طرح نگهداشت و افزایش تولید ۲۷ مخزن

SPECIFICATION FOR MATERIAL REQUIREMENTS IN SOUR SERVICE

نگهداشت و افزایش تولید میدان نفتی بینک

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Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**CLIENT Approval**
Class:2		**CLIENT Doc. Number: F0Z-707138**				

Status:

IDC: Inter-Discipline Check
IFC: Issued For Comment
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REVISION RECORD SHEET

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1.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields CLIENT (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
EPD/EPC CONTRACTOR:	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPC CONTRACTOR and approved by GC & COMPANY (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by COMPANY rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

2.0 DOCUMENT SCOPE

This document defines the requirements for all carbon steel pressure vessels and piping exposed to process streams that result in potential cracking mechanisms caused by wet H2S service environment, shall be designed and fabricated in accordance with the requirements of this specification.

3.0 NORMATIVE REFERENCES

3.1 Local Codes and Standards

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- IPS-M-PI-190 — Material And Equipment Standard For Line Pipe
- IPS-M-PI-150 — Material Standard for Flanges & Fittings

3.2 International Codes and Standards

- API 5L — Specification for Line Pipe
- ASME B16.11 — Forged Fittings, Socket-Welding and Threaded
- ASTM A105 — Standard Specification for Carbon Steel Forgings for Piping Applications
- ASTM A106 — standard specification for covers seamless carbon steel pipe for high-temperature Service
- ASTM A234 — Standard Specification for steel pipe fittings
- ASTM A694 — Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service
- NACE MR 0175/ISO 15156 — Petroleum, petrochemical, and natural gas industries - Materials for use in H2S-containing environments in oil and gas production
- NACE TM 0177 — Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion

	Cracking in H2S Environments
• NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
• NACE SP 0472	Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments
• ASTM E45	Standard Test Methods for Determining the Inclusion Content of Steel
• ASTM A578	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

3.3 The Project Documents

- BK-GCS-PEDCO-120-PI-RT-0001 Corrosion Study & Material Selection Report

4.0 ABBREVIATIONS

Carbon Steel(C.S.)	An alloy of carbon and iron containing up to 2% carbon and up to 1.65% manganese and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (Usually silicon and/or aluminum). The carbon steel used in oil industry usually contains less than 0.8% carbon.
Sour Service	Exposure to oilfield environments that contains H2S and can cause cracking of materials.
Corrosion Resistant Alloy(CRA)	Alloys that are intended to be resistant to general and localized corrosion in oilfield environments that are corrosive to carbon steels.

Hydrogen Induced Cracking(HIC)	Planar cracking that occurs in carbon and low alloy steels when atomic hydrogen diffuses into the steel and then combines to form molecular hydrogen at trap sites. Steels with high impurity levels are commonly susceptible to HIC.
Stress Corrosion cracking(SCC)	Cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) in the presence of water and H2S.High strength metallic materials and hard weld zones are prone to SSC.
Sulfide Stress Cracking(SSC)	Cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H2S.
stepwise cracking (SWC)	cracking that connects hydrogen-induced cracks on adjacent planes in a steel
stress-oriented hydrogen-induced cracking (SOHIC)	staggered small cracks formed approximately perpendicular to the principal stress (residual or applied) resulting in a “ladder-like” crack array linking (sometimes small) pre-existing HIC cracks
soft zone cracking (SZC)	form of SSC that can occur when a steel contains a local “soft zone” of low-yield-strength material
Galvanically induced hydrogen stress cracking (GHSC)	cracking that results due to the presence of hydrogen in a metal induced in the cathode of a galvanic couple and tensile stress (residual and/or applied)

5.0 MATERIALS FOR SOUR SERVICE

In-service hydrogen damage problems, arising from wet hydrogen sulfide (H2S) service fall into three main categories which are covered in this specification. These are as follows:

- Hydrogen Embrittlement Effects - Sulfide stress cracking (SSC), a hydrogen embrittlement phenomenon, is cracking caused by hydrogen diffusing into the steel when subject to tensile stress.
- Hydrogen Internal Pressure Effects - Hydrogen diffuses into the material and collects at inclusions/other defects and produces an internal pressure which results in blistering and/or various forms of hydrogen induced cracking.
- Cracking in Related Environments - These include hydrogen damage in sour environments in the presence of chlorides, cyanides, alkalis and amines. This

Specification modifies and extends, where necessary, the requirements of the NACE Standard, providing additional guidance for materials in sour service in the presence of these chemicals.

