1.0 Purpose

The purpose of this specification is to establish minimum quality assurance requirements for the shop fabrication of unfired pressure vessels supplied to NRG Energy Inc.

2.0 Scope

2.1 This specification shall apply to pressure vessels under the jurisdiction of the ASME Boiler and Pressure Vessel Code, Section VIII, Division I. All references to "Code" in this specification refer to ASME Section VIII, Division 1.

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 API – American Petroleum Institute

3.3 ASME – American Society of Mechanical Engineers

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

3.5 ASNT – American Society for Nondestructive Testing

3.6 ASTM – American Society for Testing and Materials

3.7 AWS - American Welding Society

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

3.9 ISO - International Organization for Standardization

3.10 Manufacturer - The organization making the unfired pressure vessel

3.11 Supplier - The organization providing the unfired pressure vessel

3.12 QAS - NRG Quality Assurance Specification

4.0 References

4.1 API 605, “Large Diameter Carbon Steel Flanges”

4.2 ASME B16.5, “Steel Pipe Flanges and Fittings”

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

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

4.5 ASME Boiler & Pressure Vessel Code, Section VIII, “Rules for Construction of Pressure Vessels”

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

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

4.8 NRG QAS 4.05, “Welding - Heat Treatment”

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 Vendor's bid for disposition by NRG.

5.2 The Manufacturer shall hold a valid "U" Stamp issued by the ASME.

5.3 The Supplier shall provide a Manufacturer's Data Report, (i.e., ASME U-1, U-1A or U-2) with the shipment of the pressure vessel.

5.4 The 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 assume complete responsibility for the design and construction of the vessel and its integral components and supports, and shall consider any information shown in the bid documents, purchase order or project specification as minimum design requirements subject to a design verification by the Supplier.

5.7 The Supplier shall supply a complete set of service gaskets and studs for manways, handholes, body flanges and blind flanges.

5.8 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.

5.9 NRG shall furnish the Supplier with the design temperature, pressure, loadings, service application, and corrosion allowance for the pressure vessel.

6.0 Material

6.1 Materials shall be as stipulated in the project specification or, if not specified, suitable for the intended service and permitted by the Code. All materials shall be identified by their ASME or ASTM designation.

6.2 SA-53 Grade A or B pipe is prohibited.

6.3 Vessels constructed of carbon steel shall have a minimum plate thickness of 1/4” in the shell or head, inclusive of any corrosion allowance or applied cladding.

6.4 The following requirements apply to bolting:

6.4.1 For temperature between -20° F and 850° F, bolting shall be SA-193 B7 studs, threaded full length, with SA-194 Grade 2H heavy hex nuts.

6.4.2 Above 850° F, bolting shall be SA-193 B16 studs with SA-194 heavy hex nuts of a grade suitable for the temperature.

6.5 Reinforcing pads and nozzle necks that are fabricated from plate shall be the same material as the vessel shell or head to which they are attached.

6.6 All materials of construction shall be new. All plate shall be free of injurious mill scale, grit, flaking, and rust prior to fabrication.

6.7 The Supplier shall provide certified material test reports (CMTR) for all plate 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.

7.0 Design

7.1 All pressure vessels shall be designed, fabricated, and tested in accordance with the ASME B&PV Code, Section VIII, Division I.

7.2 All pressure vessels shall comply with any applicable federal, state, and local codes and regulations.

7.3 All vessels shall be designed for the pressure and temperature specified in the project specification and the load conditions specified in Paragraphs 7.8, 7.9, and 7.10.

7.4 The Supplier shall make general arrangement drawings available to NRG for review upon request. All construction details and dimensions specified in the project specification shall be clearly

shown. The fabrication drawings shall include the following as a minimum:

7.4.1 Applicable ASME Code edition and addenda
7.4.2 The bill of materials, design data, and schedule of openings
7.4.3 Details of all weld preparations and the locations of all circumferential and longitudinal weld seams
7.4.4 The location, bill of material, and details of all nozzles, manways, and other openings or penetrations
7.4.5 Support drawings with weld details
7.4.6 Corrosion allowances
7.4.7 Joint efficiencies
7.4.8 Requirements for radiograph examination, specified by ASME Code, Section VIII designations “RT1”, “RT2”, “RT3”
7.4.9 Requirements for nondestructive examination, postweld heat treatment, and pressure testing
7.4.10 Appurtenance details (e.g., platforms, ladders, etc.)
7.4.11 Lifting and handling procedures

7.5 Complete and checked ASME Code calculation for all designs shall be submitted for review with the first set of drawings. All subsequent calculations which may be necessary shall be concurrently submitted with revised drawings.

