



نگهداشت و افزایش تولید میدان نفتی بینک  
سطح الارض

احداث خطوط انتقال گاز/مابعات گازی از ایستگاه تقویت فشار گاز  
بینک تا ایستگاه تزریق گاز سیاهمکان/واحد بهره برداری بینک



شماره پیمان:

053 - 073 - 9184

**CORROSION STUDY & MATERIAL SELECTION REPORT**

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادرکننده	بسته کاری	پروژه
D02	0001	RT	PI	320	PEDCO	PPL	BK

شماره صفحه: 1 از 18

طرح نگهداشت و افزایش تولید 27 مخزن

**CORROSION STUDY & MATERIAL SELECTION REPORT**

نگهداشت و افزایش تولید میدان نفتی بینک

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- AFC: Approved For Construction
- AFP: Approved For Purchase
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- IFI: Issued For Information
- AB-R: As-Built for CLIENT Review
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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.

As a part of the Project, New Gas/Condensate Pipelines (from Binak New GCS to Siahmakan GIS/Binak PU) shall be constructed.

### GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – Surface Facilities; Gas & Gas-Condensate Pipelines
EPD/EPC CONTRACTOR (GC):	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 EPD/EPC CONTRACTOR (GC) and approved by CLIENT (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 CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

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## 2.0 SCOPE

This document details the procedures used to corrosion study and material selection of "Construction of 8 inch gas transmission pipeline from BINAK Compressor Station to SIAHMAKAN Gas Injection Station in BINAK Oil Field" project, based on the estimated internal process conditions which are discussed in detail in this document. This document presents the resultant material selection for Process Piping, Equipment and Utilities

## 3.0 NORMATIVE REFERENCES

### 3.1 LOCAL CODES AND STANDARDS

- IPS-E-TP-740 Engineering Standard For Corrosion Consideration In Material Selection
- IPS-G-ME-150 General Standard For Towers, Reactors, Pressure Vessels and internals
- IPS-E-PI-221 Piping Material Selection

### 3.2 INTERNATIONAL CODES AND STANDARDS

- NACE MR0175/ISO 15156 Materials for use in H<sub>2</sub>S-containing Environments in oil and gas production
- API 5L Specification for Line Pipe
- ASME B31.3 Process Piping
- ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications
- ASTM A234 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

### 3.3 THE PROJECT DOCUMENTS



- BK-GNRAL-PEDCO-000-PR-DB-0001 Process Basis of Design
- BK-GNRAL-PEDCO-000-PI-SP-0006 Specification for Painting
- BK-GNRAL-PEDCO-000-PI-SP-0008 Specification For Material Requirements in Sour Service
- BK-PPL-PEDCO-320-PL-SP-0001 Pipeline Material Specification

### 3.4 ENVIRONMENTAL DATA

Refer to "Process Basis of Design; Doc. No. BK-GNRAL-PEDCO-000-PR-DB-0001"

### 3.5 ORDER OF PRECEDENCE

In case of any conflict between requirements specified herein & the requirements of any other referenced document, this subject shall be reflected to CLIENT and the final decision will be made by CLIENT.

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## 4.0 DESIGN BASIS

### 4.1 GENERAL

Materials selection has been used as the primary means of corrosion control. Various types of short-and-long-term undesirable metallurgical changes and corrosion that may be induced during fabrication and/or services have been taken into consideration.

Where necessary the selection of materials is combined with other corrosion control measures such as corrosion allowance, metallic cladding, internal and external protective coatings, hot insulation, corrosion inhibitors, and cathodic protection, to ensure design service life.

All materials selected for wet H<sub>2</sub>S environments shall be fully in compliance with NACE MR175/ISO15156 and "Specification For Material Requirements in Sour service; Document No. BK-GNRRAL-PEDCO-000-PI-SP-0008"

### 4.2 DESIGN LIFE

A total design life of 25 years has been considered based on "Process Basis of Design; Doc. No. BK-GNRRAL-PEDCO-000-PR-DB-0001".



