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TECHNICAL SPECIFICATION

Doc No: DSF-SPC-MEC-004

Rev. 1

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

HEAT EXCHANGERS (MR STATIONS)

JUNE 2021

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REVISION HISTORICAL SHEET

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1. SCOPE AND OBJECTIVES

This Job Specification, together with the individual Material Requisition, specifies the requirements for design, materials, fabrication and testing of the shell and tubes used in heat exchangers in the NGT system with sweet natural gas and sporadic passage of water and glycol.

The application is heating of gas to compensate for temperature losses in the gas stream.


The intent of this Job Specification is to supplement, amend or limit the reference Standards mentioned below. Additional information may be given in the Data Sheets and Bill of Quantities and these documents should be read in conjunction with this material specification.

In case of conflict between individual Material Requisition and Owner's Job Specifications, Vendor has to bring this to Owner's attention for clarification before proceeding.

Vendor shall be responsible to mechanically design heat exchangers and their components in accordance with the requirements of applicable documents. In no event, however, thickness can be less than those shown on Owner's heat exchanger Material Requisition unless specific written approval to the contrary from the Owner.

All heat exchangers shall be designed, fabricated and tested in accordance with the here below legislation, Standards and Owner's Job Specifications:

- EU Directive 2014/68/EU
- ELOT EN 13445
- Owner's Job Specifications:
 - Job Spec. No. DSF-SPC-PIP-001
 - Job Spec. No. DSF-SPC-MEC-006
 - Job Spec. No. . DSF-SPC-QAC-005
 - Job Spec. No. . DSF-SPC-QAC-005
 - Job Spec. No. DSF-SPC-QAC-002
 - Job Spec. No. DSF-SPC-MEC-005

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- TEMA – Standards of the Tubular Exchanger Manufacturers Association – Class "R"

2. REFERENCES

2.1 REFERENCE DRAWINGS

- Std Drawing No. STD-3-21-101
- Std Drawing No. STD-3-21 -102

In all cases, the finally accepted applicable legislation, standards and specifications shall be the revision last published at the date of order placement.

Note: Only, if justified by the thermal design the selected heat exchanger may be of a non-standard type. In this case the item shall any way conform to the design manufacture, testing and inspection of equipment under pressure.

2.2 REFERENCE DDOCUMENTS

- Job Spec. No. DSF-SPC-PIP-001

[Welding requirements for equipment and piping]

- Job Spec. No. DSF-SPC-MEC-006

[Thermal and acoustic insulation]

- Job Spec. No. DSF-SPC-MEC-005

[External Painting]

- Job Spec. No. DSF-SPC-QAC-002


[Material color coding]

- Job Spec. No. DSF-SPC-QAC-005

[Shop Inspection of equipment and materials for NGT project]

- Job Spec. No DSF-SPC-QAC-006

[Inspection and Test Instruction]


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2.3 REFERENCE CODES AND STANDARDS

- EU Directive 2014/68/EU PED
- EN 1092-1 (harmonised with EU Directive ~~97/23/EC~~ PED 2014/68/EU PED) [Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated – Part1: steel flanges]
- EN 1514 [Flanges and their joints - Dimensions of gaskets for PN -designated flanges]
- EN 12560 [Flanges and their joints - Gaskets for class-designated flanges]
- EN 13445-1 (harmonised with EU Directive 2014/68/EU PED) [Unfired pressure vessels – Part 1: General]
- EN 13445-2 (harmonised with EU Directive 2014/68/EU PED) [Unfired pressure vessels – Part 2: Materials]
- EN 13445-3 (harmonised with EU Directive 2014/68/EU PED) [Unfired pressure vessels – Part 3: Design]
- EN 13445-4 (harmonised with EU Directive 2014/68/EU PED) [Unfired pressure vessels – Part 4: Fabrication]
- EN 13445-5 (harmonised with EU Directive 2014/68/EU PED) [Unfired pressure vessels – Part 5: Inspection and Testing]
- EN ISO 8501-1 [Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings]
- TEMA – Standards of the Tubular Exchanger Manufacturers Association – Class "R"

3. ACRONYMS

NGT: Natural Gas Transmission

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DN: Nominal Diameter

OD: Outside Diameter

ID: Internal Diameter

BWG:

PN: Nominal Pressure

4. DESIGN BASIS

4.1 THERMAL DESIGN

Heat exchangers shall be of the type BEU TEMA "R" and according to EN 13445-3.

