



SUBHOLDING
REFINING & PETROCHEMICAL

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ENGINEERING GUIDELINE


CORROSION PROTECTION REQUIREMENTS FOR PIPELINES

ENGINEERING TECHNICAL STANDARDS & PROCEDURES PT KILANG PERTAMINA INTERNASIONAL DIREKTORAT PROYEK INFRASTRUKTUR

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1. INTRODUCTION

1.1 This Engineering Guideline defines the minimum requirement for Corrosion Protection Requirements for Pipelines.

2. SCOPE

2.1 This document provides minimum requirements to control internal and external corrosion and cathodic protection system for onshore and offshore pipelines.

3. CONFLICTS AND DEVIATIONS

3.1 Any conflicts between this standard and other applicable Engineering Technical Standards & Procedures (ETSP), or OWNER standard, codes, and norms shall be resolved in writing by OWNER.

3.2 All direct requests to deviate from this standard (ETSP) in writing to OWNER, who shall follow internal OWNER procedure and forward such requests to OWNER for approval.

4. ABBREVIATIONS

4.1 Abbreviations used for this specification shall have the following definitions:

CP	Cathodic Protection
CRA	Corrosion Resistant Alloy
ILI	In-Line Inspection
MAOP	Maximum Allowable Operating Pressure
MIC	Microbiologically Influenced Corrosion (MIC)
MIGAS	Minyak dan Gas Bumi (Ministry

1. PENGANTAR

1.1 *Engineering Guideline* ini menetapkan persyaratan minimum untuk Persyaratan Proteksi Korosi pada *Pipeline*.

2. LINGKUP

2.1 Dokumen ini memberikan persyaratan minimum pengendalian korosi internal dan eksternal serta sistem *cathodic protection* untuk *onshore* dan *offshore pipeline*.

3. KONFLIK DAN DEVIASI


3.1 Apabila terdapat konflik antara standar ini dengan *Engineering Technical Standards & Procedures* (ETSP) lainnya yang diberlakukan, atau konflik dengan standar, kode dan norma-norma dari PEMILIK, maka harus diselesaikan secara tertulis oleh PEMILIK.

3.2 Semua permintaan deviasi terhadap standar (ETSP) ini, harus diajukan kepada PEMILIK secara tertulis dengan mengikuti prosedur internal PEMILIK untuk mendapatkan persetujuan.

4. SINGKATAN

4.1 Singkatan yang digunakan pada spesifikasi ini harus memiliki definisi sebagai berikut:

CP	<i>Cathodic Protection</i>
CRA	<i>Corrosion Resistant Alloy</i>
ILI	<i>In-Line Inspection</i>
MAOP	<i>Maximum Allowable Operating Pressure</i>
MIC	<i>Microbiologically Influenced Corrosion (MIC)</i>
MIGAS	Minyak dan Gas Bumi

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of ESDM)

(Kementerian ESDM)

UV Ultra Violet

UV Ultra Violet

5. DEFINITIONS

5.1 The following words shall have these special meanings when used herein:

OWNER Owner of the Plant is defined as PT Kilang Pertamina Internasional

**CONTRACTOR/
CONSULTANT** Defined as the Organization to which PT Kilang Pertamina Internasional assign the work

shall Indicates that the statement is mandatory

should Indicates a recommendation

Corrosion Deterioration of a material, usually a metal, that results from a reaction with its environment. For the purposes of this document, corrosion includes general and localized corrosion mechanisms, as well as environmental cracking mechanisms, including but not limited to Stress Corrosion Cracking (SCC), Sulfide Stress Cracking (SSC), *Hydrogen Induced Cracking* (HIC) and *Stress-Oriented Hydrogen Induced*

5. DEFINISI

5.1 Penggunaan kata-kata berikut harus memiliki arti khusus sebagai berikut:

PEMILIK Pemilik Kilang didefinisikan sebagai PT Kilang Pertamina Internasional


**KONTRAKTOR/
KONSULTAN** Didefinisikan sebagai Organisasi yang ditunjuk oleh PT Kilang Pertamina Internasional untuk melakukan suatu pekerjaan

shall Menunjukkan bahwa pernyataan itu wajib

should Menunjukkan rekomendasi

Corrosion Adalah proses kerusakan suatu bahan, biasanya logam, akibat reaksi bahan tersebut dengan lingkungannya. Untuk tujuan dokumen ini, korosi mencakup mekanisme korosi umum dan *local*, serta mekanisme *environmental cracking*, termasuk namun tidak terbatas pada *Stress Corrosion Cracking* (SCC), *Sulfide Stress Cracking* (SSC), *Hydrogen Induced Cracking* (HIC) dan *Stress-Oriented Hydrogen Induced*

