	FEED for Hydrogen and C3, C4 recovery project	
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1. GENERAL

1.1. This Project Specification defines the minimum requirements for the mechanical design, fabrication, erection, inspection, testing, surface preparation & painting of static equipment which shall be installed in MOL Plc's Danube Refinery and in MOL Petrochemicals Ltd. site, at Százhalombatta and Tiszaüjváros, Hungary as part of "FEED for Hydrogen and C3, C4 recovery project", (hereafter called "Project").

1.2. Definitions

The following definitions shall apply throughout the context of this specification:

"PROJECT" - FEED for Hydrogen and C3, C4 recovery project

"OWNER" - MOL Plc. - Danube Refinery — Százhalombatta, Hungary (MOL)

"CONTRACTOR" - Engineering and Design Institute for Oil and Gas Refineries and Petrochemical Plants — Ploiesti, ROMANIA, Part of Kraftanlagen Group (IPIP)

"PURCHASER" - The Company employed or given a contract by the Owner to provide engineering, procurement and construction services totally and partially for the specified job;

"VENDOR" - Any person or company employed or given a contract by the Purchaser or Owner to perform a specified task or to supply any services, equipment or system;

"INSPECTOR" - Person assigned by the Purchaser or Owner to inspect the specified services, equipment or system being provided by the Vendor;

"Shall" - Is used where a provision is mandatory;

"Should" - Is used where a provision is advisory only.

2. PROJECT IDENTIFICATION

Client's name: MOL Plc Hungary
Project title: Hydrogen and C3, C4 recovery system
Plant locations: Danube Refinery, Százhalombatta, Hungary and MOL Petrochemicals Ltd, Tiszaüjváros, Hungary
The process units which will be included in this project are:

- Area A: Low pressure Compressor section;
- Area B: Medium & High Pressure Compressor section, Sulphur removal unit,

PSA H2 recovery unit;

- Area C: Dehydration and C3-C4 recovery unit;
- Area D: LPG tank farm;
- Area E: LPG railway ramp
- Area F: TVK olefin Plant (new evaporator)

3. SHORT DESCRIPTION OF THE PROJECT

The scope of FEED project includes following main objectives:

- Installation of 3 compressor units in order to assure the adequate pressure of the feed gas stream for the H2 recovery unit;
- Installation off a sulphur removal unit, lead —lag adsorbers technology, to assure a maximum 100 ppm wt of H2S in feed gas stream upstream of H2 recovery unit;
- Installation of a Hydrogen recovery unit PSA technology, with a recovery efficiency of min. 85 wt % H2 with 99.9 vol % purity;
- Installation of one compressor unit for PSA purge gas (tail gas) in order to feed the C3-C4 recovery unit;
- Installation a dehydration unit, membrane technology, on feed gas stream upstream of C3-C4 recovery unit;
- Installation of a C3-C4 recovery unit, membrane technology, with a C3+ recovery efficiency of min 82 wt %;
- Investigation of the reasonability of an addition hydrogen recovery membrane application in the C3-C4 recovery section;
- Installation of the required pipeline header system towards the hydrogen recovery unit, between the hydrogen recovery and the C3-C4 recovery units, and the necessary pipelines for the product streams to the refinery's hydrogen system and to the LPG storage and rail loading facility;
- Checking the natural gas supply increased capacity;
- Increasing tank farm capacity with the installation of four 500m3 sphere tanks (two of them for off spec LPG storage), with the necessary pipelines and pumps;

- Increasing the rail loading system capacities in Danube Refinery (DR) with 2 (two) new dedicated off-spec LPG loading arms installation;
- Installation of a new LPG evaporator within MOL Petchem TVK Olefin Plant, (Tiszaüjváros) ensuring the suitability of the TVK Olefin-I unit feeding.

4. UNITS

International System of Units (Sl Units) shall be used in all drawings, documents and calculations.

Temperature	^{o}C
Pressure (gauge) Pressure absolute	bar(g) bar (a)
Mass	kg
Volume	m^3
Length	m
Alternate Length	mm
Densit	kg/m^3
Mass	kg
Force	N
Moment	Nm
Stress	N/mm^2

5. CODES AND RELATED ENGINEERING STANDARDS

The design, engineering and fabrication of static equipment shall be in accordance with the applicable sections of the codes and standards as detailed in below sections.

The latest editions of standards valid at the date of signing the CONTRACT shall be applicable for design, unless otherwise specified.

