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MASTER

SPECIFICATION

FOR

HIGH PRESSURE GAS VESSELS

SPECIFICATION NUMBER SNPO-C-3
REVISION 0

MAY, 1967

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X-10928

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1.1 SCOPE

The Contractor shall provide all engineering, design, and shall furnish, fabricate, and deliver the high pressure gas vessels specified herein. This specification, together with drawings, covers the design, fabrication, inspection, testing, cleaning, and acceptance of cylindrical, high pressure gas storage vessels. The design standards set forth in this specification shall be considered to be the minimum.

1.2 APPLICABLE PUBLICATIONS

The following publications, of the latest issue with addenda on the date of invitation to bid, referred to in other portions of this specification by basic designation only, form a part of this specification to the extent indicated.

1.2.1 FEDERAL SPECIFICATION

TT-P-645	Primer, Paint, Zinc-Chromate, Alkyd Type
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1.2.2 MILITARY SPECIFICATIONS

MIL-Q-9858	Quality Program Requirements
MIL-P-27401	Propellant Pressurizing Agent, Nitrogen
MIL-I-45208	Inspection System Requirements

1.2.3 MILITARY STANDARDS

MIL-STD-22	Welded-Joint Designs
MIL-STD-271	Nondestructive Testing Requirements for Metals

1.2.4 AMERICAN SOCIETY FOR TESTING AND MATERIALS STANDARDS

A 20	Specifications For General Requirements For Delivery Of Rolled Steel Plates Of Flange And Firebox Qualities.
A 36	Specification For Structural Steel
A 300	Specification For Steel Plates For Pressure Vessels For Service At Low Temperatures
A 320	Specification For Alloy Steel Bolting Materials For Low Temperature Service
A 350	Specification For Forged Or Rolled Carbon And Alloy Steel Flanges, Forged Fittings, And Valves And Parts For Low-Temperature Service
A 370	Methods And Definitions For Mechanical Testing Of Steel Products

- A 372 Carbon And Alloy Steel Forgings For Pressure Vessel Shells
- A 508 Quenched And Tempered Vacuum Treated Carbon And Alloy Steel Forgings For Pressure Vessels
- A 543 Specification For Ni-Cr-Mo Alloy Steel Plates Quenched And Tempered For Pressure Vessels
- B 100 Specification For Rolled Copper-Alloy Lining And Expansion Plates And Sheets For Bridge And Other Structural Uses
- E 8 Methods Of Tension Testing Of Metallic Materials
- E 23 Methods For Notched Bar Impact Testing Of Metallic Materials
- E 112 Methods For Estimating The Average Grain Size Of Metals

1.2.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Boiler And Pressure Vessel Code, Section III, Nuclear Vessels.
 Boiler And Pressure Vessel Code, Section VIII, Unfired Pressure Vessels For Code Case 1205 Only.
 Boiler And Pressure Vessel Code, Section IX, Welding Qualifications. Code Case 1358.

1.2.6 AMERICAN STANDARDS ASSOCIATION STANDARDS

- B16.5 Steel Pipe Flanges And Flanged Fittings
- B18.2 Square And Hexagon Bolts And Nuts. Incl. Errata And App. V-1962

1.2.7 AMERICAN WELDING SOCIETY

- A2.0 Standard Welding Symbols
- A2.2 Nondestructive Testing Symbols
- A3.0 AWS Definitions - Welding And Cutting

1.2.8 INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

1964 Uniform Building Code

1.2.9 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NPC-200-3 Inspection System Provisions

1.3 DEVIATIONS

All deviations from the intent of these specifications and standards shall be approved in writing by the Contracting Officer prior to inclusion in the design, fabrication, or testing of the vessels. Approval of any deviations by the Contracting Officer will not waive the responsibility of the Contractor to comply with ASME Codes.

1.4 RULES FOR CONSTRUCTION

The high pressure storage vessels shall be of the single layer cylindrical type.

