	QUALITY ASSURANCE SPECIFICATION	**QAS: 1.03**
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		DATE: 08/29/2014
FABRICATED COMPONENTS – Shop-Applied Cladding and Overlay of Boiler Tubing		**PAGE 1 OF 17**

1.0 Purpose

1.1 The purpose of this specification is to establish the minimum quality assurance requirements for shop-applied corrosion-resistant cladding and overlay of boiler tubing supplied to NRG Energy Inc.

2.0 Scope

2.1 This specification applies to panels, assemblies, and loose boiler tubes.

2.2 This specification applies to any process used to apply a corrosion-resistant weld metal deposit on boiler tubing including laser cladding, weld overlay, and spiral winding.

2.3 This specification applies to projects where the strength of the cladding/overlay is included in the calculation of the tube minimum wall thickness as well as projects where the cladding/overlay strength is not included.

2.4 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 ASME – American Society of Mechanical Engineers

3.2 ASNT - American Society for Nondestructive Testing

3.3 NRG – The NRG individual responsible for the overall management of the project

3.4 ISO – International Organization for Standardization

3.5 Manufacturer – The organization responsible for certifying the clad/overlayed tubing/panels

3.6 Supplier – The organization applying the corrosion-resistant cladding or overlay

3.7 SSPC – The Society for Protective Coatings

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 V, “Nondestructive Testing”

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

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

4.5 SPPC SP-10 (NACE 2), “Near-White Blast Cleaning”

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 immediately 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. Exceptions to and deviations from these requirements 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 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.

5.5 NRG is responsible for providing the Supplier with all available drawings, tube/panel dimensions, material specifications/grade and specifying the welding process to be used.

5.6 NRG shall inform the Supplier if the strength of the cladding/overlay is included in the calculation of the tube minimum wall thickness in accordance with the ASME B&PV Code, Section I, Paragraph PG-27.

5.7 When the cladding/overlay strength is included, NRG is responsible for ensuring compliance with the tube minimum wall thickness requirements of the ASME B&PV Code, Section I.

6.0 Welding

6.1 Welding shall be performed in accordance with the requirements of the ASME B&PV Code, Section I and the quality control requirements of Paragraph 10.0.

6.2 Welding procedures, welders and welding operators shall be qualified per the Supplier's Quality Program and the ASME B&PV Code, Section IX, and specifically Paragraph QW-214 for corrosion-resistant weld metal overlay.

6.3 Weld procedure specifications (WPS) and supporting procedure qualification records (PQR) shall be made available to NRG for review.

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

6.5 Surface preparation of the tubes/panels to be clad/overlayed shall consist of grit blasting to SSPC SP-10 with a low carbon, low dusting abrasive, which does not embed itself in the substrate. The Supplier *may* elect to apply a coating of deoxyaluminate to minimize tube/panel oxidation after grit blasting, should there be a significant delay before welding. If applied, the coating shall consist of one to two mils (dry thickness) of deoxyaluminate paint.

6.6 The corrosion-resistant weld deposit material shall be stipulated in the project specification.

6.7 The Supplier shall submit a “bead sequence sketch” detailing instructions on operator technique for performing the weld metal cladding or overlay, including percent of weld metal overlap, to NRG for review and approval.

6.8 The following welding processes are permitted:

6.8.1 Pulsed Gas Tungsten-Arc (GTAW), automatic and semiautomatic with 0.045" maximum diameter filler metal

6.8.2 Pulsed Gas Metal Arc (GMAW), manual or automatic and semiautomatic with 0.035" maximum diameter electrodes. Larger diameters require workmanship samples to be submitted to NRG for approval

6.8.3 Laser-beam welding (LBW)

6.8.4 For spiral wound processes, a GTAW wash pass performed directly behind the GMAW spiral overlay is acceptable

6.8.5 Other welding processes/techniques will be considered if the Supplier can demonstrate the ability to use the process to the satisfaction of NRG. The Contractor shall submit the complete details of the welding equipment, welding techniques, welding procedures, and procedure qualification tests for each of the proposed processes to NRG for review and approval.

6.9 The weld progression shall be in accordance with the approved Supplier’s WPS.

6.10 All single or loose tubes shall be clad or overlayed 360° around the circumference for their entire length unless specified otherwise by NRG.

6.11 For cladding/overlay of P1, P3, P4, and P5A materials, the Supplier is not required or precluded from welding with water filled/flowing through the tubes. A minimum preheat temperature shall be maintained in accordance with the Supplier’s approved WPS and the ASME B&PV Code, Section I preheat and/or post-weld heat treatment requirements (applicable section of Table PW-39).

6.14 The Supplier shall meet the chemistry requirements of Paragraph 8.4.1. The minimum deposit thickness shall be 0.030" for laser cladding and 0.050" for weld overlay. The minimum deposit thickness applies only to panels where the strength of the cladding/overlay is not included in the calculation of the tube minimum wall thickness.