7.6 The design shall account for potential corrosive environment to which the vessel will be exposed. The wall thickness shall be designed to account for these conditions.

7.7 For large thin-walled vessels, the Supplier shall evaluate the need for additional stiffening to prevent shell distortion during fabrication, heat treatment, hydrostatic testing, shipment, or operation.

7.8 The vessel and it structural supports shall be designed for the operating load plus external attachments loads (such as exerted by piping), plus wind loading when applicable.

7.8.1 For pressure containing parts, the base metal thickness for the loads in Paragraph 7.8 shall be in addition to the base metal thickness required for the design pressure using the allowable stresses permitted by the Code at the design temperature. To this total required thickness shall be added the corrosion allowance.

7.8.2 Welds attaching non-pressure parts to the pressure containing parts and welds attaching highly loaded supports for important internal parts such as grids, cyclones, etc., shall be designed using the Code allowable stresses for pressure containing parts at the design temperature.

7.9 The vessel and its structural supports shall be designed for the hydrostatic test conditions including the test pressure, vessel dead load, attachment loads, and the weight of water. Stresses shall be calculated using the metal thickness less corrosion allowance at test temperature.

7.10 Vessels shall be designed for hydrostatic testing the vessel in place, with a test pressure at the top of the vessel as defined in paragraph UG-99 of the Code, without causing permanent distortion to any portion of the vessel. The maximum stress under test for the thickness less corrosion allowance shall not exceed 90% of the specified minimum yield strength for the material.

7.11 Supports for the vessel shall be designed for the vessel dead weight and the weight of water or other test fluid which may be specified in the project specification (whichever is heavier).

7.12 For horizontal vessels, the saddle tip stress and shell bending stress must be checked for the "filled-but-no-pressure" condition.

7.13 The following requirements apply to nozzles:

7.13.1 Nozzle flanges shall conform to ASME B16.5. Flanges larger than the scope of ASME B16.5 shall be in accordance with API 605.

7.13.2 Nozzle necks may be of seamless pipe, formed plate, or integrally forged with the flanged connection.

7.13.2 For clad or lined vessels, the cladding or lining shall extend through the nozzle and cover the gasket face of the flange.

7.13.3 Nozzle projections from the outside of shell or head to the face of the flange shall be as follows (unless specified otherwise):

Nominal Size	Approximate Projection
1” - 8”	8”

10” and larger	10”

Projections are based on 300# ANSI flanges with 2" insulation. For higher flange ratings and/or thicker insulation, projections shall be increased accordingly. Vendor vessel drawings shall indicate the dimension from the vessel centerline to the flange face of each nozzle, to the nearest 1/2".

7.14 The following requirements apply to manways:

7.14.1 Manway size shall be specified on the approved drawing.

7.14.2 The minimum neck thickness for manways and inspection openings shall be the same as ASME Code requirements for nozzles.

7.14.3 For vessels with alloy lining, the manway flange gasket surface and cover shall have an alloy lining of the same material, or comparable weld overlay.

7.15 The following requirements apply to flanges:

7.15.1 Flanges may be weld neck, long weld neck, or slip-on type. Slip-on type flanges are not permitted for ratings greater than 300#.

7.15.2 The finish of the gasket contact surface of flange facings shall conform to ASME B16.5.

7.15.3 Gaskets for raised face flanges shall have the outside diameter and inside diameter conform to the dimensions specified by ASME B16.5, to the inside edge of the bolts or shall be provided with a centering ring.

7.16 Nozzles and man ways shall have a corrosion allowance equal to or greater than that specified for the vessel.

7.17 The bore of nozzle necks and weld neck flanges shall match, or shall be tapered to match. Thickness after tapering shall not be less than that required by Code.

7.18 The following requirements apply to vessel supports:

7.18.1 For vessels with a design temperature between -20° F and 650° F, the support material shall be SA-36 or equal as a minimum. For vessels with a design temperature below -20° F or above 650° F, the support material shall be equivalent to the shell material for a minimum distance of 24" from the point of attachment to the pressure part. Lugs supporting vessels from the shell shall have bearing places welded to the lug proper.