5.1. International Codes, Standards & Publications

a. Pressure Equipment Directive 2014/68/EU of the European Parliament and of the Council - on the harmonization of the laws of the Member States relating to the making available on the market of pressure equipment;

b. EN 13445 part 1, 2, 3, 4 & 5 — General, Materials, Design, Fabrication, Inspection & Testing;

c. EN for materials;
d. ASME Code Sect. Vlll Div. 1 - Rules for Construction of Pressure Vessels;
e. ASME Code Sect. Vlll Div.2 - Rules for Construction of Pressure Vessels; Alternative Rules;
f. ASME Code Sect. Il - Materials;
g. ASME Code Sect. V - Nondestructive Examination;
h. ASME Code Sect. IX - Welding and Brazing Qualifications;
i. TEMA Standards of Tubular Exchanger Manufacturers Association;
j. API 660 - Shell-and-Tube Heat Exchangers;
k. API 661 - Air-Cooled Heat Exchangers for General Refinery Service;
I. API 571 Conditions Causing Deteriorations or Failures (in pressure vessels) ;
m. API 572 Inspection of Pressure Vessels
n. EN 1092-1 - Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges;
o. EN 1514-1...8 - Flanges and their joints - Dimensions of gaskets;
p. NACE MR-0103/ISO 17945 — "Petroleum, petrochemical and natural gas industries -- Metallic materials resistant to sulphide stress cracking in corrosive petroleum refining environments"
q. NACE MR-Ol 75/1SO 15156 - "Petroleum and Natural Gas Industries Materials for Use in H2S-Containing Environments in Oil and Gas Production";
r. NACE RP0472 - "Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments";
s. NACE TM-0284 - "Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking",
t. NACE TM-Ol 77 - "Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H2S Environments";
u. Welding Research Council Bulletin Number 107;
v. Welding Research Council Bulletin Number 297;
w. Stresses in Large Horizontal Cylindrical Pressure Vessel on Two Saddle Supports by L.P. Zick, as noted in ASME Pressure Vessel and Piping: Design and Analysis/A Decade of Progress, Volume Two.

5.2. National Codes & Standards

a. MSZ EN 1991-1-4•.2007 - Eurocode 1 General action - Wind load;
b. MSZ EN 1991-1-3:2005 - Eurocode 1 General action — Snow load;
c. MSZ EN 1998-1:2008 - Eurocode 8 Design structures for earthquake resistance. General rules, seismic action and rules for buildings;
d. Safety requirements related to and the conformity assessment of pressure equipment and assemblies: Order No. 9/2001 GM;
e. Technical-safety official supervision of pressure and filling facilities: Order No. 63/2004 GKM.

5.3. MOL Standards

No.	Description	Rev.
MGS-M-REF-M-I .0	General requirements for static equipment	1 .00.01
MGS-M-REF-M-I .1 .1	Tanks, separators, columns, reactors	1 .oo.oo
MGS-M-REF-M-I .3.1	Shell and tube heat exchangers	1 .00.01
MGS-M-REF-M-5.3.1	Detailed documentation of mechanical engineering	1 .oo.oo
MGS-M-REF-M-5.3.2	Detailed documentation of static equipment	1 .oo.oo
MGS-M-REF-M-5.4.2	Requirement of Vendor documentation for static equipment	1 .oo.oo
MGS-M-REF-M-6.1	Requirements of inspection and checking	1 .oo.oo
MGS-M-REF-M-6.1.3	Products handover of category 3	1 .oo.oo
MGS-M-REF-M-6.1.3.5	Equipment gaskets	1 .oo.oo
MGS-M-REF-M-6.1.3.10	Demisters	1 .oo.oo

MGS-M-REF-M-6.1.3.1 1	Reactor, column internals and filter elements	1 .oo.oo
MGS-M-REF-M-6.1.4	Products handover of category 4	1 .oo.oo
MGS-M-REF-M-6.1.4.1	Tanks, separators, filters, columns, reactors	1 .oo.oo
MGS-M-REF-M-6.1.4.3	Tube bundle	1 .oo.oo
MGS-M-REF-M-6. I .4.4	Shell and tube heat exchangers	1 .oo.oo
MGS-M-REF-M-6.1.4.17	Complete unit	1 .oo.oo
MGS-M-REF-M-6.2	Surface protection technology- coating systems	1 .oo.oo
MGS-M-REF-M-6.3	External heat insulation	1.00.01
MGS-M-REF-M-6.5	Pressure test and de-pressurising plan	1 .oo.oo
MGS-M-REF-M-6.6	Requirements of handling and maintenance	1 .oo.oo

6. CONFLICTING REQUIREMENTS

In the case of conflict between documents relating in the inquiry or order, the following priority of documents shall apply:

1 . EU Directives, National regulations and Laws valid at the date of signing the Contract;

2. Contracts;

3. MGS — Standards;

4. International and National Codes and Standards;

5. Project specification;

6. Vendor's specifications;

7. Licensor's specifications.

In case of conflict between the specifications / standards listed above, MOL will be informed for resolution. No action can be taken prior to MOL approval.