Welded Vessels	ASME certified and stamped to ASME Boiler And Pressure Vessel Code, Section III, Class A and Code Case 1358
Integrally Forged Vessels	ASME certified and stamped to ASME Boiler And Pressure Vessel Code, Section VIII, Unfired Pressure Vessels for Code Case 1205 only
Design Working Pressure	Conforming to purchase order and/or drawing
Total Design Volume	As requested in purchase order and/or drawing
Envelope Area	As requested in purchase order and/or drawing
Design Temperature	10°F to 140°F
Corrosion Allowance (without stainless steel liner)	0.0625 inch, shell and heads
Seismic	Conforming to purchase order and/or drawing
Welding Efficiency	100%

1.5 MATERIALS

ASME Boiler And Pressure Vessel Code, Section III, Materials, Article 3.
ASTM A508-64 Class 4.
ASTM A543 Class 1.
ASTM A372 Class I to V inclusive.
ASTM A240 Type 310S

Manways shall be provided in all welded vessels to provide access for periodic inspections. Seamless vessels shall have an inspection opening of two-inch pipe size or larger.

For welded vessels to be used for gaseous hydrogen storage, the vessel design will conform to the following limits:

Operating Design Pressure

Up to 5000 psi	No liner required
Above 5000 psi	Stainless steel liner required, ASTM-A240 Type 310S (Refer to Appendix)
10,000 psi	Maximum pressure allowable

For seamless vessels to be used for gaseous H₂ storage at 10,000 psi or less, no liner is required provided the ultimate tensile strength for design stress allowance does not exceed 105,000 psi and material after heat treatment does not exceed 125,000 psi UTS.

All pressure plates shall be cross rolled so that the amount of reduction is the same in both directions to maximum degree practical. The amount of cross-rolling shall be submitted for approval.

1.5.1 STUDS AND NUTS FOR FLANGES AND MANHOLE COVERS

The studs and nuts shall conform to ASTM A320 Grade L-7; nuts shall be hexagon American Standard heavy. Threads shall be lubricated before assembly with an approved lubricant.

1.5.2 WELD-METAL AND HEAT-AFFECTED TESTS

Tension tests, impact tests, and bend tests shall be conducted on a full-thickness test plate. The restrictions or conditions that apply to the base metal shall be utilized in testing the weld metal and heat-affected zones. The test samples will be taken from both the heat-affected and weld-metal zones; two tension tests, three impact tests, and one bend test will be taken from the two areas. Two full-thickness test plates are required per material combination, per weld test procedure, per filler material heat, per vessel. Excluded are nozzle welds that are less than six inches in diameter or any attachment welds. One of the required test plates shall be welded and tested prior to the welding of the vessel, and the second test plate shall be welded and tested after approximately 50% of the welding of the vessel is completed. A procedure for testing the weld-metal and heat-affected zones shall be submitted for approval. The test properties of the weld-metal and heat-affected zones shall meet the following minimum values:

- (a) For tension and bend tests the values shall be as specified for the base material.
- (b) For impact tests the values shall be at least 50% of the base metal requirement at -50° F. For information only impact tests shall be run at room temperature and the data reported.

1.5.3 BEARING PLATES, LEVELING PLATES, AND ANCHOR BOLTS

Each horizontal vessel exceeding ten feet in length shall be furnished with a Lubrite (Lubrite Division, Merriman Bros., Inc., Boston, Mass.), or equal, expansion bearing plate attached to the support saddle which is nearest the manhole end. The expansion bearing plate shall be fabricated from 3/8 inch thick rolled bronze, conforming to ASTM B100 Type A and shall contain trepanned inserts. In addition, the Contractor shall furnish all required foundation leveling plates and foundation bolts.

1.6 DRAWINGS AND REPORTS

1.6.1 DRAWINGS

The drawings for the storage system form a part of this specification and show the unit capacity, space envelope, location, and terminal piping connection points for the various gaseous systems. The vessel contractor shall provide piping to the connecting point and may furnish one or more vessels manifolded together to provide the required gaseous storage volume.

Vessels shall be contained within the dimensioned space envelope and be suitable for either horizontal or vertical installation. Nothing shown on such drawings shall relieve seller from his responsibility to furnish vessels meeting requirements of applicable codes. Conflicts between the drawings and applicable codes shall be brought to the Contracting Officer's attention.