### 4.3 CORROSION ALLOWANCES

Corrosion allowances have been based on achieving the design life stated in the above Section.

Unless stated otherwise the minimum corrosion allowances for equipment are as follows:

CLASS	AVERAGE CORROSION RATE (mm/year)	CORROSION ALLOWANCE (mm)
A-mild corrosion	<0.05	1
B-medium	0.05-0.15	3
C-sever	0.15-0.30	6

Carbon steel major equipment and piping items, taking into account also corrosion inhibition if applicable, that have calculated a corrosion allowance in excess of 6.0 mm have been upgraded to CRAs, solid or cladded, or provided with a protective coating.

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#### 4.4 PRODUCED FLUID

The plant feed contains a significant fraction of both acid gasses CO<sub>2</sub> and H<sub>2</sub>S, the first of these two corrosive species resulting in general corrosion, the latter involving risk of sulfide stress corrosion cracking hence NACE MR0175/ISO15156 requirements shall be considered.



On the basis of the fluid composition data coming from gas wells, a process simulation have been carried out for the process and CO<sub>2</sub> and H<sub>2</sub>S molar contents in the process streams have been estimated and reported in the process data.

#### 5.0 CORROSION PHILOSOPHY

Equipment and pipes are susceptible to various kinds of corrosion in different media, internally and externally. Some types of corrosion gradually reduce the thickness and strength of the equipment material and this may cause breakdown and failure during working period of the plant. Thus, for safe design of the plant an estimation of corrosion rate is necessary, so as to make allowance for corrosion during operation period of the plant and to foresee some controlling measures for corrosion, if necessary.

Different types of corrosion that are probable for a pipeline containing gas, hydrocarbons and common impurities are as follows:

- External Corrosion
  - Internal Corrosion
- 1- Uniform attack corrosion by CO<sub>2</sub>
  - 2- Galvanic Corrosion
  - 3- Pitting and crevice
  - 4- Under deposit corrosion
  - 5- Corrosion by Oxygen
  - 6- Erosion corrosion
  - 7- Sulfide Stress corrosion cracking(SSC)
  - 8- Stepwise cracking
  - 9- Chloride Stress Corrosion Cracking (CSCC)
  - 10- Microbiologically induced corrosion(MIC)

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Presence of H<sub>2</sub>S, CO<sub>2</sub>, water, and salt in handled gas usually increases the rate of corrosion, but the dependence of corrosion rate to each of these parameters follows complicated trends and it depends also on the other parameters, like temperature and pressure for a particular alloy. The following parts of the report investigate different aspects of the corrosion problem and provide the results of preliminary calculations of corrosion rate.

### 5.1 EXTERNAL CORROSION

All above-ground tanks, vessels, separators, piping, piping components shall be protected from external corrosion using paint schedule as per standard "BK-GNRAL-PEDCO-000-PI-SP-0006".

Some CRAs like austenitic stainless steel are susceptible to pitting due to chlorides. Further, if piping were to be insulated, it is necessary to specify (and ensure) use of chloride-free insulation otherwise the combination of external coating of austenitic stainless steel piping and thermal insulation might protect the piping total protection against Chloride Stress Corrosion Cracking (CSCC) and make the use of 304L and 316L viable.

All buried metallic pipelines and flow lines shall be externally coated and shall be protected by using cathodic protection system.

### 5.2 UNIFORM ATTACK CORROSION



Uniform attack on metal is the common form of corrosion characterized by a chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface. The metal becomes thinner and eventually fails.

Uniform corrosion arises from the presence of carbon dioxide (CO<sub>2</sub>) in a wet or condensing water-saturated hydrocarbon process stream. CO<sub>2</sub> can dissolve in water to form carbonic acid.