All Materials for sour service shall comply fully with requirements and recommendations of the NACE MR0175/ISO 15156-2015 standard for resistance to all mechanisms of cracking that can be caused by H2S, including sulfide stress cracking (SSC), stress corrosion cracking (SCC), hydrogen-induced cracking (HIC) and stepwise cracking (SWC), stress-oriented hydrogen-induced cracking (SOHIC), soft zone cracking (SZC) and galvanically induced hydrogen stress cracking (GHSC).

The services listed and defined hereinafter are considered severe as they require special materials or additional fabrication requirements or improved testing.

5.1 Material Requirement in Sour Service

This section is applicable to all materials exposed directly to sour service fluid and all attachments materials that are welded to pressure parts.

Carbon steel, Low alloy steel and corrosion resistant alloys materials adopted for wet H2S environments shall be in compliance with the requirement of NACE MR0175/ISO 15156-2015.

All carbon steel material shall be fully killed, fine-grain treated and supplied in the normalized condition. Normalizing shall be carried out as a separate heat treatment by the steel supplier.

Carbon steel shall be in compliance with the following requirements:

- Hardness of base metal shall be 22 HRC max.
- Chemical analysis shall be restricted as follows:

Elements %	Plate/Welded pipe	Pipe (Seamless)	Forged	Cast
Carbon	≤0.20	≤0.20	≤0.20	<0.23
Manganese	≤1.30	≤1.30	≤1.30	<1.35
Sulphur	≤0.003	≤0.010	≤0.02	-
Phosphorous	≤0.015	≤0.020	≤0.020	≤0.020
Niobium	≤0.040	≤0.040	≤0.040	≤0.040
Vanadium	≤0.050	≤0.050	≤0.050	≤0.050
Silicon	≤0.45	≤0.45	≤0.45	≤0.45

Residuals:

Chromium	0.25 % max

Copper	0.25 % max
Molybdenum	0.10 % max
Nickel	0.30 % max

- Carbon Equivalent shall be 0.42 maximum. The carbon equivalent (CE) will be defined as below:

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15}$$

Note: CE ≤ 0.45 is acceptable for plate thickness 50 mm and greater.

- For plate material, the maximum chemical composition of unspecified elements shall be in accordance with Table.1 of ASTM A20.

- For pipelines and API 5L pipes, chemical composition of steel pipes according to IPS M-PI-190 shall be followed.

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All carbon steel welds shall be post weld heat treated even if not required by the applicable design/construction codes.

Thermal stress relieving is required for cold bend zones producing outer fiber deformation greater than 5%, even if it is not required by code.

Dissimilar welds between stainless steel and carbon or low alloy steels shall be avoided in wet H_2S service.

Maximum Hardness of production welds shall be 235 HB.

PWHT is mandatory for carbon steel pressure containing components, including equipment and piping (circumferential welds only), irrespective of their thickness.

Socket welding of carbon steel shall be prohibited in sour service.

Spiral welding and Electric Resistance Welding (ERW) fabrication processes are not allowed.

Unless otherwise specified in the relevant design codes or fabrication specifications, PWHT shall be carried out for CS at minimum 620°C for 1 hour per inch (25 mm) of thickness (1 hour minimum) in accordance with Table UCS-56 of ASME Section VIII, Division 1. Using a lower temperature for a longer period of time is not permitted.

During heat-up and cool-down, the maximum temperature differential between the thickest and thinnest pressure boundary components, as measured at the weld, should not exceed 140 °C.