1.6.2 SHOP AND ASSEMBLY DRAWINGS

Within thirty days after date of notice to proceed and before proceeding with any fabrication, the Contractor shall submit to the Contracting Officer, for approval, checked prints of shop assembly and detail drawings. Unchecked drawings will be stamped "Disapproved" and returned to the Contractor without further checking by the Contracting Officer. Shop drawings shall show the size and location of all circumferential and longitudinal welded seams, size of welds and joint symbols in accordance with MIL-STD-22, AWS A2.0, A2.2 and A3.0 for each joint. Shop drawings shall show the finish dimensions, location and details of nozzles, liner details, if required, internal supports, appurtenances, and loading and foundation design requirements. The Contractor shall furnish design computations covering all parts of the vessels. Details of design, not fully shown on the Contracting Officer's drawing, shall be developed by the Contractor and shown on the shop drawings. Approval of drawings will not relieve the Contractor from any responsibility under codes, drawings, or specifications. After final approval of drawings, the Contractor shall furnish certified prints in quantities listed herein and one certified reproducible transparency to the Contracting Officer for inspection and record purposes.

1.6.3 REPORTS

The Contractor shall furnish quantities listed herein and one certified reproducible of the following listed items. Certified mill test data reports shall show location, heat numbers, chemical analysis, physical and mechanical properties and melting records of shell and head materials and other pressure parts used in fabrication of the vessel. Records of all plates shall be available upon request for the melting records of heats, the processing histories, identification to location in vessels and records of test samples from locations in plates and/or test material.

TABLE OF REPORTS AND DRAWINGS REQUIRED
AS A PORTION OF THE WORK

	<u>For Approval</u>	<u>Certified</u>	<u>With Bid</u>
Material Specifications	6	3*	3
Inspection Plan	3		
Welding Procedures	3	3*	
Vessel Outline Drawings Showing Supports, Nozzles And Anchor Bolt Locations	6	10	3

*Reproducible transparency not required for this item.

TABLE OF REPORTS AND DRAWINGS REQUIRED
AS A PORTION OF THE WORK (CONTINUED)

	<u>For Approval</u>	<u>Certified</u>	<u>With Bid</u>
System Storage Plot Plan Showing Vessel Arrangement	3	3	3
Detail Shop And Assembly Drawings	10	10	
Design Computations	3	3*	
Charpy Impact Test Data		3	
Mill Test Data Reports		3*	
Description of Quality Control System			3*
Hydrostatic Test		3	
Cleaning Procedures	3	3*	
Code Acceptance (Form No. 1 or U-1)		3*	
Ultrasonic Inspection	3	3*	
Radiographic Testing	3	3*	
Magnetic Particle And Penetrant Inspection	3	3*	
Tensile Test		3*	
Manufacturing Data Report		3	
"As Built" Dimensions		10	
Certification of Welding Operators		3*	
Chemistry Records		3*	
Bend Test		3*	
Deviations		3*	

* Reproducible transparency not required for this item.

1.7 FLANGED NOZZLES, MANWAYS, AND SUPPORTS

Each vessel shall be complete with manways or inspection openings, closures, and supports as required as shown on the drawings. One set of extra gaskets shall be provided with each vessel. Flanges shall be of materials compatible with the vessel material selected. A nozzle should be located in the pressure vessel for in-place cleaning.

1.8 FABRICATION

Fabrication shall be in accordance with the standards and practice of the applicable ASME Boiler And Pressure Vessel Code.

1.8.1 CERTIFICATE OF AUTHORIZATION

Certificate of authorization from the ASME, in force at time of quotation, shall be in the possession of the shop fabricating vessels to these specifications.

1.8.2 MACHINERY AND EQUIPMENT

Machinery and equipment used to fabricate vessels under these specifications shall be capable of performing any and all operations in accordance with the best modern practices for the class of work to be performed. The Contracting Officer reserves the right to determine the adequacy of the Contractor's facilities by plant inspection or other means. No fabrication work shall be subcontracted to other shops without prior written approval of the Contracting Officer.