CO<sub>2</sub> corrodes carbon steel bringing to a loss of thickness in lines and equipment. The rate of attack may be modified by dissolved salts and liquid hydrocarbons, and usually becomes more rapid with increase in pressure (partial pressure of acid gas). Temperature can lead to the formation of a stable protective layer of FeCO<sub>3</sub> on the steel surface. High fluid velocities, however, can destroy the film by erosion effects.

The rate of uniform corrosion depends primarily on the concentration of H<sub>2</sub>S, CO<sub>2</sub>, and water in handled gas. Actually, the influence of CO<sub>2</sub> on corrosion rate depends on the concentration of H<sub>2</sub>S in a complicated way. For example, corrosion rate of carbon steel resulted from CO<sub>2</sub> gas, may increase in the presence of H<sub>2</sub>S, but the relation between corrosion rate and H<sub>2</sub>S concentration follows a very complex scheme. The presence of water in the system also aggravates the effect of CO<sub>2</sub> on corrosion.



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Mitigation of this form of corrosion can be achieved by inhibitor injection and/or avoiding stagnation of water. Presence of oil and temperature above 60 °C may be beneficial.

CO<sub>2</sub> corrosion is generally assumed to be eliminated when the chromium level in the material is at least 13%.

The rate of carbonic acid corrosion can be predicted for carbon steel by semi-empirical calculation models.

According to IPS-E-TP 740, the minimum corrosion allowance for uniform corrosion, to be considered for piping and equipment, depends on the required service life of the piping and equipment multiplied by the expected corrosion rate under process conditions.

$$C.A \text{ (in mm)} \geq \text{Life (year)} \times C.R \text{ (mm/y)}$$

Where:

C.A = Corrosion allowance

C.R = Corrosion rate



According to the above equation the following classes shall be considered for piping and equipment with a design life of 20 years.

Where the corrosion rate is more than 0.3 mm/y or the total corrosion over the design life exceed 6 mm then use of inhibitor injection, Corrosion resistance linings or solid corrosion resistance material shall be evaluated. For piping minimum corrosion allowance of 1 and 3 mm for sweet and sour services respectively shall be considered according to related IPS standard which has been mentioned in codes and standards. Vessel corrosion allowance shall be provided to all non-removable internal parts and removable parts.

All specified minimum corrosion allowance which mentioned above shall be considered when calculated corrosion allowance was less than specified minimum corrosion allowance.

### 5.3 GALVANIC CORROSION

Galvanic corrosion results when dissimilar metals form a corrosion cell or couple. This cell results when metals with different electrochemical potentials are immersed in an electrolyte. If the two metals are connected electrically, electrons will flow in the metallic circuit to the cathode from the anode.

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The tendency of a metal to corrode in a galvanic cell is determined by its position in the “galvanic series” (or electrochemical series) of metals and alloys. A metal tends to corrode when connected to a metal more cathodic than it (above it on the table). The farther apart the metals are in the series, the more tendencies there is for corrosion of the more anodic metal.

The rate of corrosion resulting from galvanic action depends upon the relative exposed areas of the two metals in contact. The use of corrosion at the anode to protect the cathode is the basis for cathodic protection by sacrificial galvanic anodes.

Galvanic corrosion is not limited to cells in which totally dissimilar metals are in contact while exposed to an electrolyte. Differences in the composition or surface condition of otherwise similar metals often result in galvanic corrosion cells.

The conductivity of a solution (electrolyte) in which dissimilar metals are placed will have a significant effect on the corrosion rate. For example, more galvanic corrosion problems occur in saltwater, because of its higher conductivity, than in fresh water.



In summary, galvanic attack is minimized or prevented by:

- Avoiding unfavorable metal combinations, that is, metals far apart in the galvanic series
- Avoiding combinations involving relatively small areas of the more active (anodic) metal
- Where material change from carbon steel to CRA, “ISOLATION KIT” shall be used to prevent contact (and completion of the electrical circuit) between dissimilar metals
- Avoid coating the anode of the couple. This is important because gaps in the coating will expose small areas of anode creating unfavorable anode-to-cathode areas. Coat the cathode to reduce galvanic corrosion

#### 5.4 PITTING AND CREVICE

Pitting is a localized corrosion that makes holes in the metal. Often, pitting is caused by chlorides, particularly on stainless steels. Pitting usually occurs in stagnant conditions, and the pitted metals will show little general or uniform corrosion. It causes pipe to fail because of perforation with only a small percent weight loss of the entire pipeline.