Heat exchangers to TEMA classification shall be a vertical (preferably) unit with both the gas inlet and outlet flanges on the same centerline.

The preferred tube length for shell and tube exchangers is 1220/2440/3660/4880 mm.

The maximum bundle diameter shall be limited to 1.500 mm. The bundle weight shall be 15.000 Kg as maximum.

The fouling factors shall be as a minimum as shown on Material Requisition/Process Data Sheet.

The preferred tube pitch shall be:

Shell side - Clean Service

(fouling < 0.0004 metr.) DN 32- Triangular

(fouling > 0.0004 metr.) DN 32 Square - Dirty Service

Preferred tube size shall be as follows:

a. Carbon Steel and Low Alloy

OD (min) 21,3 mm

BWG (min.) 12

b. High alloy (including non-ferrous alloy)

OD (min) 21,3 mm

BWG (min.) 14

Tubes with DN 20 may be acceptable upon Owner's approval.



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4.2 DIFFERENTIAL PRESSURE

The design of exchanger internal pressure parts for a differential pressure less than the shell and/or tube design pressure shall not be allowed unless specifically shown on the Material Requisition. When such a differential pressure design is permitted, a special nameplate or warning tag shall be attached to the exchanger to make this condition known.

4.3 CORROSION ALLOWANCE

Corrosion allowances shall be as shown on the Material Requisition.

No corrosion allowance shall be added to tubes or non-ferrous, stainless steel, or other high alloy parts unless indicated in the Material Requisition. For clad parts, no corrosion allowance shall be required on the base metal under the cladding.

The total cladding thickness shall be considered as the corrosion allowance.

The cladding thickness shall not be considered as part of the wall thickness for pressure calculations

4.4 STACKED SHELLS

On stacked multiple shell units, means shall be provided to accommodate the full load from the shells above to prevent distortion which might cause binding of the tube bundle.

Unless specified to the contrary, the Vendor shall assume all multiple shell units are stacked two shells high. Differential thermal expansion between shells shall be considered.

Interconnecting nozzle flanges should be bolted together with gaskets in position before final welding.

Raised faces flanges finish must be used for interconnecting nozzles, if not otherwise specified in Material Requisition.

Vendor shall provide all necessary stacking material including bolting, gaskets and shims.



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Each bottom mounted shell shall be provided with at least two additional steel supports to enable mounting one shell upon the other.

4.5 TUBE BUNDLE

Carbon steel tubes shall be of seamless construction. For other materials, both welded and seamless tubes are acceptable.

U-tubes shall be of one-piece construction. Heat treatment of U-bends shall be as follows:

- a. Carbon steel U-bends shall be stress relieved after bending when specified on individual Material Requisition.
- b. Low-alloy U-bends shall be always stress relieved after bending.
- c. Austenitic stainless-steel U-bends shall be solution annealed after bending when specified on individual Material Requisition.
- d. The heat-treated portion of the U-bends shall extent at least 300 mm, beyond the point of tangency on each leg.

When tube to tubesheet seal welds are specified on the Material Requisition, they shall be in accordance with ELOT EN 13445-3 with the exception that the length of plain fillet weld should not exceed the tube thickness.

When strength welds are specified, they shall be in accordance with ELOT EN 13445-3 for tubes having a thickness of (2.1 mm) or greater.

Special care shall be taken for strength welding of tubes with a thickness lower than (2.1 mm), to minimize the risk of melting through the tubes.

Suitable sliding bars shall be provided to facilitate bundle extraction when bundle weight exceeds 10 tons up to 15 tons.