1.8.3 FABRICATION PROCEDURES AND RESPONSIBILITY

As soon as practicable after receipt of notice to proceed and prior to start of work, the Contractor shall submit to the Contracting Officer for approval all items as indicated in Paragraph 1.6.3 of this specification. The Contractor shall assume full responsibility for the vessels and shall complete the vessels in accordance with this specification, the pertinent drawing and all applicable code requirements without unnecessary delay and in a manner acceptable as being best trade practice.

1.8.4 WELDING

Where stress due to internal pressure is a factor, the weld joint design and location shall be such as to assure it can be satisfactorily welded to provide for full penetration and complete radiography. This includes welded joints connecting nozzles to shells, heads or flanges.

1.8.5 WELD REPAIR

Where a given area has not been satisfactorily repaired after two repair attempts, the Contracting Officer shall be notified prior to attempting

a third repair. Where radiography is a requirement, the first repair film of a given area shall be designated R1, the second repair R2, etc.

1.8.6 HEAT TREATMENT

The heat treatment shall conform to required ASTM designations for the specified material, except that stress relief temperature shall not be below 1100°F when stress relief is a requirement of the ASME Code. All mechanical properties of the material required shall be obtained in the final heat-treated condition. All necessary weld repairs shall be stress-relieved by the same manner as the original stress-relieving procedure.

1.8.7 GRAIN SIZE

Fine grain melting practice shall be used and shall meet the quality requirements of the material specification.

1.8.8 CHEMISTRY

Complete chemical compositions of all heats shall be obtained and recorded.

1.9 QUALITY ASSURANCE PROGRAM PLAN

The Contractor shall provide and maintain a program plan that shall comply with the intent of NASA NPC-200-3, Military Specification MIL-Q-9858 or MIL-I-45208. A quality control manual or similar document shall contain as minimum requirements the systems utilized for control of:

- a. Preparation and submittal of an inspection plan
- b. Qualification of special processes and certification of applicable personnel.
- c. Drawing/specification releases and changes
- d. Supplier selection and quality level
- e. Material acceptance
- f. Inspection measuring and test equipment
- g. Control and disposition of nonconforming articles
- h. Documentation

The inspection plan required in (a) above shall be submitted to the Contracting Officer with the shop drawings. This plan shall show the major fabrication steps, i.e., forming, welding, stress relieving and corresponding inspection points, i.e., material release, nondestructive tests, dimensional checks, hydrostatic tests, leak tests, shop acceptance tests, field assembly, and final acceptance tests. During the life of the contract, any changes made to the quality program plan or inspection plan shall be transmitted to the Contracting Officer prior to implementation.

1.10 MECHANICAL AND CHEMICAL TESTING

All materials of construction shall be tested for mechanical and chemical properties. Test procedures shall be in accordance with applicable ASME and ASTM standards. All results shall meet the specifications to which the materials are to conform.

1.11 NONDESTRUCTIVE TESTING

Nondestructive testing shall be performed, for the main part, during the normal fabrication sequence; exceptions (a) materials shall be tested in their final heat treated condition, and (b) pressure welds shall be radiographed after hydrostatic test. The contractor shall perform all nondestructive tests required by the applicable code sections, with the following additional requirements:

1.11.1 Ultrasonic testing in lieu of the nondestructive examinations called out in paragraph N-321.1 of the ASME Code, all pressure containing material and material one and one-half inches and over in thickness used for critical load bearing parts shall be ultrasonically tested in accordance with MIL-STD-271. A 5% notch may be used in lieu of the 3% notch required by MIL-STD-271. The acceptance standards of the ASME Code, Section III for Class A vessels shall be used for laminar defects. The specific procedure shall be submitted for approval prior to implementation. Repair methods as specified in the applicable ASME Code still apply.