The contemporary presence of H<sub>2</sub>S and chlorides in an aqueous medium can lead to pitting and crevice corrosion of CRAs. Chloride doesn't participate directly in the electrochemical corrosion reaction but can catalyze the breakdown of the passive film of stainless alloys or the formation of surface pits, with or without crevices.

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The occurrence of pitting depends on the temperature, chloride concentration, H<sub>2</sub>S partial pressure and local flow conditions and can be avoided selecting materials having an appropriate Pitting Resistance Equivalent Number (PREN).

Crevice is less dramatic in sour environments than in oxygen-bearing environments such as sea water. It consists in a later stage of pitting thus it is usually prevented by preventing pitting itself.

#### 5.4.1 PREVENTATION

The methods suggested for combating crevice corrosion generally apply also for pitting. Materials that show tendencies to pit, during corrosion tests shall not be used to build the plant under consideration.

Adding inhibitors is sometimes helpful, but this may be a dangerous procedure unless attack is stopped completely. If it is not, the pitting may be increased.



Where the corrosion problem is not uniform, and is localized such as; stress corrosion cracking, pitting, crevice, sulphide stress cracking, etc.; the material selection shall be on the basis of specific corrosion problem. As a general rule, stainless steels should be avoided in chloride-containing aqueous solutions if the fluid velocity is less than 1 m/s. Saline waters, even at ambient temperature, require the use of materials with PREN > 40, Ni-Crbase alloys or Titanium alloys.

#### 5.5 UNDER DEPOSIT CORROSION

Deposits can not only reduce heat transfer and cause restricting flow problems, but corrosion; specifically under-deposit corrosion can lead to some significant damage. This corrosion can occur both directly and indirectly.

When the attack is direct, the deposit itself contains corrosive substances which when concentrated at a localized or generalized site can cause wastage. An example of such a deposit would include chlorides.

Indirect attack is more commonly associated with under-deposit corrosion. This wastage occurs when the accumulation of deposits shields the covered surface from the bulk water system. Corrosion occurs on a metal surface due to some inherent or environmental difference between one area on that surface and another. These differences will create anodic and cathodic areas, setting up a basic corrosion cell. The anode is the area at which the metal is lost. The electrons given up by the metal flow to the cathode to be consumed in a reduction reaction. The growth of bacteria and formation of biofilms may also result in under-deposit corrosion.

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Biofilms are notorious for not only acting like a deposit and instigating corrosion and heat inefficiencies, but also for entrapping suspended debris. Biofilms are also capable of the formation of mineral scales by engulfing ions like calcium and magnesium. The trapped ions are now more readily available for a reaction with carbonate and phosphate anions.

Whether the scale or debris accumulation or the biofilm occurred first each is most likely present in even a moderate accumulation. These accumulations inhibit full penetration of biocides and corrosion inhibitors, thus accelerating anaerobic growth underneath deposits and corrosion. Sulfate-reducing bacteria are especially active in covered, anaerobic areas. These organisms reduce sulfate compounds to sulfuric acid and hydrogen sulfide, both creating an acidic attack on the metal surface.

Scale and debris accumulation should be removed and cleaned regularly to prevent under deposit corrosion.

## 5.6 CORROSION BY OXYGEN

Oxygen is strong oxidant and reacts with the metal very quickly. The dissolved Oxygen in the formation/produced water is one of the primary causes of corrosion in the production equipment. Although Oxygen is not present in the well fluids, Oxygen ingress takes place in the well fluids through leaking pump seals, casing and process vents, open hatches. The forms of corrosion associated with Oxygen are mainly uniform corrosion, pitting type corrosion.