7. SITE CONDITIONS

Meteorological data:

Barometric Pressure norm./min./max. mbar	1013 / 979.4 / 1056
Ambient air temperature max. °C min. °C	+ 38 - 25
Daily average temperature on hottest summer day °C	+ 26
Dail average temperature on coldest winter day °C	- 15
Annual average temperaturę °C	+ 10.5
Maximum and minimum ambient air temperature for air cooler design °C	+ 32 - 25
Minimum design metal temperature for equipment that is significantly pressurised at ambient temperature, for structural design according to MSZ EN 1991-1-5:2005 °C	- 20
Avera e air humidit = 15 °C d -bulb,	70
Tem erature with 33.49 kJ/k enthal %	
Prevailin wind direction	from north-west
Terrain Category (Table 4.1) (Wind load calculation shall be according to MSZ EN 19911-4:2007, NA4.1	CLASS Ill.
Basic wind speed , (MSZ EN 1991-1-4•.2007, NA4.1) m/s	23,6
Snow load kN/m^2	1 .25
Max. rainfall in one hour mm	30.0
Max. avera e rainfall in 12 hours mm	14.0
Permissible soil pressure 2 m depth of upper layers to 3.5 m depth for light structures (Clay at more than 12.0 m depth for piled heavy structures like columns, reactors kN/m^2	250 for shallow foundations
Ground T pe according to MSZ EN 1998-1	Class C
Seismic design	According to: MSZ EN 1998-1
Calculated freezin limit below rade, m	1

8. BASIC DATA FOR DESIGN

8.1 Minimum corrosion allowance

Materials of construction and corrosion allowance for static equipment shall be for a design life of 25 years (except for heat exchanger tubes). In this conditions, minimum corrosion allowance shall be 3 mm, unless otherwise specified.

For stainless steel and alloy steels no corrosion allowance is required unless for specific process duties where corrosion or erosion is possible.

Corrosion-resistant linings shall be provided for equipment in highly corrosive service. The thickness of liners, cladding, or weld overlays shall not be included in calculating the minimum thickness of lined part.

The corrosion allowances are not required for tubes and non-pressure parts such as baffles, supports, impingement baffles, pass partition plate etc.

Vessel supports, including anchor bolting shall be designed with a minimum of 1.5 mm corrosion allowance.

8.2 Minimum wall thickness

The wall thickness of the pressure vessels may not be less than defined by strength calculations or imposed by design code requirements.

In addition to this, minimum wall thickness not be less than the greater out of the following values: (ID+2500)/1000 or 5 (mm).

8.3 Minimum design metal temperature (MDMT)

Minimum design metal temperature (MDMT) shall be minus 20 ^{o}c if not otherwise provided by design process conditions.

8.4 Principles of defining the design parameters

Pressure

The operating pressure is the pressure applied during unit normal operation necessary for purpose of the process units as per basis of design. This is the normal working pressure for the equipment or system at operating temperature.

Maximum operating pressure (MOP) is a temporary peak pressure that could occasionally be reached during an operating cycle, due to a foreseeable event that may decrease pressure drop (e.g., bypassing an upstream exchanger), closing of a valve downstream of the vessel, or temporary overpressure due to a temporary increase in temperature. This is the highest possible pressure in the equipment or system at the process extreme operating conditions.

MOP shall be established based on all possible operation condition including up-set or transient conditions such as start-up, shut-down etc.

Design pressure of static equipment shall be based on maximum operation pressure (MOP) and is the value used for the mechanical sizing of equipment.

Design pressure shall not be lower than the maximum operating pressure.

Design pressure of equipment (excluding storage tanks & atmospheric tanks) will be taken as follows:

Maximum Operating Pressure (MOP) (barg)	Design Pressure (barg)
Atmospheric	0.5
MOP < 2.0	3.5
2.0 < MOP < 15.0	MOP + 1.5
15.0 < MOP < 100.0	MOP x 110%
MOP > 100.0	MOP + 10

The design pressure for vessels directly connected to the flare network (flare knockout drums) is the flare design pressure or 3.5 bar(g), whichever is greater.

Design pressure for heat exchangers low pressure side shall be not less than 0.77 times the design pressure of the high pressure side (10/13 rule), to avoid the need to install a PSV for tube rupture. This higher value of design pressure should apply up to first block valves.

Vessels shall normally be protected by pressure relief valves. Relieving pressure of a safety relief valve (PSV) shall be set at the vessel design pressure. If the valve is not directly mounted on the vessel, then the PSV setting shall also include the effects of static head and line pressure drop.

For storage pressure vessels, containing liquefied gas (LPG), MOP is the vapor pressure of the liquefied gas (with known composition) at maximum operating temperature.

Equipment subject to operate at pressure below atmospheric pressure will be designed for full vacuum.

The steam out condition: Steaming out will be done with MP steam, according Refinery practice.

Equipment that is steamed out shall be designed for full vacuum at 270 ^{0}C.

Equipment that is normally in Low Pressure Steam service shall be designed for full vacuum at 1500C.

Equipment that is normally in Medium Pressure Steam service shall be designed for full vacuum at 270 ^{0}C.

Equipment which may have to bear the shut-off pressure of a pump shall have a design pressure equal to or higher that the pump shut-off pressure.

Temperature

Operating temperature (OT) is the temperature to which the inside of the pressure vessels is exposed during normal operation necessary for purpose of the process units as per basis of design. This is the temperature inside the equipment under normal operating conditions at the operating pressure.