1.11.2 RADIOGRAPHIC TESTING

Radiographs shall represent not more than one and one-quarter (1.25X) times the finished thickness. The image quality indicator (penetrameter) must represent the finished thickness of the strength member adjacent to weld joint. The film emulsion must be fine grain or extra fine grain. The double film technique shall be used. The H-D density through areas of interest of the lightest film shall be 1.5 minimum. A technique sketch and radiographer's report must accompany the film package. Calcium tungstate screens are not permitted. The radiographic negatives shall be submitted with the report for the approval of the Contracting Officer's representative. Unacceptable welds shall be repaired and reradiographed in accordance with the requirements of the ASME Code and to the satisfaction of the Contracting Officer. Upon approval, the negatives shall be returned to and filed by the manufacturer as required by the ASME Code. During the five-year storage period of negatives, the files shall be accessible to representatives of the government as may be required for reference. All pressure welds of the vessel shall be represented by a complete set of x-rays depicting the weld joints in the final heat treat condition and after the hydrostatic testing and prior to cleaning. All other radiography as found necessary to insure quality shall be performed by the fabricator for his own convenience and process control. Acceptance by radiography shall be based on the x-rays following hydrostatic testing.

1.11.3 PENETRANT OR MAGNETIC PARTICLE TESTING

Weld preparation surfaces and back chipped surfaces shall be subjected to magnetic particle examination for magnetic material and liquid penetrant examination for non-magnetic material.

1.11.4 ULTRASONIC TESTING OF INTEGRALLY FORGED VESSELS

Each vessel shall be ultrasonically inspected with MIL-STD-271, essentially following the requirements of paragraph 7.5.3, except that testing need only be accomplished for radial defects and the beam shall be directed circumferentially in the clockwise and counterclockwise directions. The specific procedure shall be submitted for approval prior to implementation.

1.12 HYDROSTATIC TEST

The vessel shall be hydrostatically tested in accordance with the applicable ASME Code. Hydrostatic testing shall be performed prior to cleaning.

1.13 MECHANICAL TEST REQUIREMENTS

1.13.1 IMPACT TESTS

All material for welded vessels shall meet the requirements and sampling plan of N-330, Section III of the ASME Code, except for ASTM A508-64 Class 4 and ASTM A543 Class I which shall meet the requirements of 30 ft.-lbs. at -120°F. The material for unwelded vessels shall meet the impact requirements of SA-300, Class I and sampling plan per A372 substituting in this case the three (3) impact specimens for each required tension specimen.

Unless otherwise agreed upon, the tests on all material shall be conducted at a temperature at least as low as -50°F. All material shall be tested in the final condition of the vessel (including forming and stress relief).

1.13.2 TENSILE AND BEND TEST

Tensile and bend tests shall meet the requirements of ASTM Designation E8 and A20, except that the yield point of material will be determined by 0.2% offset method only. Two tensile samples shall be taken in the longitudinal orientation and at quarter thickness locations. One transverse bend test shall be made on samples taken from the top of each unit plate. All material shall be tested in the final condition of vessels (including stress relief). Data reported shall include ultimate tensile strength, yield strength, and per cent elongation (in two inches). Two tensile specimens shall be taken from the top of each unit plate which makes up the vessel or from the test rings as required for A372.

1.14 INTERNAL CLEANING

The internal surfaces of each vessel shall be cleaned until the permissible contamination limits are complied with, dried and protected. The cleaning procedures shall be submitted for approval. The Contractor shall employ whatever cleaning procedures are necessary to comply with the permissible contamination limits. Inspection and tests shall be witnessed by the Contracting Officer's representative.

1.14.1 PERMISSIBLE CONTAMINATION LIMITS

Permissible contamination limits for the vessels shall not exceed the following:

- a. Hydrocarbon - none as evidenced by 1.14.5 Inspection Numbers 1, 2, 3 and 4.
- b. Total solids and fibrous particles not exceeding 10 ppm by weight of sample.
- c. No particles greater than 500 micron size.
- d. No fibers greater in size than 200 micron diameter by 2000 micron length.

1.14.2 DEFINITIONS

(1) Demineralized Water. Demineralized water is defined for use in these specifications as water having a total maximum of 20 ppm by weight suspended and dissolved impurities. The water shall be filtered through a 10-micron rated filter (40-micron absolute rating).

(2) Clean Water. Clean water is defined for use in these specifications as color-free water containing no visible suspended particles or hydrocarbons.