Suitable rollers shall be provided when bundle weight exceeds 15 tons.

Impingement plates when required by TEMA Std shall be supported by at least two tie rods or the equivalent.



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All tubesheet holes for expanded joints shall be machined with at least two grooves.

4.6 GASKETED JOINTS

A minimum clearance shall be provided between flange faces on full face tubesheet joints. This clearance shall be obtained by providing 8 mm male steps and 5 mm female recesses.

When this clearance is not specified on Material Requisition, two DN 20 diameter jackscrews shall be provided to facilitate the breaking of all gasketed joints.

All fabricated flanges shall conform to the requirements of EN 13445 regardless of whether the flange is hubbed or not.

4.7 GASKETS AND FLANGE FACINGS

All flanged nozzle shall have gasket face finish in accordance with EN 13445, EN 1092-1, EN 1514 series and EN 12560 as the following table, unless otherwise specified on the Material Requisition:

FLANGE FACE	GASKET TYPE	FACE FINISH
Raised & full face	1.5 mm soft ring	"Stock"
Raised face	Spiral wound	Smooth ($>3,6\mu\text{m Ra}$)
Ring Joint	Oval ring	Very smooth ($<1,6\mu\text{m Ra}$)
Raised face	Metal jacketed	Very smooth ($<1,6\mu\text{m Ra}$)

No gasket shall contain asbestos fibers in any form.

Fibers used for soft ring or as filler material for metal jacketed and spiral wound gaskets shall be suitable to withstand the specified design temperature.

Girth flanges should have metal jacketed, solid metal or spiral wound gaskets.

Face finish and asbestos-free fibers shall comply with the requirements of the previous paragraph.



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The use of soft ring gaskets on girth flanges is prohibited except for cooling water streams.

Gasket coating other than graphite, oil or grease is prohibited and shall not be used under any circumstances.

The Vendor shall furnish the gaskets for intermediate flanges between multiple shells, direct-connected exchangers.

4.8 NOZZLES AND CONNECTIONS

4.8.1 PRESSURE GAGE CONNECTIONS

All process nozzles with DN 40 and larger shall be provided with one horizontal coupling of DN 15, PN 420 bar (maximum cold working pressure), threaded, complete of plug, for a pressure gage.

4.8.2 THERMOMETER CONNECTIONS

All process nozzles with DN 100 and larger shall be provided with one horizontal coupling of DN 25, PN 420 bar (maximum cold working pressure), threaded, complete of plug, for a temperature gage.

4.8.3 CHEMICAL CLEANING CONNECTIONS

If chemical cleaning is required Vendor shall provide on all process nozzles DN 100 and larger chemical cleaning connections, installed horizontally.

The chemical cleaning connections shall be DN 50, PN 100 weld-neck flange complete of blind, gasket and bolting (unless otherwise specified on individual Material Requisition).

4.8.4 VENT AND DRAIN CONNECTIONS

All high and low points on shell and tube sides not otherwise vented or drained shall be provided with coupling of DN 20 threaded complete of plug.



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All connections with DN 40 and larger shall be flanged. Dimensions shall be in accordance with EN 13445.

Flanged nozzles through DN 50 size inclusive shall be forged steel long welding necks.

Built-up nozzles may be accepted in special cases, if they are in accordance with the next paragraph.

Nozzles over DN 50 size may be built-up using forged steel welding neck flanges.

All connections and nozzles for temperature sensors, pressure reliefs, vents, drains etc. shall be located so that the connecting valves, instruments etc are easily accessible, but not located in a vertical position to allow condensate run-off. Alignment of connection nozzles shall be within a tolerance of 1/2 degree.

Nozzle lengths shall be long enough to permit the removal of a standard-length stud bolt from the back side of the flange to clear the exchanger body and insulation. If not specified, a minimum of 100 mm insulation shall be assumed, except on surfaces in contact with cooling water.

Do not use nozzles with DN 32, 65, 90 or 125 on exchangers.