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	<i>Cracking (SOHIC).</i>		<i>Cracking (SOHIC).</i>
In-Line Inspection	Internal inspection of a pipeline using an in-line inspection tool. Also called Intelligent or Instrument Pigging.	Inspeksi <i>In-line</i>	Inspeksi internal pada <i>pipeline</i> menggunakan alat inspeksi <i>in-line</i> . Disebut juga <i>Intelligent</i> atau <i>Instrument Pigging</i> .
In-Line Inspection Tool	Device or vehicle that is designed to travel through a pipeline and survey the condition of the pipeline wall using nondestructive examination (NDE) techniques. Also known as Intelligent or Instrument Pigging.	Alat Inspeksi <i>In-line</i>	Perangkat atau sarana yang dirancang dapat melintas melalui <i>pipeline</i> dan melakukan survei kondisi dinding <i>pipeline</i> menggunakan teknik NDE. Juga dikenal sebagai <i>Intelligent</i> atau <i>Instrument Pigging</i> .
Microbiologically Influenced Corrosion (MIC)	Corrosion mechanisms attributed to microorganisms and their by-products.	<i>Microbiologically Influenced Corrosion (MIC)</i>	Mekanisme korosi dikaitkan dengan mikroorganisme dan produk sampingannya.

6. CODES AND STANDARDS

The following Codes, Standard and Specifications apply to this specification. When an edition date is not indicated for a code or standard or any update in codes and standards in this specification document, the latest edition and addendum in force at the time of purchase shall apply. Material & equipment shall be as a specification or an equal approved by OWNER.

6.1 American Society of Mechanical Engineers (ASME)


ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
ASME B31.8	Gas Transmission and Distribution Piping

6. KODE DAN STANDAR

Kode, standar, dan spesifikasi berikut berlaku untuk spesifikasi ini. Kode dan standar harus menggunakan edisi yang terbaru atau edisi yang berlaku pada saat pembelian. *Material* & peralatan harus sesuai spesifikasi atau setara dengan yang disetujui oleh PEMILIK.


6.1 American Society of Mechanical Engineers (ASME)

ASME B31.4	<i>Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids</i>
ASME B31.8	<i>Gas Transmission and Distribution Piping</i>


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Systems	Systems
6.2 Deutsches Institut für Normung (DIN) DIN 30760 Polyethylene Coatings for Steel Pipes and Fitting-Requirement and Testing	6.2 <i>Deutsches Institut für Normung (DIN)</i> DIN 30760 <i>Polyethylene Coatings for Steel Pipes and Fitting-Requirement and Testing</i>
6.3 International Organization for Standardization (ISO) ISO 12944 Paints and Varnishes – Corrosion Protection of Steel Structures by Protective Paint System	6.3 <i>International Organization for Standardization (ISO)</i> ISO 12944 <i>Paints and Varnishes – Corrosion Protection of Steel Structures by Protective Paint System</i>
ISO 15589 Petroleum, Petrochemical and Natural Gas Industries – Cathodic (Part 1,2) Protection of Pipeline Transportation Systems	ISO 15589 <i>Petroleum, Petrochemical and Natural Gas Industries – Cathodic (Part 1,2) Protection of Pipeline Transportation Systems</i>
ISO 16276 Corrosion Protection of Steel Structures by Protective Paints Systems	ISO 16276 <i>Corrosion Protection of Steel Structures by Protective Paints Systems</i>
ISO 21809-1 Petroleum and Natural Gas Industries – External Coatings for buried or submerged Pipelines used in Pipeline Transportation Systems – Part 1: Polyolefin Coatings (3-Layer PE and 3-Layer PP)	ISO 21809-1 <i>Petroleum and Natural Gas Industries – External Coatings for buried or submerged Pipelines used in Pipeline Transportation Systems – Part 1: Polyolefin Coatings (3-Layer PE and 3-Layer PP)</i>
ISO 21809-2 Petroleum and Natural Gas Industries – External Coatings for buried or submerged Pipelines used in Pipeline	ISO 21809-2 <i>Petroleum and Natural Gas Industries – External Coatings for buried or submerged Pipelines used in Pipeline Transportation</i>