Maximum operating temperature (MOT) is a temporary peak temperature reached inside of the equipment systematically during an operating cycle (e.g. end of run) or occasionally due to a foreseeable event (e.g. bypassing an upstream exchanger). This is the maximum temperature value expected inside the equipment during extreme operation conditions.

Minimum operating temperature (MinOT) is minimum process fluid temperature expected inside of the equipment during an up-set condition or other condition than normal operating condition (e.g. start-up, shut-down, different operating condition etc.).

Pressure vessels that will operate at temperatures O ^{O} C and lower shall be designed for minimum anticipated operating temperature, including depressurization.

Design temperature of static equipment will be based on maximum operation temperature (MOT) and is the value used for the mechanical sizing of equipment.

Maximum design temperature (DT max) for process equipment shall be settled as the higher value resulted from criteria listed below:

ODT max = MOT + 30 °c but not less than 60^0C, in the absence of any other specific criteria;

ODT max = Boiling temperature at design pressure of the process medium (fluid) inside — for saturated liquid.

Maximum temperature for equipment exposed to sunlight (design): 70^0C in the absence of any other specific criteria.

The Minimum design temperature (DT min) for all equipment operating at temperatures O ^{O}C and above shall be specified and shall be settled as lower value resulted from the correspondent criteria listed below:

- Minimum Design Temperature = minus 5^0C;
- Minimum ambient temperature.

The Minimum design temperature (DT min) for all equipment operating at temperatures below O^{O}C shall be specified and shall be settled as lower value resulted from the correspondent criteria listed below:

- Minimum Design Temperature = MinOT — 5^0C;
- Minimum ambient temperature.

Minimum Design Metal Temperature (MDMT): minus 20^0 C

The effect of auto refrigeration due to depressurization to atmospheric pressure shall be taken into consideration for equipment containing liquid C3 cut or lighter or for LPG systems.

The resulting temperature for depressurization is the Minimum Design Metal Temperature (MDMT) defined as the boiling temperature of the liquid at atmospheric pressure. This temperature

will be considered as MDMT for the concerned equipment if lower than the project MDMT specified in the climatic data section (minus 200C).

8.5 Heat Exchangers limits and conditions

- Maximum accepted nominal tube length: 6 m;
- Preferred outside tube diameter: 25 mm;
- Preferred tube wall thickness: BWG 13 for carbon steel (for cooling water: BWG 12);
- Maximum Bundle Diameter: 1200 mm;
- Maximum Bundle Weight: 15 t;
- Typical fouling factor shall be as per TEMA standard;
- U-tube bundle type shall not be used for cooling water due to the high deposition.

8.6 Equipment connections

Vents Drains Steam-out Connections

Vessels will be normally provided with vents and drains and steam-out connections in accordance with the following table:

Volume, V (m^3) or Diameter, D (mm) of vessel	Vent diameter (mm) (1)	Drain diameter (mm) (1)	Steam-out diameter (mm) (2)
V < 75 or D \<4,500	50	50	50
75 < V 220 or 4,500 < \<6,000	80	80	80
220 < vs \<420 or D > 6,000	100	100	100
v > 420	150	100	100

Note: 1) Vent and drain connections are not necessarily located on vessels.

1) Steam-out nozzles will be located on the lower part of heads for horizontal vessels and in the bottom section for vertical vessels.

Manways

Vessel Type	Manwa -ID (mm)	Manwa Placement
Vertical/Horizontal ID\< 900	Flanged Heads	Heads
Vertical 0>900	Min 600 (must accommodate internals installation	Lateral side/Top Head
Horizontal ID>900	Min 600 (must accommodate internals installation	Lateral side at or below centerline Top side (half-lined vessels)
Columns with trays	Min 600 (must accommodate internals installation	Top head of the column At Feed tray At any tray where internals removal are required Bellow the bottom tray Intermediate oints

8.7 Maximum equipment dimensions and weights for transport by road without special permit

	Maximum
Outside diameter, m	2.5
Overall Length, m	40
Height, m	2,5
Weight, kg	22t (10t/axle)

8.8 General requirements

The standards EN, API, ASME can be applied for supplying of technological units, packages and equipment. Whichever standards will be applied, the PED (2014/68/UE) regulation is to be satisfied.

The pressure equipment which comes under competence PED, shall be delivered with a Declaration of Conformity, which shall be issued by Vendor.

Local regulations for technical equipment safety and health safety shall be fulfilled in case of international standards using.

Construction material shall be selected according to applied standards with fulfilling the PED requirements.

Material selection philosophy shall take into consideration the most extreme operating conditions.

8.9 Particular requirements

8.9.1 The standards EN, API, ASME can be applied for supplying of technological units, packages and equipment. Whichever standards will be applied, the PED (2014/68/UE) regulation is to be satisfied.

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8.9.4 Construction material shall be selected according to applied standards with fulfilling the PED requirements.