4.9 ALLOY LININGS

The use of nozzles fabricated from integrally clad plate or alloy protected with deposited weld metal is preferred.

Nozzle with DN 50 and smaller may be fabricated using a loose sleeve type liner welded to the face end of the nozzles and to an expansion ring welded to the shell liner.

Rolled liners for nozzles are not permitted.

Details of loose sleeve type liners must be approved by the Owner.

Plug welded, spot welded or loose liners are not permitted except as described in para 4.7.



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Welded overlay shall be deposited in at least two passes, and the composition of the top 2.5 mm of the finished thicknesses shall be equal to or better than the specified metallurgy for cladding.

The minimum thickness of finished cladding shall be 3 mm. Other thicknesses specified by the Material Requisition shall govern.

4.10 TEMPERATURE CONTROL

For heat exchangers to EN 13445 classification the heating fluid temperature control shall be via a temperature controller sensing the gas temperature downstream of the pressure regulator valve.

The gas limit temperature shall be controlled by temperature controllers with input from temperature sensors placed in the heaters.

4.11 SHELL SUPPORTS

Each exchanger shall be provided with at least two steel supports with saddles for distributing the dead load.

Supports shall withstand a pulling force equal to the bundle weight unless otherwise specified.


The bolt holes in the saddle on one end of each exchanger shall be slotted to allow for expansion under the design temperature.

Vertical exchangers shall be supported by lugs welded to the shell in such a manner that the shell shall not be overstressed or distorted.

4.12 LIFTING LUGS

Suitable lifting lugs, rings or eyebolts shall be provided on the shell and the fixed tube sheet, in order to facilitate handling and bundle removal. Lifting lugs shall also be provided on removable channels.

Pulling lugs or tapped holes for insertion of eyebolts shall be provided on the outer face of tube sheets on removable bundles to permit removal from the shell.

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4.13 CHANNEL

Design of channel, bolting and pass partitions shall consider the stresses imposed by differential thermal expansion.

5. MATERIALS

The materials used for all pressure retaining parts shall cover the requirements of EN 13445-2. All materials for pressure retaining parts shall be accompanied by material certificates 3.1 or 3.2 in accordance with EN 10204 as required by Job specification DSF-SPC-QAC-005. Materials others than those specified in EN-13445-2 shall be used only after a particular material appraisal has been performed to verify that the requirements of EN 13445-2 are met. Materials used shall cover the requirements for prevention of brittle fracture (Annex B of EN 13445-2) including specific impact energy requirements.

Carbon content on heat analysis shall never exceed 0,22%.

Bolting for pressure parts shall be in accordance with EN 13445-2. Thermal expansion of flange material and bolting shall be considered in selecting adequate materials.


All clad plates, regardless of their thickness, and all plain plates having a thickness exceeding 50 mm shall pass ultrasonic examination as per EN 13445.

All clad products shall cover the requirements set by Annex D of EN 13445-2.

6. FABRICATION

6.1 HEADS AND SHELL

The entire length of the shell shall be checked for tube bundle clearance by means of a riding, accurately callipered template consisting of two baffle diameter discs 300 mm apart. All welds shall be ground smooth on the inside of the shell to facilitate removal of the bundle. The transverse baffle and support plate clearance between shell ID and baffle OD shall not exceed the values shown in EN 13445 for the various classes unless specifically waived by the Owner.

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When a difference in thickness exists between shell plates or plates and heads, the inside diameter shall be held.

6.2 POST WELD HEAT TREATMENT

Post weld heat treatment shall be given to various exchanger parts as specified in EN 13445.

The complete stress relieving procedure for welds joining austenitic steel to dissimilar materials and for clad or lined exchangers shall be submitted to Owner for approval.

6.3 REPAIRS

Owner shall be advised and consulted concerning all repairs.

Owner's Representative has the right to witness all repair work.

6.4 WELDING

Welding procedures, processes welders and welding equipment shall be qualified in accordance with the EN 13445 and Job Spec. No. DSF-SPC-PIP-001.