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	Transportation Systems – Part 2: Single Layer Fusion-Bonded Epoxy Coatings		<i>Systems – Part 2: Single Layer Fusion-Bonded Epoxy Coatings</i>
ISO 9223	Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Classification, Determination and Estimation	ISO 9223	<i>Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Classification, Determination and Estimation</i>
ISO 21457	Petroleum, Petrochemical and natural gas industries – Materials selection and corrosion control for oil and gas production systems	ISO 21457	<i>Petroleum, Petrochemical and natural gas industries – Materials selection and corrosion control for oil and gas production systems</i>
6.4 DNV		6.4 DNV	
DNV ST F101	Submarine Pipeline Systems	DNV ST F101	<i>Submarine Pipeline Systems</i>
DNV RP F101	Corroded Pipelines	DNV RP F101	<i>Corroded Pipelines</i>
DNV RP B401	Cathodic Protection Design	DNV RP B401	<i>Cathodic Protection Design</i>
DNV RP F103	Cathodic Protection of Submarine Pipelines	DNV RP F103	<i>Cathodic Protection of Submarine Pipelines</i>
DNV RP F106	Factory Applied External Pipeline Coatings for Corrosion Control	DNV RP F106	<i>Factory Applied External Pipeline Coatings for Corrosion Control</i>
DNV RP F112	Duplex Stainless Steel – Design against Hydrogen Induced Stress Cracking	DNV RP F112	<i>Duplex Stainless Steel – Design against Hydrogen Induced Stress Cracking</i>
6.5 European Standard (EN)		6.5 European Standard (EN)	
EN 12474	Cathodic Protection of Submarine Pipelines	EN 12474	<i>Cathodic Protection of Submarine Pipelines</i>
EN 12954	Cathodic Protection of	EN 12954	<i>Cathodic Protection of</i>

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Buried or Immersed
Metallic Structures –
General Principles and
Application for
Pipelines

*Buried or Immersed
Metallic Structures –
General Principles and
Application for
Pipelines*

6.6 The National Association of Corrosion
Engineers (NACE)

6.6 *The National Association of Corrosion
Engineers (NACE)*

NACE MR0103 Materials Resistant to
Sulfide Stress
Cracking in Corrosive
Refinery
Environments

NACE MR0103 *Materials Resistant to
Sulfide Stress Cracking
in Corrosive Refinery
Environments*

NACE MR0175 Petroleum and Natural
Gas Industries-
Materials for Use in
H2S ISO 15156
Containing
Environments in Oil
and Gas Production

NACE MR0175 *Petroleum and Natural
Gas Industries-
Materials for Use in
H2S ISO 15156
Containing
Environments in Oil and
Gas Production*

NACE SP 0169 Control of External
Corrosion on
Underground or
Submerged Metallic
Piping systems

NACE SP 0169 *Control of External
Corrosion on
Underground or
Submerged Metallic
Piping systems*

NACE SP 0286 Electrical Isolation of
Cathodically Protected
Pipelines

NACE SP 0286 *Electrical Isolation of
Cathodically Protected
Pipelines*

6.7 Norsok Standard

6.7 *Norsok Standard*

Norsok M-001 Materials selection

Norsok M-501 Surface preparation
and protective coating

Norsok M-001 *Materials selection*


Norsok M-501 *Surface preparation
and protective coating*

**7. PIPELINE INTERNAL CORROSION
PROTECTION**

**7. PROTEKSI KOROSI INTERNAL PADA
PIPELINE**

The internal corrosion of a pipeline is
determined by the internal operating
environment. This includes the operating
pressure, temperature, and the occurrence
of corrosive substituents in the internal

Korosi internal pada *pipeline* ditentukan oleh
kondisi operasi internal. Kondisi tersebut
termasuk tekanan operasi, temperatur, dan
terjadinya *substituent* yang korosif dalam
cairan internal.

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fluids.

The selection of internal corrosion protection methods shall be based on the results of the internal corrosion assessment.