8.9.5 Material selection philosophy shall take into consideration the most extreme operating conditions.

8.10 Particular requirements

8.10.1 Stabilized austenitic steel shall be used when stainless steel is required for static equipment fabrication.

8.10.2 The carbon content of all carbon steel materials which are welded has to be less than or equal to 0.23%.

The carbon equivalent Ceq = C + Mn/6 + (Cr+Mo+V)/5 +(Cu+Ni)/15 must be less than or equal to 0.45%.

8.1 0.3 Shell and tube heat exchangers will meet the requirements of the TEMA Class R.

8.1 0.4 For Water Cooler, shell and tube heat exchangers floating head type is preferred.

8.1 0.5 Each nozzle located on the equipment shall be designed and fabricated with counter flange, gasket, bolts & nuts. 100% spares of gaskets and 10% spares of bolts & nuts shall be also provided.

8.1 0.6 Nozzles directly connected to piping shall be designed for the most severe condition of actual piping loads acting upon them. Analysis shall be performed in accordance with Welding Research Council Bulletin Number 107 and Number 297 or EN 13445.

The nozzles that cannot be analysed adequately using standard calculation procedures (the above standards are falling out of limits) shall be modelled using finite element analysis (FEA).

8.10.7 All nozzles shall be designed to withstand all expected external loads.

8.10.8 Equipment and their supports including anchor bolts shall be designed to support combinations of loads and forces to which the equipment mat be subjected.

8.10.9 Anchor bolts shall be furnished by others, but designed by equipment Vendor.

8.10.10 Wind or earthquake load, whichever is greater, shall be considered in the equipment design.

8.10.1 1 All equipment shall be designed to be self-supporting without benefit of guys or braces, if otherwise is not specified.

8.10.12 During erection or operation, all applicable loads shall be considered as acting simultaneously, including either wind or earthquake, whichever governs.

8.10.13 During hydrostatic testing, wind load (wind pressure) equivalent to 2/3 of wind load in operating conditions shall be considered acting simultaneously with the hydrostatic test load.

8.10.14 Lifting and tailing lugs, including skirt bracing shall be designed for an impact factor of 1.5. Following check shall be performed:

- lifting analysis (from horizontal to vertical position) for vertical equipment and lifting & tailing lugs;
- stress analysis to verify the integrity of the equipment during transportation.

Mechanical design of lifting devices as well as analysis of all loads arising from the erection phase shall be investigated.

Location and projection of lifting devices shall be studied in such a manner to allow easy erection of equipment.

8.10.15 Nozzles up to and equal with DN50 shall be of forged long welding neck type.

8.10.16 Studs for nozzle flanges or girth flanges shall be full length threaded and length shall be measured from first thread to the last thread.

8.10.17 The thickness of reinforcement pads shall not exceed the 1.5 times of the equipment wall thickness, unless otherwise approved.

8.10.18 Dished heads shall be of semi-ellipsoidal type having a ratio of major axis to minor axis , if otherwise is not specified.

8.10.19 The inside edge of nozzles and manholes shall be rounded at a radius of minimum 3 mm.

8.10.20 All bolts holes for flanges shall straddle the principal center lines of the equipment.

8.10.21 All reinforcing pads shall be provided with a 6 mm NPT tell-tale hole. Where a reinforcing pad consists of two or more plates welded together after being fit to the equipment, a test hole shall be provided for each sealed section of the plate.

8.11 Equipment design life

Equipment design life shall be 25 years.

Tube bundles for shell & tube heat exchangers design life shall be 15 years.

9. FABRICATION

9.1 Fabrication shall be in accordance with the requirements of applicable codes, regulations and standards, listed at para. 7.

9.2 All materials used in the fabrication of pressure parts shall have a material certificate issued by the steel works specifying the chemical analyses and mechanical tests, in accordance with the appropriate specifications.

9.3 All materials used for equipment fabrication shall be new and shall be properly stored and identified before their use.

9.4 The materials (plates, pipes, forgings etc.) shall be UT examined in accordance with applicable standards.

9.5 All the internal and external attachments shall be positioned so that the distance between the fillet welds of these attachments and the shell welded joints shall be, toe to toe, not less than 50 mm or twice the shell thickness, whichever is greater, unless otherwise is specified.

9.6 Whenever possible dished heads shall be made of a single piece.

9.7 The welds shall meet the specifications of the ASME IX and PED or the EN standards and PED.

9.8 Welding procedure and welders and welding operators shall be qualified in accordance with codes in section 7.

9.9 Only welder or welding machine qualified for the corresponding procedure and welding position may perform welding on pressure vessel.

9.10 The preheat temperature shall be established by the manufacturer to avoid hard zone cracking in the heat affected zone, for each type of welding including those for all attachments and tack welds.

9.1 1 All filler metal shall have the same quality as or higher quality than the base metal.

9.12 For welds between dissimilar metals, welding electrodes or filler metals shall be selected to obtain the deposited weld metal of the same quality as the higher grade metal.

The number of dissimilar welds shall be of minimum and subject to MOL Group's approval.