6.5 NON-PRESSURE ATTACHMENTS

The edges of all structural members in contact with pressure parts of the exchanger shall be completely seal welded to prevent atmospheric corrosion between the structural element and the shell of exchanger.

6.6 DIMENSIONAL TOLERANCES

Dimensional tolerances shall conform to EN 13445, except that stacked units shall be assembled together in the shop to assure correct fit.



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6.7 ZINC ANODES AND INTERNAL EPOXY PAINTING

This paragraph covers the minimum requirements for zinc anodes and epoxy painting to be used in the galvanic protection of heat exchangers in water service, when specified on Material Requisition.

Zinc anodes characteristics shall be in accordance with a cathodic protection study that has been approved by the Owner.

The anode iron supports shall be buried in the anode itself, during the fusion process.

Anodes threaded on the supports are not acceptable.

The supports must be welded before protective lining application.


During the painting work, the anodes shall be accurately protected.

Zinc quantity must be distributed the several passes, avoiding that anode presence to cause further pressure drops.

Internal epoxy painting work shall be as follows:

- a. Sharp edges and fillets shall be ground to a smooth radius of at least 3 mm with 6 mm preferred.
- b. All rough welds shall be ground to remove sharp edges, undercuts and other such irregularities.
- c. All weld spatters shall be removed.
- d. Surface preparation shall be "white metal blast cleaning" as per EN ISO 8501-1.
- e. Before any rusting or contamination take place, apply two coats of coal tar epoxy paint.

Coal tar epoxy paint shall be used only when tubes and shell fluid temperatures are below the maximum temperature the painting is suitable for. In case the temperatures do not permit the use of coal tar epoxy paint, coats suitable for the process condition will be selected.

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6.8 HYDROGEN SERVICE REQUIREMENTS

When heat exchangers are specified in hydrogen service in the individual Material Requisition the following must be considered:

- a. The oval ring joint type is mandatory for all nozzles flanges.
- b. The maximum carbon content in the fabrication materials must not be higher than 0.25%.
- c. Materials having yield strength greater than 490 N/mm² shall not be employed.
- d. All attachments and pads welded on exchanger will have a vent hole.
- e. All internal and external welds performed exchanger will must be full penetration and shall be fully magnetic particle inspected.
- f. The internal lining of nozzle obtained by sleeve is not permitted.
- g. The tubes must be strength welded to the tube sheet.
- h. Threaded connections shall not be used. Weld-necked raised face flanges with DN 40 shall be used for necessary vents, drains, pressure, and temperature connection in hydrogen service.


7. INSPECTION AND TESTING

7.1 INSPECTION

Inspection will be performed by a Notified Body.

Inspection requirements are defined in the following documents.

- a. EU Directive 2014/68/EU
- b. Material requisition.
- c. Job Spec. No DSF-SPC-QAC-005

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- d. Relevant project specifications.
- e. Inspection clauses of applicable specifications.

Inspection procedures to be followed are detailed in Job Spec. No DSF-SPC-QAC-006 "Inspection and Test Instructions".

7.2 TESTING

All heat exchangers shall receive a shop hydrostatic test in accordance with the provisions of EN 13445-5 or as specified on individual Material Requisition. Exchanger designed for stacking shall be hydrotested in the stacked position.

For solid or clad austenitic and ferritic stainless steel exchangers the chloride content of the hydrotest fluid shall not exceed 500 ppm.

In addition the equipment shall be immediately drained after hydrotesting and carefully dried by blowing with air and an absolute absence of any water pocket must be ensured.

The hydrotest fluid shall be at least 15° C above the ductile/brittle transition temperature of the material. The minimum hydrotest temperature shall be stated on the Vendor's drawings.


It is the Vendor's responsibility to carry out any tests necessary to establish the transition temperature.

The extent of radiographic examination and heat treatment shall be denoted both in Vendor's bid and on contract drawings.