The followings are several methods to be used as the internal corrosion protection system:

- To utilize the corrosion resistant material (Corrosion Resistant Alloys (CRA), cladding, etc)
- Physical treatments by removing the main corrosive elements or conditions (dehydration, CO₂ or H₂S removal, cooling, filtration, etc)
- To determine specific design requirements (allowable flow velocities, avoidance of water accumulation and trapping, prevention of air entries, etc)
- To determine the corrosion allowances
- To utilize the chemical treatments (inhibition, biocide, pH control, oxygen removal, etc)
- To apply internal coatings
- To utilize internal cathodic protection

The suitability and selection of the candidate pipeline materials were assessed as a minimum based on the following:

- Pertinent International Guidance Documents (i.e. ISO 21457, Norsok M-001)
- Corrosion Testing Data
- Behavior of materials in a certain


Pemilihan metode proteksi korosi internal harus didasarkan pada hasil *assessment* korosi internal.

Berikut ini adalah beberapa metode yang akan digunakan sebagai sistem proteksi korosi internal:

- Menggunakan material tahan korosi (*Corrosion Resistant Alloys* (CRA), *cladding*, dan lain-lain)
- Perlakuan fisik dengan menghilangkan elemen atau kondisi korosif utama (dehidrasi, penghilangan CO₂ atau H₂S, pendinginan, penyaringan/ filtrasi, dan lain-lain)
- Menentukan persyaratan desain khusus (kecepatan aliran yang diizinkan, menghindari akumulasi dan jebakan air, pencegahan masuknya udara, dan lain-lain)
- Menentukan *corrosion allowance*
- Menggunakan perlakuan kimia (penghambatan, biosida, kontrol pH, penghilangan oksigen, dan lain-lain)
- Menggunakan *internal coating*
- Menggunakan *cathodic protection* internal

Kesesuaian dan pemilihan kandidat bahan *pipeline* dinilai minimal berdasarkan hal-hal berikut:

- Dokumen Panduan Internasional Terkait (yaitu ISO 21457, Norsok M-001).
- Data hasil pengujian korosi
- Perlakuan bahan dalam kondisi

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environmental conditions

- The internal fluids properties to identify corrosive substituents

Level of CO₂ shall be identified as the corrosion severity increases with increasing CO₂ partial pressure and temperature.

Considering the risk of water remaining from hydrotest and the possibility of accidental introduction of water during flushing for subsea hoses replacement, the following are the minimum measures required:

- Avoid internal exposure of all items to raw seawater.
- If any item is expected to be exposed to raw seawater (e.g. when opening a tie-in subsea for further connection), use chemical treatments to minimize the corrosivity of seawater by inserting biocide or inhibitor sticks into opened pipework prior to sealing.
- Systems inboard of the last isolation valve before the sea should be kept positively pressurized to minimize leakage past the valve.
- Use gel plugs or isolation pigs to limit seawater ingress in areas where valves are not available.
- System should be designed to permit flushing where possible and flush the area with treated seawater after connection.


lingkungan tertentu.

- Sifat cairan internal untuk mengidentifikasi adanya *substituent* yang korosif.

Kandungan CO₂ harus diidentifikasi sebagai tingkat keparahan korosi yang meningkat dengan kenaikan tekanan parsial CO₂ dan kenaikan suhu.

Mempertimbangkan risiko adanya sisa air dari *hydrotest* dan kemungkinan masuknya air secara tidak sengaja selama proses *flushing* untuk penggantian *subsea hose*, berikut ini adalah tindakan minimum yang diperlukan :

- Menghindari paparan berbagai kontaminan dalam *pipeline* terhadap *raw seawater*.
- Jika ada kontaminan yang diperkirakan akan mengkontaminasi *raw seawater* (misalnya saat membuka *tie-in subsea* untuk dilakukan penyambungan lebih lanjut), gunakan *chemical treatment* untuk meminimalkan sifat korosifitas *seawater* dengan memasukkan batang *biocide* atau *inhibitor* ke dalam pipa yang terbuka sebelum dilakukan *sealing*.
- Sistem di dalam *isolation valve* terakhir sebelum ke laut harus dijaga tetap bertekanan positif untuk meminimalkan kebocoran melalui *valve*.
- Menggunakan *gel plug* atau *isolation pig* untuk membatasi masuknya *seawater* di area di mana *valve* tidak tersedia.
- Sistem harus dirancang agar dapat dilakukan *flushing* pada saat kondisi memungkinkan dan melakukan *flushing* pada area tersebut dengan *treated seawater* setelah penyambungan.


