non load-carrying attachment welds shall be examined by magnetic particle or liquid penetrant testing. Any of the following are unacceptable and grounds for rejection:

10.12.1 Any cracks or linear indications

10.12.2 Rounded indications with dimensions greater than 3/16”

10.12.3 Four or more rounded indications in a line separated by 1/16” or less, edge to edge.

10.13 One hundred percent (100%) of all load-carrying attachment welds shall be examined by magnetic particle or liquid penetrant testing. The acceptance criteria of Paragraph 10.12 apply.

10.14 One hundred percent (100%) of all butt welds shall be inspected by radiography.

10.15 The radiographic examination shall be performed using the single shot elliptical technique in accordance with the ASME B&PV Code, Section V.

10.16 Acceptance criteria for radiography shall conform to the ASME B&PV Code, Section I, PW-51. The radiograph film, copies thereof, or an electronic copy of digital radiographs shall be provided to NRG for review. The film will be returned after review.

10.17 A hydrostatic test shall be conducted for each completed assembly. Tests shall be performed in accordance with the ASME B&PV Code, Section I at 1.5 times the design pressure. Water used for testing shall not exceed 5 ppm of chlorides and fluorides. After testing, the assembly shall be drained and air dried. Air used for drying shall be free from all oil or oil vapors.

10.18 Final inspections shall be performed prior to the application of any protective coating and capping of the tubes or assemblies for shipping or storage.

11.0 Repairs

11.1 Through-wall defects shall not be repaired by welding. A new tube or tube section shall be installed.

11.2 When a new tube section is installed, the following applies:

11.2.1 Butt welds shall be examined per Paragraphs 10.15 and 10.16.

11.2.2 The repair procedure, including welding and NDE procedures, shall be submitted to NRG for approval prior to performing the repair. NDE shall be in accordance with Paragraphs 10.1 and 10.2.

11.2.3 The repair shall be documented on an NCR and submitted to NRG for approval.

11.3 If it becomes necessary to rework the outside surfaces of the tubes due to physical damage or arc strikes, this shall be done by previously-approved methods so as to maintain the minimum wall thickness. Following re-working, liquid penetrant or magnetic particle testing shall be performed to assure that no harmful defects are left on the pressure boundary of the tubes.

12.0 Quality Control Requirements

12.1 The Supplier shall develop and implement a Quality Program for the control of quality for all materials and services to be supplied. The Supplier's Quality Program shall be documented by written policies, procedures, and instructions, which, as a minimum, shall comply with the requirements of the codes and standards in Paragraph 4.0. The Supplier's Quality Program shall be submitted to NRG for review and approval with the bid documents.

12.2 Supplier's Quality Program shall address inspection planning, inspections, inspection personnel, and inspection results, and shall include, but not be limited, to the following:

12.2.1 The Supplier shall establish a documented, pre-planned inspection program that shall be used by the Supplier for inspections to be performed at receiving, during storage, during in-process work, upon completion of fabrication, and prior to shipment.

12.2.2 The inspection program shall identify those elements, characteristics, and processes essential for verification by the Supplier's inspection personnel to assure conformance to applicable specification and drawing requirements. The Supplier shall prepare inspection checklists identifying the specific elements, characteristics, and steps in the process to be inspected, and shall include the accept/reject criteria for each. Criteria and recording of inspection results shall be quantitative where possible.

12.2.3 The Supplier's inspection checklist or shop traveler shall be submitted to NRG for review, approval, and identification of those inspection activities to be witnessed by NRG. The Supplier shall submit checklists at least four (4) weeks in advance of scheduled inspections to which they apply.

12.2.4 The Supplier's utilization of approved inspection checklists does not relieve the Supplier of responsibility for compliance with the requirements of the contract, specifications, and drawings.

12.2.5 The Supplier shall implement the pre-planned inspection program by performing the inspections identified on the checklists and documenting actual inspection observations, measurements, and results. The inspection shall be performed and documented as work progresses. A copy of the actual results of each inspection shall be submitted to NRG at the completion of the work.

12.2.6 Supplier personnel performing NDE shall be qualified and certified in accordance with the Supplier's written program. Evidence of their qualification and certification shall be available to NRG for review.