Hydrostatic Test Procedure & Test Ring Requirements as per EN 13445-5.

7.3 PREPARATION FOR SHIPMENT

After completion of fabrication the exchanger shall be thoroughly cleaned and drained. Loose mill scale, spatter and debris shall be removed. Exchangers shall be painted in accordance with Job Spec. No. DSF-SPC-MEC-006. Exposed machined surfaces shall be coated with an easily removable rust preventative. Flanged openings shall be

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protected with wooden covers and threaded openings shall be provided with a bar stock plug 150 mm. long of material comparable to that of the threaded opening. Nozzles that are beveled for welding shall be suitably covered to prevent entrance of foreign materials and to protect the bevel from damage.

8. GUARANTEE

Refer to Purchase Order

9. SPARE PARTS

The following spare parts, as a minimum, shall be included in the supply and delivered with heat exchanger:

- one set of gaskets
- 10% of bolting (minimum 4 bolts complete with relevant two heavy hexagonal nuts)

10. DRAWINGS AND DOCUMENTATION

Vendor shall supply drawings and documentation in English as per following table.

Also, electronic files (word documents and/or AutoCAD drawings as applicable) of all Documents and Certificates must be submitted by Vendor to the Owner.



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	PRINTS (1) WITH BID	(3) FOR APPROVAL (2)	CERTIFIED (4) AFTER APPROVAL			NO APPROVAL REQUIRED PRINTS
		PRINTS	REPRO	PRINTS	ELECTR. FILES	
1 -Outline Dimensions Dwgs	1	8	3	16	1	
2-Assembly Erection Dwgs					1	
3-Cross Section Dwgs					1	
4-Data Sheet	1	8	3	16	1	
5-Shop Details		8	3	16	1	
6-Vendor Data Index	1	2		12	1	
7-Performance Data					1	
8-Wiring and/or Piping Diagrams	1	8	3	16	1	
9-B.M and/or Appurtanancece		2			1	
10-Parts List					1	
11 -Recommended Spare Parts List					1	
12-Manufac Code Form Report					1	
13-Operating Manual					1	
14-Maintenance Manual					1	
15-Instruction Manual					1	
16-Inspection Data Book				5	1	
17-Test, Certificate Reports					1	
18-W.P.S./P.Q.R.		3		3	1	
19-Calculations	1*	3		3	1	
20-Foundry Reports					1	
21-Consumobles					1	
22-Rubbing Certificates					1	
23-Standard Catalog Information as per AF					1	
24-Special Requirements					1	
A-"As built" Drawings					1	
B-Mill Test Reports					1	
C-Sketch showing location of X-rays		3		3	1	
D-Sketch showing location of Heat Numbers & Weld Seams					1	
E-Radiographic Reports					1	
F-Heat Treat Charts		3		3	1	
G-Hydrostatic Test Charts					1	
H-Index of Contents					1	
I-Vendor Drawing List					1	
K-Inspection Reports					1	
L-Equipment List					1	
M-Microfilms			2		1	



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N-Vendor Production Schedule	2	5			1	
* Thermal and pressure drop calculations						

Notes:

- 1) Where Vendor design sketch for bid no prints are required with bid.
- 2) Preliminary outline and/or assembly drawings adequate for foundation design shall be furnished within two weeks after letter of intent.
- 3) For approval drawings of categories 1, 2, 18 shall be provided not later than 3 weeks after letter of intent.
- 4) Other drawings as shown in Vendors' production schedule.
- 5) Certified drawings required two weeks after return of "For Approval" drawings.
- 6) All drawings must be marked with purchase order number and the equipment item to which they apply.
- 7) Originator of requisition shall delete standard requirements where these are obviously not applicable as prints with bid for safety valves etc.
- 8) All drawings (except those with bid) shall be addressed to Owner's Document Control.
- 9) Contents of item 16 are defined in Job Spec. No. DSF-SPC-QAC-006, as applicable which is attached to the P.O. and shall be addressed to Owner's Inspection Dept.