Oxygen is directly involved in the corrosion reaction and promotes general corrosion of steel and localized corrosion and cracking in stainless steels.

One of the prevention provisions is to inject Oxygen scavenger in disposal water.



## 5.7 EROSION

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a metal because of relative movement between a corrosive fluid and the metal surface. This kind of corrosion is induced by high flow velocities and can be avoided by keeping flow velocity at less than a critical limit.

Erosion is the physical removal of wall material by the flowing process fluids. Erosion is a complex issue; dictated by fluid phase, flow regime, density, solids content, solids hardness, solids geometry, and flow corrosivity (erosion - corrosion).

Potential mechanisms that could cause significant erosion damage are:

- Particulate erosion

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- Liquid droplet erosion

It is generally accepted that particulates (sand & ...) are the most common source of erosion problems in gas and hydrocarbon systems. Because of the absence of particulate in handled gas particulate erosion cannot take place in present case. Droplet erosion is obviously confined to wet gas and multiphase flows in which droplets can form. The erosion rate is dependent on a number of factors including the droplet size, impact velocity, impact frequency, and liquid and gas density and viscosity.

### 5.8 SULFIDE STRESS CORROSION CRACKING

The electrochemical reaction between the metal and an aqueous H<sub>2</sub>S-bearing environment leads to the formation of atomic hydrogen that can enter the steel at the corroding surface.

The presence of hydrogen in the steel may cause embrittlement and cracking depending on the steel type, microstructure and residual or applied stresses.



The Sulfide Stress Cracking (SSC) occurs when the atomic hydrogen diffuses into the crystal lattice where it remains in solid solution and promotes dislocations that propagate following the stresses present into the metal structure and due to the mechanical assembling of the line/equipment or followed to a fabrication/welding process. With the reduction in ductility and deformability the embrittled metal can easily and rapidly crack leading to a catastrophic failure.

Tendency to give SSC increases if hard phases are present in the metal structure. The phases can be inherently present, for example, in high strength low alloy steels or they can form due to incorrect heat treatment. Limiting hardness, particularly in HAZs, of metals exposed to sour environments is an effective way to control SSC or at least to reduce its likelihood. High strength metallic materials and hard weld zones are prone to SSC.

SSC can develop both in CS and in CRA but in the latter case the presence of chlorides is fundamental and has been taken into account in selecting materials. A widely accepted guideline to avoid SSC is given in the Standard NACE MR0175/ISO 15156.

### 5.9 STEPWISE CRACKING

Also known as HIC, the Stepwise Cracking (SWC) is encountered mainly in steel lamination products (plates and welded tubes) as they contain in the metal matrix planar inclusions of manganese sulfides whose particular form promote collection and recombination of atomic hydrogen to molecular hydrogen. Where this phenomenon occur internal stresses are generated

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in microscopic voids at interfaces between the inclusions and the matrix and cracks may develop with first a crack initiation phase and then propagation along the metallurgical structures sensitive to this type of hydrogen embrittlement, linking each other in a characteristic stepped appearance. HIC can be avoided using clean steels, that is steel characterized by low sulfur contents and globular-shape (instead of planar) inclusions of manganese sulfide, minimizing segregations and microstructural discontinuities, to reduce the availability of crack initiation sites.

HIC may arise without the concurrence of external or residual stresses. The most susceptible materials are rolled steels whereas the likelihood of HIC occurrence in seamless and forged pipes is lower than in welded pipes.

SOHIC is another form of HIC in which it assumes a typical ladder-like array.

## 5.10 CHLORIDE STRESS CORROSION CRACKING



CSCC is the most common form of SCC. It requires the contemporary presence of water, oxygen and chlorides in contact with a stressed material. The stresses can be due to mechanical load, pressure load or can be induced by the fabrication processes (welding, cold working, etc.).