7.18.2 Horizontal vessels shall be supported on steel saddles with 120° wrappers (minimum). Ring supports shall be used when required for stability. Wrappers on vessels shall be continuously welded to the shell. Saddles shall be welded to the vessel prior to post-weld heat treatment, if post-weld heat treatment is required. Saddles may be field welded only with written approval.

8.0 Fabrication

8.1 The following requirements apply to the vessel layout:

8.1.1 Longitudinal seams shall not be located behind downcomers of trayed vessels or behind any other obstruction which could prevent visual inspection or non-destructive examination of the welds.

8.1.2 Support saddles or lugs shall not be placed over vessel circumferential or longitudinal seams.

8.1.3 Circumferential welds shall not be located within 1-1/2” of the tray ring.

8.1.4 Nozzles and manholes and their reinforcements shall not be located in any seam unless approved by NRG. If so approved, the welded joint shall be ground smooth and radiographed for its entire covered length, plus 1” on each side.

8.2 Drain and vent connections shall be trimmed flush with the inside surface of the vessel. All other connections may project internally.

8.3 Exposed edges of manhole and nozzle necks shall be rounded at the inside surface of the vessel.

8.4 High temperature thermiculite (e.g., flexitallic) gaskets rated at the design temperature of the shell shall be used, unless a substitute material is approved by NRG.

9.0 Welding

9.1 All welding shall be performed in accordance with the requirements the ASME B&PV Code, Section VIII and the quality control requirements of Paragraph 13.0.

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

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

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

9.5 Shell and head joints shall be full penetration, double welded butt joints. Single welded, full penetration joints utilizing permanent backup strips or consumable inserts are permitted only on the closing circumferential joint of vessels which are not provided with a manway, except that vessels less than 24" in diameter may have two closing circumferential joints with permanent backup strips.

9.6 Nozzles, man ways, and couplings shall be welded to the steel and heads with double welded full penetration welds unless specifically noted otherwise in the project specification, or access for back welding from the inside is not possible. When access is not possible, temporary backup strips may be used but shall be removed after completion of welding.

9.7 The following welding processes are allowed:

9.7.1 SMAW - Shielded Metal Arc Welding
9.7.2 SAW - Submerged Arc Welding
9.7.3 FCAW - Flux Cored Arc Welding
9.7.4 GTAW - Gas Tungsten Arc Welding
9.7.5 GMAW - Gas Metal Arc Welding (spray transfer)

9.8 NRG restricts the following welding processes as follows:

9.8.1 The gas metal arc welding process (GMAW) shall not be used in the short circuiting arc transfer mode.

9.8.2 The Flux Cored Arc Welding process (FCAW) shall be used with gas shielding.

9.8.3 For submerged arc welding (SAW) where the design temperature is at or above 850°F, the following shall apply:

9.8.3.1 The welding flux shall be basic with a basicity index of at least 2.0 as derived from the following formula.

$$BI = \frac{CaO + CaF2 + MgO + K2O + Na2O + Li2O + \frac{1}{2}(MnO + FeO)}{SiO2 + \frac{1}{2}(AI2O3 + Ti\,O2 + Zr\,O2)}$$

SOURCE: Metals Handbook, 9th Ed Vol. 6, pg. 125

9.8.3.2 A basicity index calculation, including the trade names of the wire/flux combination to be utilized, shall be submitted to NRG for review upon request.

9.8.3.3 Weld beads shall be deposited so that the fine grain microstructure will not align through the weld throat.

9.8.3.4 The cover pass shall be made using stringer beads.

9.8.4 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:

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

9.9 All circumferential butt welds in tube and pipe shall utilize a gas tungsten arc (GTA) welded root pass unless specifically permitted otherwise by NRG.

9.10 Low hydrogen electrodes shall be used for SMAW process.

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

9.12 Additional welding on vessels which have been postweld heat treated is not permitted.

10.0 Preheat and Post-weld Heat Treatment

10.1 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.

10.2 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.

10.3 Post weld heat treatment (PWHT) of carbon and low alloy materials shall be performed in accordance with QAS 4.05 and the ASME B&PVC, Section VIII, Division I, applicable section of Table UCS-56.