6.15 The Supplier shall submit a "typical" workmanship sample to NRG that is welded using the same methods, procedures, and processes that will be employed during production welding including post-weld heat treatment, if required. The following applies to the workmanship sample:

6.15.1 The minimum size shall be three tubes wide by six inches long for panel cladding/overlay or one 2-foot long tube for single tube cladding/overlay.

6.15.2 The sample shall be submitted at least four weeks prior to production welding. Production welding shall not commence until the workmanship sample has been approved by NRG.

6.15.3 Cross sections taken from the sample shall not exhibit a through-wall heat-affected zone (HAZ)

6.15.4 The sample shall exhibit no untempered martenstite in the weld HAZ.

6.15.5 The hardness in the weld HAZ shall not exceed 25 Rockwell C.

7.0 Post-Weld Heat Treatment

7.1 Post-weld heat treatment, if required, shall be performed in accordance with the ASME B&PV Code, Section I, Paragraph PW-39 for the subject tube material grade.

7.2 Post-weld heat treatment shall be performed:

7.2.1 When straightening is required to meet the requirements of Paragraph 8.12 or 8.13, in which case post-weld heat treatment shall be performed prior to straightening

7.2.2 When required to meet the hardness and microstructural requirements of Paragraph 6.15.2 through 6.15.5.

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

8.0 Inspection and Testing

8.1 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.

8.2 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.

8.3 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.

8.4 The Supplier shall take alloy analysis readings on the outside surface of the finished cladding/overlay to verify the as-deposited weld chemistry. For panels, a minimum of nine readings shall be obtained from each panel. For loose tubes, a minimum of three readings shall be obtained from each tube. The following chemistry requirements shall be met:

8.4.1 For Inconel 622, a minimum of 20.0% chromium, 12.5% molybdenum, and 2.5% tungsten.

8.5 Visual inspection of tubing and panels shall be performed to assure the cladding/overlay is consistent in thickness, smooth and continuous with no gaps, voids, porosity, or cracks, and all stops, starts and tie-ins blended/ground to a smooth transition. Tubes/panels shall be rejected for any of the following reasons:

8.5.1 Arc strikes
8.5.2. Cracks
8.5.3 Lack of fusion
8.5.4. Surface undercut greater than 1/32" deep

8.5.5 Incorrect bead sequence

8.6 All completed panels shall be inspected after cladding/overlay 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 each tube following cladding/overlay. The Supplier shall set up an accountability system to assure recovery of all balls inserted into the tubes.

8.6.1 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

8.6.2 Balls shall be selected from the next smallest commercial size from the result obtained in Paragraph 8.6.1, but not less than 1/16” of the result obtained in Paragraph 8.6.1.

8.7 Ten percent (10%) of all tubes with 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 shall be rejected. NRG reserves the right to perform borescope examination of additional tube internal surfaces.

8.8 The Supplier shall perform 100% liquid penetrant examination of the final clad/overlay surfaces using a water washable method. The cladding/overlay shall be free of linear indications greater than 1/16”. This requirement applies to <u>all panels</u> including those where the strength of the cladding/overlay is included in the calculation of the tube minimum wall thickness.

8.9 For panels where the strength of the cladding/overlay is included in the calculation of the tube minimum wall thickness, the Supplier shall comply with all NDE requirements of the ASME B&PV Code, Section I, Paragraph PW-44, including the Supplier’s examination of a workmanship sample. During tube cladding/overlay production, the Manufacturer shall establish an NDE program to be implemented by the Supplier in accordance with ASME B&PV Code Section I, Paragraph PW44.8. Test results from the workmanship sample and from the Production Examination Program shall be

provided to NRG immediately after sample testing and Production Examination.

8.10 All temporary attachment welds shall examined by liquid penetrant testing following their removal.

8.11 Final inspection shall be performed prior to the application of any protective coating and capping of the tubes or panel for shipping or storage.

8.12 Waterwall panels shall meet the dimensional tolerances of Attachment 1 after the cladding/overlay is applied.

8.13 Individual tubes shall be straight +/- 1/8" over their entire length.

9.0 Repairs

9.1 Through-wall defects that result from the cladding/overlay process shall not be repaired by welding. A new tube or tube section shall be installed as follows:

9.1.1 The Supplier is responsible for installing a new tube(s) at no cost to NRG.

9.1.2 The repair procedure, including welding and NDE procedures, shall be submitted to NRG for approval prior to performing the repair.

9.1.3 Butt welds shall be examined by radiography to the acceptance standards of the ASME B&PV Code, Section I

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

9.2 If it becomes necessary to rework the outside surfaces of the cladding/overlay, this shall be done using the same welding process that was initially used to apply the cladding/overlay or with GTAW.

10.0 Quality Control Requirements

10.1 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.

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

10.2.1 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.

10.2.2 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.

10.2.3 The Supplier's inspection checklist 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.

10.2.4 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.

10.2.5 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.

10.2.6 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.

10.3 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.

10.4 Inspection Witness Points will be indicated by NRG on the Supplier's inspection checklist and returned to Supplier (see Paragraph 10.2.3). 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.

10.5 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.

10.6 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.

10.7 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.

10.8 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.