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

- PWHT procedure, indicating type of furnace, method of heating etc.
- Number and location of thermocouples
- Heating and cooling rate

Plates shall be HIC tested as per par. 6.4 of this specification. HIC testing also shall be performed on carbon steel materials clad with corrosion resistance alloys.

Plate material shall be inspected by ultrasonic examination for internal defects in accordance with ASTM 578– level A, including supplementary requirements S1 (100%) scanning. For API 5L pipe, the Table K.1 of IPS-M-PI190 shall be considered. D01

All carbon steels produced for plate shall be manufactured by the basic oxygen or electric arc furnace. The steel shall be vacuum degassed.

Strip welding is not acceptable for cladding of plates.

For plate, Calcium to Sulphur ratio to be 2 ≤ Ca/S ≤ 4. But, Calcium treatment is not mandatory where %Sulphur ≤ 0.002.

Welded pipe shall be HIC tested as per par. 6.4 of this specification. For welded pipe HIC testing shall be performed on one plate and on one finished welded pipe such as to include parent metal and weld area as required in NACE MR0175/ISO 15156-2015, for each heat and for the thinnest plate.

Welded pipes shall be Longitudinal Seam Submerged Arc Welded (SAW) with at least two passes, one inside and one outside, and with filler materials with a nickel content of not more than 1.00%.

Longitudinal welds shall be examined on their full length by ultrasonic examination or radiographic examination in accordance with applicable pipe material standard specification.

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Unless otherwise stated in specification, No HIC Testing is required on seamless pipe & fitting.

For forged, %Sulphur ≤ 0.020 plus HIC test. However, HIC test can be waived if %Sulphur ≤ 0.015 for forged and %Sulphur ≤ 0.020 for cast.

Ultrasonic Testing as per A388 shall be required for forgings greater than 50 mm thickness.

Stainless steel can be used for some parts of equipment. If so, the following requirements and restrictions shall be applied:

- 13% Cr Stainless steel shall be heat-treated and have a hardness complying with NACE MR0175 / ISO 15156-2015.
- Austenitic or austenitic-ferritic stainless steel shall be in the solution annealed condition.
- If welding and/or post-weld heat-treatment is required on austenitic stainless steel, this steel shall be low carbon or titanium-stabilized steels.
- If welding repairs are required to the bodies of cast equipment in type 304 or 316 stainless steel, the procedure shall be subject to approval.
- In all cases, limits of use of stainless steel and the suitability of alternative material for specific applications shall be sought from the Contactor.
- Any equipment or process pipe work made of austenitic or austenitic-ferritic stainless steel or nickel base alloys shall comply with NACE MR0175 / ISO 15156-2015 requirements with respect to hardness level and heat treatment (if any) unless otherwise approved by the Contactor.

5.2 HIC Testing of Carbon Steel

When required in the previous paragraph HIC testing shall be performed following the NACE MR0175/ISO 15156-2015 by using of the Solution A. HIC procedure shall be in accordance with NACE TM0284.

The test frequency is of one test for each heat. If more than one thickness is rolled from the same heat, the test shall be carried out on all thicknesses.

- Acceptance criteria for the HIC test are as follows:

Parameter	Overall average of three samples
CLR	≤ 15.0 %
CTR	≤ 3.0 %
CSR	≤ 1.0 %

- No individual crack length shall be more than 5 mm. Also, blistering area shall not be more than 1% of the exposed area of two wide faces of each coupon.

5.3 Material Certificates and Material Traceability

Material certificate shall clearly mention that the material is adequate for sour service.

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Type 3-2 of EN 10204 certificates must be supplied for all materials. These certificates must include a full chemical analysis sufficiently detailed to show that the relevant chemical element contents criteria are met for each type of material.

The Contractor reserves the right to perform any counter-analysis, particularly on chemical analysis of finished products, to ascertain the correctness of the material certificates submitted with the supply.

All bulk materials must be fully traceable and correctly identified, particularly to the heat and test numbers of the matching certificates.