10.4 Post-weld heat treatment may be accomplished by either heating the vessel in a gas furnace or electric furnace. Localized postweld heat treatment must have prior approval by NRG.

10.5 The Supplier shall make available the post-weld heat treatment procedure to NRG for review upon request.

10.6 Post weld heat treatment furnace charts shall be made available to NRG upon request.

11.0 Inspection and Testing

11.1 The requirements for non-destructive examination (NDE) shall be in accordance with the Code.

11.2 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 upon request.

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

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

11.5 All equipment shall be hydrostatic pressure tested after fabrication and prior to shipment in accordance with the requirements of the applicable Code and in the presence of NRG. It shall be NRG's prerogative to waive the witnessing of the test after being contacted by the Supplier.

11.6 Hydrostatic pressure testing shall be accomplished with clean, demineralized water at a temperature of not less than 60° F. 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.

11.7 Leak tests of reinforcing pads shall be performed by procedures in accordance with the ASME B&PV Code, Section V. Each reinforcing pad shall have one test hole, tapped 1/4 NPT and located at least 45° off the longitudinal axis of the vessel. This applies to each pad or segment of a multiple piece pad. The welds of each pad or segment shall be given an air-and-bubble solution pressure test before hydrostatic testing the vessel. The pressure shall be at least 15 psig, but shall not exceed 20 psig. Test holes shall be filled with corrosion inhibiting grease after the hydrostatic test and prior to shipment.

11.8 After completion of the vessel hydrostatic test, additional welding on the vessel is not permitted without prior approval by NRG.

11.9 All radiographs, including original weld reject film, subsequent repair reshots and final acceptable film, shall be made available to NRG upon request.

12.0 <u>Marking</u>

12.1 A stainless steel nameplate shall be provided on all vessels. The nameplate shall be stamped in accordance with the ASME code and the project specification. The nameplate shall be mounted on a bracket welded to the vessel and shall project from the surface at least as far as the surface of any insulation specified.

12.2 Lined vessels shall be clearly marked on the outside by the following: "LINED VESSEL - DO NOT WELD".

13.0 Quality Control Requirements

13.1 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 upon request.

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

13.2.1 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.

13.2.2 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.

13.2.3 The Supplier's inspection checklist shall be submitted to NRG for review upon request, 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.

13.2.4 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.

13.2.5 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.

13.2.6 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 upon request.

13.3 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.

13.4 Inspection Witness Points will be indicated by NRG on the Supplier's inspection checklist and returned to Supplier (see Paragraph 13.2.3). 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.

13.5 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.

13.6 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.

13.7 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.

13.8 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.

14.0 Shipping

14.1 All accumulative fabrication debris shall be thoroughly cleaned out and all water completely drained from each vessel.

14.2 Exposed flanged connections shall be protected by steel or wooden covers which extend to the edge of the flange. All threaded connections shall be filled with steel plugs. Socketweld couplings shall have plastic caps. Welded stub ends shall be provided with steel weld bevel protectors.

14.3 All exterior steel surfaces, except tubes and machined surfaces, shall be cleaned of dirt, grease and loose scale by power wire brushing or equal, and shall receive one prime coat of zinc chromate or red oxide primer.

14.4 Exposed machined surfaced shall be properly protected with an easily removable rust preventative coating.

14.5 Spare gaskets shall be enclosed in a plywood container, marked with the purchase order number and the vessel equipment number, and securely attached to the vessel.

14.6 All internal and external parts and piping assembled with the vessel shall be suitably supported and/or braced to prevent damage during handling and transport.

14.7 Small, easily damaged parts shall be removed for shipment. Individually packed items shall be painted or coated with rust preventive and wrapped in a heavy moisture-proof paper. These

parts shall be properly identified and reference the purchase order or contract document.

14.8 The pressure vessel shall be protected during shipment with tarps, covers, plastic, etc. to prevent exposure to weather, road salt, etc.

15.0 Documentation

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

15.1 Signed U-1 forms
15.2 Certified material test reports
15.3 General arrangement drawings with design data and assumptions
15.5 Hydrostatic test certificate of compliance (when applicable)
15.6 Heat treatment charts or certificate of compliance (when applicable)
15.7 NDE Reports including:
15.7.1 Visual/dimensional results
15.7.2 PT, MT, UT, and RT examination (when applicable)
15.8 Repair procedures (when applicable)
15.9 Nonconformance reports