(3) Dry Air. Dry air is defined for use in these specifications as oil-free air which has been processed through a dehydrator so that its dew point is minus 63.5°F at one atmosphere or 26.3 ppm water vapor or less by volume.

(4) Nitrogen. Nitrogen shall mean nitrogen in accordance with MIL-P-27401 and which has been filtered through a 40 micron absolute rated filter with an element constructed of stainless steel dutch twill weave. The filter shall have been cleaned to insure that it does not contaminate the system with which used, in excess of the filter rating.

(5) Hydrocarbon. A hydrocarbon is any combustible compound containing carbon and hydrogen or oxygen or any combination of these.

(6) Solid Particle. A solid particle is defined as any solid material which cannot be classified as a fiber. The size of a solid particle shall be determined by its longest dimension.

(7) Fiber. A fiber is defined as a threadlike structure and may be composed of any material.

(8) Nominal Rated Filters. The nominal rating of a filter describes the efficiency of a filter and specifies the removal of 98% by weight of all particles whose two smallest dimensions are greater than the pore size or openings in the filter media. Filters made by powder metallurgy processes shall not be used.

1.14.3 RUSTPROOFING OF VESSELS WITHOUT A STAINLESS STEEL LINER

Within five minutes after completion of the final rinse, the following rustproofing procedures shall be initiated:

(1) Flush with sodium hydroxide solution, 1/4 to 1/2 per cent, until slightly alkaline.

(2) Rinse with demineralized water, using a pressure spray nozzle.

(3) Surface treat for one hour in a filtered (10 micron nominal rated filter) solution of the following percentages at a temperature range of 140-160°F:

Monosodium Phosphate	1/2%
Disodium Phosphate	1/2%
Sodium Nitrite	1/2%
Demineralized Water	99 %

1.14.4 DRYING

The vessels shall be dried by heating them in an oven at 140°F to 250°F for no less than one hour or by vacuum evacuation. If evacuation is used, the vessel shall be considered dry when the vacuum is maintained at 0.5 inch of mercury for a minimum of five minutes. The dry gas used for purging and drying shall be filtered through a ten-micron nominal rated filter.

1.14.5 INSPECTION

Each vessel shall be inspected, shall comply with the permissible contamination limits with results of such inspections witnessed and certified to by a certified laboratory test approved by the Contracting Officer. Such inspections shall be conducted in the order listed below. Any vessel which is rejected by any one of these inspection procedures shall be recleaned or reworked to the extent necessary to meet the requirements.

(1) Inspection No. 1 - Final Rinse. During the final rinse and prior to the drying operation, a one-liter sample of the effluent shall be examined by the Millipore method, or equivalent, method. For this purpose, the rinse shall be performed using a pressure spray nozzle on all interior surfaces of the vessel to insure dislodgment of particles. Effluents which contain any contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

(2) Inspection No. 2 - Visual. All vessels shall be examined for evidence of corrosion products, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals or other contamination or foreign matter. The use of special devices such as inspection mirrors or borescopes to visually examine inaccessible areas of vessels is required. Any evidence of contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

(3) Inspection No. 3 - Wipe Test. The wipe test shall be made on all interior surfaces of the vessels which can be reached by using a clean filter paper (Whatman #2, S, S-602) or other approved wiping material. This test shall consist of at least two movements of the filter paper along one-foot lengths, but area covered may be reduced as necessary where small lines and parts are involved. Any evidence of contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

(4) Inspection No. 4 - Ultraviolet Light (Black Light). Visual inspection with the aid of an ultraviolet light source shall be accomplished on all accessible surfaces to determine the presence of petroleum-type hydrocarbons. Contractor's personnel using the ultraviolet light shall be qualified in its use. Any evidence of contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection. The ultraviolet light source used for this inspection and light intensity meter shall conform to the following:

(a) Light source shall be 100-watt spot mercury arc bulb 2500 to 3700 Angstrom units.

(b) Transformer shall be approved by Underwriters' Laboratories for portable equipment and shall meet the recommendations of the bulb manufacturer.

(c) Filter shall be approximately five inches diameter, convex and round.