11.0 Shipping

11.1 All weld spatter, mill scale, arc strikes, rust, loose particles, and any potentially harmful foreign matter shall be removed from the completed tubes/panels. All sharp edges and roughness shall be ground smooth to a rounded contour. Unless otherwise specified in the project specification, preservatives shall not be used on the tube internal surfaces.

11.2 All panels and individual tubes shall be identified by the Supplier's Job Number, panel number, heat/batch number (i.e., Laser Clad Lot # XXX), and the NRG Purchase Order Number.

11.3 For panels, this information of Paragraph 11.2 shall be stamped onto a 1/8" or 10 gage carbon steel plate using letters not less than 1/4" in height. Each waterwall panel shall have this identification plate located 18" from either end at the panel centerline. The plate shall be attached to the casing side of the panel by welding to the membrane and not the tubes.

11.4 For individual tubes, the information of Paragraph 11.2 shall be stenciled on the tubes.

11.5 For panels, the casing side shall be painted with a rust inhibiting primer except for the tube ends/weld preps, membrane cut backs/toggle slots, nameplates, or the sides of the panel, which will be coated with deoxyaluminate 1 to 2 mils dry mil thickness. No paint shall be applied within three inches of weld preps and within one inch of membrane cut backs/toggle slots.

11.6 Panels shall be shipped on a flat bed truck with the cladding/overlay side up. Panels shall be stacked with wood spacers wide enough to allow for subsequent handling with a fork lift.

11.7 Suitable weather protection shall be provided to protect the tubes/panels 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 8.11.

12.0 Documentation

The Supplier's final documentation package shall include the following:

12.1 Signed P-4 form
12.2 Heat treatment charts or certification of compliance (when applicable)
12.3 NDE reports including:
12.3.1 Visual inspection results
12.3.2 Alloy analysis of weld deposit
12.3.3 Workmanship sample results (when clad strength is included in minimum wall calculations)
12.3.4 Production Examination Program results (when clad strength is included in minimum wall calculations)
12.4 Repair procedures (when applicable)
12.5 Nonconformance reports

13.0 Attachments

1. Waterwall Panel Dimensional Tolerances
Waterwall Panel Dimensional Tolerances

1.0 The following are the allowable tolerances for waterwall panel fabrication.

Dimension	Tolerance (inches)
Panel Width	+0,-1/4"
Panel Length	±1/8"
Tube Centerline to Centerline	±1/16"
Membrane Recess Length	±1/4"
Membrane Cut Back Length	±1/4"
Membrane Cut Back Width	3/16" max.
Membrane Length	±1/4"
Tube End OD Scarfing	+1/8", -0"
Outside Tube to Outside Tube Centerline	+0", -1/4"
Bowing	±1/4"
Crowning	±1/4"
Membrane Flatness	±1/4"
Panel Squareness	±1/4"
Tube End Parallelism	±1/16"
Tube Ovality (straight tubes only)	2%

2.0 Gang bent panels shall be supplied such that the first panel bend radius is within ±3/8" of the drawing dimension, and each subsequent panel of the order or item is within ±1/8" of the first panel, unless other tolerances are agreed upon by the Purchaser and Supplier prior to the pressure part arrangement drawings.

3.0 The inspection definitions and terminology are as follows:

3.1 Bowing – a measure of the flatness of the panel, top to bottom. Bowing is measured by stretching a tape from one end of the panel to the other end of the panel on a randomly selected tube of each panel. This measurement shall be done on both the front and back of the panel. The largest distance between the tape and the tube shall be the maximum bowing.

3.2 Crowning – a measure of the flatness of the panel, side to side. Crowning is measured by stretching a tape from the panel's left side tube to the panel's right side tube. This measurement shall be done on both sides the front and the back of the panel at two different locations along a panel's length. The largest distance between tape and the tube shall be the maximum crowning.

3.3 Flatness (for bars only) - shall be measured on membrane bars by stretching a tape from one end to the other lengthwise along the bar and perpendicular to the ends. The maximum distance between the tape and the bar shall be the out-of-flatness.

3.4 Panel Squareness - a combination of how parallel the opposite sides of a panel are to how perpendicular the adjacent sides of the same panel are. This condition is achieved when the diagonal distance from panel corners are equal to each other within the tolerance specified.

3.5 Tube End Parallelism - a measure of the straightness or "saw-toothing" of the tube ends of a panel. This attribute shall be measured by first checking the tubes at each corner for squareness (see definition of squareness). Next, stretch a line taut from one side of the panel to the other across the tube faces. The line shall be tangent to the tube faces. The distance from the line to each tube face is the deviation from tube end parallelism.

3.6 Tube End Squareness - a measure of how closely the tube ends match a right angle. This property shall be measured with a template at two points around the tube end's circumference. The points shall be opposite each other.

3.7 Tube Ovality - the out-of-roundness of the tube. The measurement shall be made at each end and at the tube center. At the tube ends, the inner diameter shall be checked at four equally spaced locations. The center of the tube shall be tested for ovality by measuring the outside diameter at four different, equally spaced points.