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In case there is excessive internal seawater, contingency plan must include:

- Recovery with treated seawater as soon as practical
- A formal assessment of the likely damage to the pipeline during the exposure to seawater and the need for any remedial inspection or repair
- The potential long-term impact of corrosion shall be considered during design, and it shall be demonstrated that the pipeline can remain fit-for-purpose throughout its lifetime.
- When sour service conditions are foreseen, as specified in NACE MR0175, the pipe material and other materials shall be specified to resist sour service, regardless of whether or not the fluid is to be dehydrated.
- Carbon steel pipe material may be used in "light" sweet corrosive conditions (typically where corrosion rates would not exceed 0.5 mm/year without inhibition), with appropriate corrosion allowance and inhibitor injection, regular high resolution intelligent pig monitoring, and under strictly controlled operating conditions.
- Corrosion allowances more than 3 mm shall not be considered without a detailed analysis by corrosion specialists. Materials able to resist sweet corrosion include duplex stainless steels and carbon steels with internal austenitic cladding.

Dalam hal terjadi *seawater* didalam pipa berlebihan, *contingency plan* harus mencakup :

- Pemulihan dengan *treated seawater* sesegera mungkin.
- Penilaian formal untuk mengonfirmasi kemungkinan kerusakan *pipeline* selama terpapar *seawater* dan perlunya inspeksi atau perbaikan.
- Potensi dampak korosi jangka panjang harus dipertimbangkan selama desain, dan harus ditunjukkan bahwa *pipeline* tetap sesuai untuk memenuhi fungsinya sepanjang masa pakainya.
- Jika kondisi *sour service* diperkirakan akan terjadi, seperti ditentukan dalam NACE MR0175, bahan pipa dan bahan lainnya harus ditentukan agar tahan *sour service*, terlepas apakah fluida tersebut akan mengalami dehidrasi atau tidak.
- Bahan pipa *carbon steel* dapat digunakan dalam kondisi korosif "ringan" (biasanya di mana laju korosi tidak melebihi 0,5 mm/tahun tanpa *inhibitor*), dengan *corrosion allowance* dan injeksi *inhibitor* yang tepat, pemantauan menggunakan *intelligent pig* resolusi tinggi secara teratur, dan dengan kondisi operasi yang dikontrol secara ketat.
- *Corrosion allowance* lebih dari 3 mm tidak boleh dipertimbangkan tanpa analisis rinci oleh spesialis korosi. Bahan yang mampu menahan *sweet corrosion* termasuk *duplex stainless steel* dan *carbon steel* dengan *internal austenitic cladding*.

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8. PIPELINE EXTERNAL CORROSION PROTECTION

The external corrosion mitigation shall be based on the external corrosion assessment that cover:

- Onshore or offshore environments
- Aerial, submerged or buried environments
- Transition zone between different types of environments (landfalls, splash zones, etc.)

The corrosion assessment in aerial environment shall be performed as per ISO 12944-2 and ISO 9223, with a classification from C1 to C5.

The corrosion assessment in buried environment shall be performed as per ISO 12944-2, with a classification from Im1 to Im3.

External corrosion protection system shall be based on a combination of material selection, painting or coating for aerial surfaces and coating and cathodic protection for buried or submerged pipeline/piping.

Technical requirements for the execution of painting works of new built offshore and onshore pipelines are in accordance to Specification for External Protection of Pipelines by Painting.

9. EXTERNAL COATING CORROSION PROTECTION

9.1 Pipeline External Corrosion Coating

The coating system applied to the pipeline

8. PROTEKSI KOROSI EKSTERNAL PADA PIPELINE

Mitigasi korosi eksternal harus didasarkan pada penilaian korosi eksternal yang meliputi :

- Kondisi lingkungan di *onshore* atau *offshore*
- Lingkungan udara, terendam atau tertanam/ terkubur.
- Zona transisi antara berbagai jenis lingkungan (*landfall, splash zone, dll.*)

Penilaian korosi di lingkungan udara harus dilakukan sesuai ISO 12944-2 dan ISO 9223, dengan klasifikasi dari C1 hingga C5.