(d) Bulb shall be replaced when intensity of ultraviolet light through filter is less than 550 microwatts per square centimeter when measured 24 inches from the outside surface of the filter or after 500 hours of use, whichever occurs first.

1.15 INSPECTION ACCESS

Representatives of the Contracting Officer shall have access to the Contractor's plants at any reasonable time for purpose of inspection of work and materials. The Contractor shall notify the Contracting Officer at least ten days in advance of checkout of each complete vessel in order that the Contracting Officer or his duly authorized representative may be present to witness such checkout.

1.16 PRESSURIZING AND CLOSING VESSEL

1.16.1 SEALS

The vessels shall be sealed immediately after it has been determined that the vessels are clean in accordance with the cleaning inspections. Seals shall be tight enough to prevent contamination and shall be protected so that they will not be broken or warped during shipment. Tape for sealing procedures shall not leave any residue on connections, when removed.

1.16.2 FLANGED OPENINGS

Flanged openings shall be sealed with a suitable full face blank teflon 1/8 inch thick gasket or polyethylene disk at least 1/16 inch thick and a bolted blank flange of aluminum or corrosion-resisting steel at least 1/4 inch thick. Corrosion-resisting steel bolts shall be used in contact with corrosion-resisting steels. Cadmium-plated bolts may be used in contact with aluminum but shall not be used in contact with corrosion-resisting steels. There shall be a bolt in each bolt hole. Locknuts shall be torqued to avoid warping of the flanges and to insure an air-tight seal. Gaskets and flanges shall be cleaned as required by this specification.

1.16.3 THREADED OPENINGS

Threaded openings shall be sealed with caps or plugs made of corrosion-resisting steel.

1.16.4 PRESSURIZING

The vessels shall be pressurized to not less than five or more than twenty-five psig with nitrogen immediately following the cleaning inspections and sealing of the vessels. The vessels shall be maintained at not less than five psig, compensating for temperature variations, during storage at the plant or at the site, shipment, installation and prior to field testing. All vessels shall be equipped with a shut-off valve and a zero to twenty-five psig gage for pressurizing. A protective metal cover shall be provided around the gage and valving. Complete loss of pressure shall be cause for reinspection and recleaning by and at the expense of the Contractor.

1.16.5 RIGHT RESERVED

The right is reserved to correct any defects in material or workmanship charging all expense in connection therewith to the account of the Contractor, provided, however, that the Contractor has been notified of such defects and has been afforded an opportunity of making the necessary repairs without delay.

1.16.6 SURFACES OF WELDS

The surfaces of all welds shall be ground or otherwise finished so that the weld contour shall blend smoothly with the adjacent base metal to prevent notches and stress-risers. In addition, the weld surfaces shall be of such quality to permit satisfactory interpretation of the inspection methods.

1.16.7 NICKS, GOUGES AND SCRATCHES

Nicks, gouges, arc strikes, and deep scratches shall be removed from the inside and outside surfaces of each vessel and blended in smoothly with the adjoining unaffected base metal. When performing such blending operations, care shall be exercised to prevent reducing of the vessel wall beyond the minimum specified by design.

1.17 CAPACITY

At the time the hydrostatic tests are being made, the water volume of the vessel shall be measured on a volumetric basis and its water volume recorded to the nearest one cubic foot. Total volume shall include the volume of each opening up to the blind flange, plug, or other closure as provided under Paragraph "FLANGED NOZZLES, MANWAYS AND SUPPORTS," of this specification. The quantity in cubic feet shall be placed on the vessel nameplate.

1.18 PAINTING

1.18.1 EXTERIOR SURFACES

The exterior surfaces of all vessels, including supports but excluding stainless steel surfaces, shall be cleaned and painted in the shop, and abraded or corroded spots shall be wire brushed and touched up with the same material as the paint coat.