In neutral aqueous solutions the susceptibility of a given alloy to chloride-induced corrosion depends mainly from the temperature of the system. Austenitic (AISI 300 series) and austenitic-ferritic stainless alloys are particularly prone to crack by CSCC, in fact they have been classified based on the maximum temperature at which they can be exposed in presence of chlorides and oxygen.

All Materials for sour service shall comply fully with requirements and recommendations of the ISO 15156 Standard for resistance to all mechanisms of cracking that can be caused by H<sub>2</sub>S, 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).

## 5.11 MICROBIOLOGICALLY INDUCED CORROSION

Microbes commonly found in oil and gas systems are sulfate-reducing bacteria (S.R.B) and acid-producing bacteria (A.P.B). Some of the bacteria are plank tonic, free floating in the liquids; others are sessile and are attached to the surfaces in the system. Samples of the liquids indicate

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the presence of the plank tonic bacteria; however, their presence does not necessarily indicate that microbiologically influenced corrosion has or will occur. M.I.C is usually found in aqueous environments or services where water is always or sometimes present; especially where stagnant or low flow conditions allow and/or promote the growth of microorganisms e.g. bottom water of storage tanks, piping with stagnant or low flow, and piping in contact with some soils. The following shall be considered to prevent M.I.C.

- Systems that contain water (cooling water, storage tanks, etc.) should be treated with biocides such as chlorine, bromine, ozone, ultraviolet light or proprietary compounds.
- Minimize low flow or stagnant zones.
- Systems that are not designed or intended for water containment should be kept clean and dry.
- Empty hydro test water as soon as possible. Blow dry and prevent moisture intrusion.
- Wrapping and cathodically protecting underground structures have been effective in preventing M.I.C.

## 6.0 CORROSION CONTROL

### 6.1 GENERAL PHILOSOPHY



CRAAs, solid or clad, or internally lined carbon steel have been selected where bare carbon steel with a high corrosion allowance cannot provide the required design life.

In addition to material selection the following measures have been properly taken into account to combat and to control internal corrosion:

- Chemical injection
- Internal and external coating
- Cathodic protection

### 6.2 CORROSION INHIBITION

Inhibitor treatment is intended as corrosion control technique to mitigate corrosion of carbon steel (CO<sub>2</sub> corrosion in particular). For an inhibitor to work effectively it must be absorbed on to all wetted surfaces and under the system conditions it must be sufficiently effective to maintain a protective film on the surface to provide adequate protection. Areas which cannot be inhibited effectively will either be in CRA, as solid or clad, or have high corrosion allowance made for reduced inhibitor effectiveness. The efficacy of the inhibitor is affected by the temperature, inhibitor concentration, flow regime and phase behavior.

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In wet gas streams corrosion inhibitor may be injected only where unexpected water condensation, even for short periods, may cause severe corrosion on carbon steel.

The Corrosion Injection selection has been prescribed as a precautionary measure for wet oil and water lines where bare carbon steel selection may not be fully adequate to provide the desired design life because of the uncertainty of formation water chemical analysis.

Monitoring points aimed at verifying the treatment efficiency shall be at least 5 meters or 10 times of O.D. (which is greater) downstream the corrosion inhibitor injection points for assuring an effective mixture. Individual distance between corrosion probe and coupons shall be 0.5 meter for each pipe. The final Corrosion Injection locations have been marked on the Material Selection Diagram. The exact location of probes and injection points will be finalized in detail design based on defining high risk locations.

### 6.3 CORROSION INHIBITORS

It has been common practice for many years to inject corrosion inhibitors into CO<sub>2</sub> containing production tubing and process streams carried by carbon steels.

Corrosion inhibitors are chemicals which may be divided in a few categories. Among these, the most used class in horizontal flow lines/pipelines is the film forming amine type.

The effect of film forming inhibitor is thus to establish a first layer of flat molecules just on the steel surface, a second layer of aliphatic tails and a third layer of oil/condensates. Water cannot thus reach the steel surface and promote corrosion.