9.13 Pipes and plates may be cut, shaped and bevelled for welding by mechanical means. Edges may also be prepared by power burning or plasma cutting after which the edges shall be ground back to bright metal. The edges to be welded shall be uniform and smooth. All foreign materials such as oil, grease, cutting lubricant, paint and layout markings shall be removed from the areas subject to heating. Solvents used for cleaning shall be sulphur-free.

9.14 Edges shall be visibly checked before welding to ensure that there are no cracks, laps, laminations or other defects.

9.15 All weld joint preparations and back gouged surfaces for all pressure parts and all parts welded directly to pressure parts are to be MT examined prior to welding.

9.16 Immediately prior to welding, the edges shall be cleaned and dried.

9.17 Welds of parts, such as nozzles, pads, clips, supports etc. shall avoid to cross the main welds of the equipment or nozzle welds.

9.18 Alignment of sections of edges to be butt welded shall be such that maximum offset is not greater than the value specified in the Code.

9.19 All thickness of reinforcement of weld shall not exceed the value specified in the design code.

9.20 Equipment shall be post weld heat treated in accordance with the requirements of applicable codes.

9.21 If after-weld, stress relieving heat treatment (PWHT) is specified, it shall be carried out on completion of the welding works. After heat treatment no more welding is permitted.

9.22 Should this be unavoidable, it can be made only with specifications of special measures.

9.23 Hardness tests shall be carried out after the final heat treatment on the inside of each shell section, head, longitudinal weld, and nozzles, and each longitudinal girth and nozzle weld, in accordance with applicable code requirements.

10. INSPECTION, TESTING AND ACCEPTANCE REQUIREMENTS

1 0.1 Inspection during fabrication and final tests shall be carried out by purposely authorized inspector. The owner's representative can also attend the inspection and tests.

10.2 Before the equipment visual inspection and size checking, loose scale, slag, dirt, welding spats, paint, oil and other foreign matters should be removed to assure proper conditions for inspection.

10.3 The product dispatch acceptance or authorization issued by the purposely authorized inspector does not acquit or release the Vendor from his responsibility of strictly meeting the provisions of this specification and/or the guarantees, and neither the Owner, by this approval, is responsible for these provisions and/or guarantees.

10.4 Inspection methods and acceptance criteria for all examinations shall be in accordance with the applicable codes.

10.5 Vendor shall issue his Quality and Control Plan (QCP) which shall include the scheduled dates for each test and the "witness" and "hold" points as foreseen in Purchaser's ITP. Test procedure, reference codes and acceptability criteria shall also be included. Once approved, VENDOR's QCP shall become the basis for tests and inspections to be carried out on the equipment included in his scope of supply.

10.6 Material certificates shall be provided for all pressure and non-pressure parts.

1 0.7 Inside surface on knuckle area of the heads shall be examined 100% MT or PT, where MT examination is not possible.

10.8 Equipment fabricated in shop shall be subject to hydrostatic test in horizontal position in the vendor's shop as a rule.

10.9 Vertical equipment shall be supported on the saddle supports during hydrostatic testing.

10.10 No abnormal deformation or leak of test medium shall be acceptable during hydrostatic testing.

10.11 Gaskets used for hydrostatic test shall be the same type as service gaskets. Gaskets used for hydrostatic test shall not be used during operation.

10.12 Pressure tests shall be performed on reinforcing pads using air at 50 kPa and soapy solutions, prior to post weld heat treatment and final hydrostatic test.

11. SURFACE PREPARATION AND PAINTING

1 1 .1 Surface preparation and painting requirements shall be in accordance with Specification No. MGS-M-REF-M-6.2- Surface protection technology- coating systems.

1 1.2 The entire equipment (including supports) shall be primed and/or painted. Nozzles shall be painted on the flange edges, inside bolt holes, and up to the gasket surface.

12. PREPARATION FOR SHIPMENT

12.1 Equipment shall be free of loose scale, dirt and foreign material. Liquid used for testing or cleaning shall be completely drained. Equipment openings shall be blanked.

12.2 High alloy equipment shall be blown dry with air, and all nozzle, manhole, vent and connection openings shall be blanked, plugged or capped to prevent the entry of moisture.

12.3 Vendor shall supply shipping saddles for all vertical equipment, unless, otherwise agreed.

12.4 Austenitic stainless steels used in equipment shall not be exposed to wetting by salt water or salt spray. Protective coating or coverings used to prevent such exposure shall be approved by the Purchaser.

12.5 Temporary supports in contact with high alloy equipment, for shipping and storage, shall not be of a moisture retaining material such as raw wood.

12.6 Prior to shipping, equipment shall be internally purged with pressurized inert gas.

12.7 Exposed edges of shells shipped in 2 or more pieces shall be protected by welding ring angles extending beyond the edges.

12.8 Each loose piece or assembly shall be properly protected to prevent damage during normal shipping and handling.

12.9 All parts shall be marked for identification and preparation for shipment.

12.10 Each removable piece of equipment that will be shipped separately from the equipment shall be identified with a metal tag. The tag shall be securely wired to each item with stainless steel wire.