1.18.2 CLEANING AND PREPARATION OF SURFACES

Exterior surfaces shall be clean before applying paint. All oil, grease, dirt, loose rust, loose mill scale, and other foreign substances shall be removed. The removal of oil and grease shall be accomplished before

mechanical cleaning is started, using mineral spirits or other paraffin-free solvents having a flash point higher than 100°F. Clean cloths and clean fluids shall be used to avoid leaving a film of greasy residue. Mechanical cleaning shall be accomplished by means of emulsions, steam, flame-cleaning, high speed power wire-brushing, blast-cleaning or other approved methods. The use of chipping tools that produce cuts, burrs, and other forms of excessive roughness will not be permitted. Tight mill scale that cannot be removed by applying a sharp knife to any edge and minor amounts of residual rust not removable except by thorough blast cleaning will be permitted.

1.18.3 PAINTING OF SURFACES

A primer coat of zinc chromate paint conforming to Federal Specification TT-P-645 shall be applied to the exterior surfaces of the vessel before applying supplementary coats.

1.19 PREPARATION FOR DELIVERY

In addition to sealing and pressurizing the vessels, the vessels shall be prepared as follows:

1.19.1 PACKING

Packing shall meet Consolidated Freight Classification rules or the regulations of other common carriers as applicable to the mode of transportation.

1.19.2 PHYSICAL PROTECTION

Adequate measures shall be taken to insure no damage to the vessels during shipment. Cushioning, blocking, bracing, and bolting shall be such as to insure safe delivery of the vessels. The vessels shall be protected to withstand an acceleration force of 3g in any direction during transportation. Temporary supports, blocking and bracing or isolation mounts may be used to meet this requirement and shall be clearly marked for removal during installation. No welding is permitted on the pressure parts.

1.20 NAMEPLATE

Each vessel shall be permanently identified on the spherical portion of the head with an appropriate nameplate affixed to welded brackets and bearing the following information:

Capacity, cubic feet (water volume)
Maximum allowable working pressure, PSI
Item number
Weight
Shell thickness, in.
Head thickness, in.

Corrosion allowance, in
Hydrotest pressure, PSI
Date of hydrotest (month and year)
Material

1.21 ACCEPTANCE

Final acceptance of the work performed under this contract will be accomplished after the vessels have been delivered in satisfactory condition at the site, and written certificates of completion and compliance as required in the specifications have been furnished by the Contractor to the Contracting Officer.

APPENDIX

Minimum Requirements And Instructions For Use Of A Stainless Steel Liner

- a. All surfaces exposed to high pressure gaseous hydrogen shall be ASTM A-240 type 310S (Austenitic stainless steel).
- b. When a stainless steel liner is used, the corrosion allowance requirement is waived.
- c. The austenitic stainless steel cannot be integrally bonded to any pressure containing low alloy steel. This requirement eliminates clad plate or weld overlay or any bonded process.
- d. The stainless steel liner to low alloy interface surfaces shall be grooved or periodically separated by some means to assure escape of the diffused gaseous hydrogen to radial vent holes. Sufficient separation and vent holes shall be installed to preclude the buildup of a positive gage pressure.
- e. The ASTM-A240 type 310S liner shall not be less than 3/8 inch thick and be designed to withstand loads to which it will be subjected.
- f. The stainless steel liner shall not be considered as a pressure containing member in the design of the pressure vessel.
- g. The use of a stainless steel liner shall not alter any of the specification requirements for the low alloy pressure vessel except:
 1. Magnetic particle inspection of weld O.D. surfaces after hydrostatic test is substituted for radiography.
 2. Magnetic particle inspection of O.D. and I.D. weld surfaces and weld radiographic inspection is required after stress relief.
- h. The stainless steel liner weld joints shall be subjected as a minimum to the following nondestructive tests:
 1. Liquid penetrant tests of weld preparations, back chipped surfaces and weld OD and ID surfaces. The weld ID shall be liquid penetrant tested after hydrostatic testing.
 2. Radiography, with the penetrameter based on the liner thickness, prior to insertion of the liner in the low alloy pressure vessel.
- i. The completed vessel shall be hydrostatically tested in accordance with Section III, Class A vessels of the ASME Code. Test pressure shall be held for a period of not less than one hour with the pressure source blanked off. Leakage is unacceptable. Specific attention shall be directed to examination of the radial vent holes, seals and liner/low alloy interfaces for evidence of leakage.