### 6.4 COATINGS

Non-metallic internal coatings have been specified to mitigate corrosion in large carbon steel equipment, like vessels and sumps, where liquid stagnant conditions could lead to corrosion rates higher than the required design life, fluid temperature allows coating application and CRA selection is not a viable alternative.

### 6.5 CATHODIC PROTECTION

Cathodic protection systems could be considered both for external and internal corrosion control of carbon steel and low alloy equipment.



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BK	PPL	PEDCO	320	PI	RT	0001	D02											

## 7.0 CORROSION CALCULATION SOFTWARE

PREDICT 6.1 encapsulate state-of-the-art corrosion prediction technologies, and includes critical, hitherto unavailable data on various aspects of corrosion prediction of carbon steels for production and transmission applications. PREDICT 6.1, a by-product of years of corrosion research and modelling, incorporates a completely re-worked and enhanced user interface to provide access to a comprehensive knowledge base on corrosion decision-making. It is an easy-to-use tool that integrates effects of a complex set of environmental parameters on carbon steel and low alloy steels to provide corrosion rate quantification based on extensive Joint Industry Program (JIP) data and laboratory evaluation, as well as data from literature and field experience. PREDICT 6.1 has predicted very practical general corrosion and pitting probability. Considering above points results of PREDICT 6.1 been considered as the basis of material selection. The results of this software are in section 8.4.

## 8.0 SELECTED MATERIAL SYSTEMS

### 8.1 PROCESS SYSTEM

According to corrosion mechanism in above the calculation is considered. Regarding NACE materials requirements when specified in the process streams, materials should have adequate resistance to the various forms of Sulphide attack, including

- Sulphide Stress Cracking (SSC)
- Hydrogen Induced Cracking (HIC)



### 8.2 PIPING SYSTEM

The system is normally not flowing, so carbon steel with 3.0 & 6.0 corrosion allowance can be selected for above ground drains. The same applies to vent system and pipe work.

Material selection for the utilities system equipment is the following table.

### 8.3 PROCESS EQUIPMENT (PIG LAUNCHER, PIG RECEIVER)

The minimum corrosion allowance for carbon steel shall be 1.6 mm for sweet service and 3.2 mm for sour service unless otherwise specified.(IPS-G-ME-150-1).

 <b>NISOC</b>	<b>نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض</b>								
	<b>احداث خطوط انتقال گاز/مابعات گازی از ایستگاه تقویت فشار گاز بینک تا ایستگاه تزریق گاز سیاهمکان/واحد بهره برداری بینک</b>								
شماره پیمان: 053-073-9184		<b>CORROSION STUDY &amp; MATERIAL SELECTION REPORT</b>						شماره صفحه : 18 از 18	
		پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک		
		BK	PPL	PEDCO	320	PI	RT	0001	D02

Equipment Tag.	Description	Fluid	NACE	CA	Base Material
<b>PL-3201 PR-3202</b>	Gas Pipeline Pig Launcher/Receiver	Hydrocarbon Gas	Yes	3.2 mm	CS

## 8.4 PIPELINE

Lines corrosion circuit is comprised as below table with the results Predict 6.1 software for Gas Pipeline.

Predict 6.1 Results for Gas Pipeline

Pipeline	Size (in)	Press. (Bara)		Temp (°C)				Dew Point (°C)		PREDICT 6.1 Results mm/year		corrosion mm/25 years (For Worst Case)	Corrosion Inhibitor Injection (Yes/No)	Corrosion mm/25 years (If CI required)	Selected Material+ Corrosion Allowance	NACE MR 0175
				S		W		S	W	S	W					
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet									
Gas PPL to Siahmakan	8	47	36	56.6	32	56.6	15.04	57.6	57.6	0.4	0.4	10.0	Yes	2.0	CS+6mm	Yes

## 9.0 ATTACHMENTS

Predict 6.1 (.prd) original files, PFD and P&ID has been attached to this document to support the results.