12.11 The identification tag shall be metal die stamped with the item number, platform number, piece number, and total number of pieces. The identification tag shall include the equipment tag number to which each piece corresponds.

APPENDIX 1

REQUIREMENTS FOR EQUIPMENT IN WET SOUR SERVICES

1. INTRODUCTION

This Appendix defines the materials, welding, thermal treatment, examination, and testing requirements for Carbon steel Pressure Vessels which are intended for operation in "Sour" wet H2S process environments.

The requirements of this specification primarily to Pressure Vessels designed to ASME Vlll div 1 or 2.

However, when other Design, Fabrication Testing codes are specified such as National, European, International codes, directives (PED) or regulations, application of subject codes and associated norms, standards shall superseded those referred into this specification.

For licensed units, this specification will have to be applied together with applicable licensor specifications. The more stringent requirements shall govern.

Requirements of this Appendix are intended to prevent the risk of several types of cracking and blistering that may occur in materials and equipment when exposed to H2S containing environment.

2. MATERIALS

All materials shall comply with NACE MR0103 and supplementary requirements of this specification.

Unless otherwise specified, the requirements of this specification for chemical analysis shall apply to the heat analysis. For welded components, chemical analysis, shall include as well the elements used for the determination of Carbon Equivalent.

All carbon steel materials shall be supplied in the normalized condition. Normalizing shall be carried out as a separate heat treatment by the material manufacturer.

All carbon steel materials shall be killed.

2.1 Plates

Chemistry Requirements

The plate material shall comply with following chemical heat Analysis:

Elements	% Maximum
Carbon	**0.21**

Manganese	**1 .20**
Silicon	**0.45**
Sulphur	**0.003**
Phosphorous	**0.015**
Copper	**0.20**
Nickel	**0.30**
Chromium	**0.20**
Molybdenum	**0.20**
Carbon Equivalent (CE)	**0.43**

The following formula shall be used to calculate the CE:

$CE = C+Mn/6+(Cr+Mo+V)/5+(Cu+Ni)15$

Deliberately added microalloying elements shall require prior approval. Microalloying elements are considered to be deliberately added when the single values of Niobium (Nb), Vanadium (V), and Titanium (Ti) are greater than 0.01 and Boron (B) greater than 0.0005.

Manufacture of steel plates

The steel shall be produced by electric arc furnace or in the basic oxygen furnace process. The steel shall be vacuum degassed and produced to a fine grain practice, with low sulphur and phosphorus process. Grain size shall be 7 or finer as defined by ASTM E 1 12.

The Steel shall be shape control treated by Calcium except for low sulphur content equal or less than 0.002 %, which shall be left at steel manufacturer's option.

Calcium addition shall not exceed 3 times the sulphur content.

Ultrasonic testing

All plates of thickness greater than 12.7 mm shall be ultrasonically examined in accordance with ASTM A 578 with supplementary requirements Sl . Acceptance criteria level C shall apply.

HIC testing

Unless otherwise specified, HIC testing shall be required for each steel manufacturing supplier, each steel grade and manufacturing steel process at following extent:

-at the beginning of production; the thickest and thinnest plate shall be tested from one of the first heat produced,

-during production; the thickest and thinnest plate shall be tested from one of the heat exhibiting the highest sulphur content.

HIC shall be in accordance with the procedure defined in NACE Standard TM 0284, using the Test solution A .

Acceptance criteria: Crack Length Ratio (CLR) <5%.; CT R, CSR shall be in accordance with NACE TM 0284.

If any of the specimen failed to meet above acceptance criteria, additional HIC specimens for retesting may be taken from the same location of the original plate.

Furthermore, three additional heats selected by the CONTRACTOR shall be subject to HIC testing.

HIC Report shall include following information:

- Results of cracking evaluation indicating individual and average CLR, CTR and CSR for each section.
- Photomicrographs of the specimens showing cracking, together with photomicrographs of adjacent material structures:
- Unetched, showing the type of inclusions in the steel (magnification200X),
- Etched, showing the parent material microstructure (magnification 200X),
- pH of IHS saturated solution at the beginning and at the end of the test and type of solution,
- Photographs of specimens showing blister,
- location and dimensions of specimens,
- Full chemical analysis and mechanical properties results of material tested.

Material certification

Material test certificate shall include the provisions for simulated Post Weld Heat Treatment to anticipate maximum heat treatment cycle foreseen during fabrication of the equipment in accordance with the supplementary requirements S3 of ASTM A 20.

Material certificate shall include:

- Chemistry
- Mechanical properties (including tests after simulated PWHT)
- HIC testing results (when required)

- Ultrasonic examination results
- Impact tests results (when required to satisfy Minimum Design Metal Temperature requirements)
- Heat treatment reports
- Hardness test results and location.

2.2 Seamless pipes and seamless pipe fittings

Chemical Analysis shall include all elements required by applicable material standards as well as the elements used for the determination of Carbon Equivalent.