12.3 The Supplier shall arrange for NRG to have free access to all Supplier's or Supplier's Subcontractor's facilities concerned with the supply or manufacture of materials, for the purpose of performing inspection or surveys of parts, prior to or during assembly and to witness any or all fabrication processes, testing, or NDE. The Supplier shall advise NRG of any advance-notice requirements which must be met in order to gain access to the Supplier's or Supplier's Subcontractor's facilities.

12.4 Inspection Witness Points will be indicated by NRG on the Supplier's inspection checklist or shop traveler and returned to Supplier (see Paragraph 12.2.3). Supplier shall notify NRG of the expected fabrication start date, expected dates of Witness Point(s), and expected date of final inspection by the Supplier.

12.5 The Supplier shall provide any documents and copies of or access to all drawings, procedures, or test reports related to the job as deemed necessary by NRG.

12.6 NRG inspection or surveys at the Supplier's facilities and the Supplier's Subcontractor's facilities may be performed at NRG's discretion. Specific NRG inspections may be identified upon receipt of the Supplier's Quality Program.

12.7 Supplier shall initiate, disposition, and control Nonconformance Reports (NCRs), to report deficiencies in characteristics, documentation, or procedures, which do not comply with

specification or drawing requirements. Items which can be corrected (reworked) by completion, re-machining, reassembly, or other means to conform to drawing/specification requirements shall be documented by Supplier on the appropriate inspection checklists. Items which cannot be corrected to original drawing/specification requirements shall be reported immediately on an NCR. Supplier shall provide recommended disposition for each deficiency and shall route the NCR form to NRG for review and approval. Upon NRG's approval of the recommended disposition of the NCR, Supplier shall take the necessary actions to correct the nonconforming item in accordance with the disposition on the approved NCR.

12.8 The Supplier's work shall comply in all respects with applicable drawings, specifications, and contract documents. NRG's final acceptance of Supplier's work shall be based upon satisfactory completion of inspection/tests, and upon resolution of all open or incomplete items.

13.0 Shipping

13.1 All weld spatter, mill scale, arc strikes, rust, loose particles, and any potentially harmful foreign matter shall be removed from the completed assemblies. All sharp edges and roughness shall be ground smooth to a rounded contour. Sponging shall be performed to ensure internal tube cleanliness. Tube preservatives shall not be used on the tube internal surfaces.

13.2 The Supplier shall provide a means to mechanically restrain the assemblies and tube sections during shipment and to facilitate handling at the job site and installation in the boiler. The restraints shall not be welded to the tubes if at all possible and shall accommodate the attachment of lifting cables. The Contractor shall submit the proposed restraint arrangement and lifting plan to NRG for review and approval.

13.3 All completed assemblies and tube sections shall be clearly marked with the material designation and size, assembly/tube section number, Supplier's Job Number, and the NRG Purchase Order Number.

13.4 Suitable weather protection shall be provided to protect the equipment from damage in transit and during storage for up to six months. Such protection shall include, but not be limited to, applying deoxaluminate on weld end preps and protective end caps. Capping shall not be done prior to final inspection or release

by NRG, as specified in Paragraph 10.18. The method of protection shall be submitted to NRG for review and approval.

14.0 Documentation

The Supplier's final documentation package shall, as a minimum, include the following:

14.1 Signed P-4 forms
14.2 Certified material test reports
14.3 Copy of tube Manufacturer's ISO 9001 certification
14.3 General arrangement drawings with joint maps, filler metals, and attachment designs
14.4 Hydrostatic test certificate of compliance
14.5 Heat treatment charts or certificate of compliance (when applicable)
14.6 NDE reports including:
- 14.6.1 Visual/dimensional results
- 14.6.2 Tube wall thickness report
- 14.6.3 Eddy current examination of tubing (when applicable)
- 14.6.4 Ultrasonic thickness/ovality examination of bends
- 14.6.5 Radiography examination of butt welds
- 14.6.6 Magnetic particle and/or liquid penetrant examination of attachment welds
- 14.6.7 Borescope inspection (when applicable)

14.7 Repair procedures (when applicable)
14.8 Nonconformance reports