Chemical analysis on heat shall be in accordance with following restrictions:

Elements	% Maximum
Carbon	0.18
Manganese	1 .1
Silicon	0.30
Sulphur	0.010
Phosphorus	0.020
Carbon Equivalent (CE)	0.41

Process of Manufacture

Pipe may be supplied in quench and tempered condition, but preference shall be given to pipe supplied in normalized condition.

Non destructive testing for seamless pipe

Seamless pipe, of thickness greater than 19 mm shall be examined on their full length by ultrasonic, by pulse angle beam method in accordance with ASTM E 213.

In addition, each end of tube of thickness greater than 38 mm shall be examined by compression waves on a distance of 130 mm for the detection of any lamination- like imperfections which shall not be acceptable.

HIC Testing

Unless otherwise specified no HIC testing shall be required provided that pipe manufacturer can demonstrate to CONTRACTOR through previous HIC data results, its capability of producing "Sour service tubes".

Should HIC tests be required, HIC test procedure defined at para. 2 shall apply.

2.3 Forgings

Forgings shall comply with following chemical analysis:

Elements	^{0}/0 Max.
Carbon	0.21
Manganese	1 .35
Phosphorus	0.015
Sulphurus	0.010
Carbon Equivalent	0.43

For any reduction of 0.01 % below the specified Mn content, an increase of 0.01 S and P above the specified maximum values shall be permitted up to respectively 0.025 for P and 0,015 for S.

No HIC Testing is required on Forgings.

The steel shall be made by vacuum degassing process.

Forging will preferably be made from hollow ingots.

Forgings shall be ultrasonic examined in accordance with ASME SA-388.

2.4 Supplementary requirements for fittings

All fittings shall be supplied in the normalized, normalized and tempered or quenched and tempered conditions.

All fittings shall be magnetic particle inspected 100% on forged or extruded surface in accordance with MSS SP 53.

2.5 Exchanger tubing

Tubing chemical analysis shall be in accordance with para. 2.2 of this specification.

A non-destructive electric test in accordance with ASTM A 450 shall be carried out in addition to the hydrostatic test.

No HIC testing is required on tubing.

2.6 Bolting

The bolting material used for carbon steel internal bolting (including floating head bolting) and all external bolting on piping or equipment including all flanged joints that will be buried, insulated, equipped with flange protectors or otherwise denied direct atmospheric exposure shall meet the requirements of NACE MR0103 including hardness.

No HIC testing is required on bolting.

3. WELDING FABRICATION OF PRESSURE RETAINING COMPONENTS AND EQUIPMENT

All welding procedure qualifications shall be qualified in accordance with the requirements of ASME IX supplemented by macro hardness survey Vickers HVIO as defined in the European norm EN 1043-1 or other standards approved by CONTRACTOR.

Pressure retaining welds shall be made with low hydrogen electrodes.

Nickel content of the welding consumables shall not exceed 1%.

Preheat temperature shall not be lower than specified in the applicable WPS.

For each qualified welding procedure used for welded joint of categories A and B of each vessel or group of vessels (1) a production weld coupon shall be required for macro-hardness test survey. Welding of dissimilar material between Ferritic steel to Austenitic stainless steel shall not be permitted when directly exposed to sour wet H2S environment.

4. POSTWELD HEAT TREATMENT (PWHT)

PWHT is required for pressure vessels irrespective of thickness.

The PWHT temperature and time shall be in the range of 600^0 C to 625^0 C, 1 hour per 25 mm of thickness, 1 hour minimum. Using a lower temperature for a longer period of time is not permitted. The heat-up and cool-down rates shall be in accordance with ASME Section Vlll Division 1 or 2, as applicable.

The following documentation shall be submitted for approval prior to PWHT.

- PWHT procedure, indicating type of furnace, method of heating etc. ♦ Local PWHT if any
- Number and location of Thermocouples

- Heating, cooling rate.
- Temperature and soaking time.

5. NON DESTRUCTIVE EXAMINATION

Non-destructive examination shall be as specified by code and Job's specifications supplemented as follows:

	Joint category 1	Before PWHT	After PWHT
Thickness \< 50mm	A,B	-	100 % RT 2
	D	-	100 % UT
Thickness > 50mm	A,B	100 % RT 100 % UT	100 % RT 100 % UT
	D	100 % UT	100 % UT

Notes :

(1) Weld joint of category are defined in ASME Vlll Div 1 UW-3

(2) For thickness between 12.5 mm and 50mm, 100% radiography examination may be performed before PWHT provided to supplement it by 100% Ultrasonic examination after PWHT

In addition 100% of all internal accessible attachment Fillet Weld and branch connection shall be examined by Wet Magnetic Particle Test (WMT).

6. HARDNESS TESTING

All pressure-retaining welds in equipment shall be hardness tested after PWHT.

Hardness shall not exceed 200HB.

When access is available, tests shall be performed on the process contacted side of the weld, otherwise testing may be conducted on non-process side.