Corrosion assessment di lingkungan tertanam/ terkubur harus dilakukan sesuai ISO 12944-2, dengan klasifikasi dari Im1 hingga Im3.


Sistem proteksi korosi eksternal harus didasarkan pada kombinasi pemilihan material, pengecatan atau *coating* untuk permukaan udara, serta *coating* dan *cathodic protection* untuk *pipeline/ piping* tertanam/ terkubur atau terendam.

Persyaratan teknis untuk pelaksanaan pekerjaan pengecatan *offshore* dan *onshore pipeline* yang baru dibangun sesuai dengan *Specification for External Protection of Pipelines by Painting* (Spesifikasi Perlindungan Eksternal *Pipeline* dengan Pengecatan).

9. PROTEKSI KOROSI PADA COATING EKSTERNAL

9.1 Coating korosi pada eksternal *pipeline*

Sistem *coating* yang diterapkan pada

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is the primary form of external corrosion prevention. The coating system is then supplemented by the cathodic protection system to protect areas where coating damage or deterioration has occurred. The application of high integrity coating system will significantly reduce the cathodic protection requirement and hence the necessary weight of anode material required for sacrificial anode CP.

If the pipelines requiring thermal insulation, the anti-corrosion coating must also able to form a good bond with the insulation coating.

The selection of suitable anti corrosion coating and field joint coating were considered based on coatings performance history at field and the behavior of the coating.

All the coatings have specified maximum operating temperature for constant exposure. Above these temperatures, the coating properties deteriorate, including general loss of mechanical properties such as adhesion, strength and impact resistance.

The followings are the desirable characteristics of coatings:

- 1) Effective electrical insulator
- 2) Effective moisture barrier
- 3) Applicability
- 4) Ability to resist development of holidays with time
- 5) Good adhesion to pipe surface

pipeline adalah bentuk utama pencegahan korosi eksternal. Sistem *coating* kemudian dilengkapi dengan sistem *cathodic protection* untuk melindungi area di mana kerusakan atau proses kerusakan *coating* telah terjadi. Penerapan sistem *coating* integritas tinggi secara signifikan akan mengurangi persyaratan *cathodic protection* dan karenanya diperlukan berat bahan anoda yang dibutuhkan untuk proteksi jenis *sacrificial anode CP*.


Jika *pipeline* membutuhkan insulasi termal, *coating* anti korosi juga harus dapat membentuk ikatan yang baik dengan lapisan insulasi tersebut.

Pemilihan *coating* anti korosi dan *field joint coating* (sambungan pipa yang dilakukan di lapangan) yang memadai telah dipertimbangkan berdasarkan riwayat kinerja *coating* di lapangan dan perlakuan *coating*.

Semua *coating* telah menentukan temperatur operasi maksimum untuk paparan konstan. Di atas temperatur ini, kemampuan *coating* akan menurun, termasuk hilangnya sifat mekanik secara umum seperti daya rekat, kekuatan dan ketahanan terhadap benturan.

Berikut ini adalah karakteristik *coating* yang diinginkan :

- 1) Insulasi elektrik yang efektif
- 2) Penahan/ penghalang kelembaban yang efektif.
- 3) Kecocokan penerapannya
- 4) Kemampuan untuk menahan berkembangnya *holiday (coating* yang, mengalami degradasi, tidak mencukupi atau diskontinyu) seiring berjalannya waktu.
- 5) Daya rekat yang baik ke permukaan

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- | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>6) Ability to withstand normal handling, storage (UV degradation) and installation</p> <p>7) Ability to maintain substantially constant electrical resistivity with time</p> <p>8) Resistance to disbonding</p> <p>9) Ease of repair</p> <p>10) Nontoxic interaction with the environment</p> | <p>6) Kemampuan untuk menahan kondisi <i>handling</i>, penyimpanan (degradasi UV) dan instalasi normal.</p> <p>7) Kemampuan untuk mempertahankan resistivitas listrik secara substansial konstan seiring berjalannya waktu</p> <p>8) Ketahanan terhadap daya rekat</p> <p>9) Kemudahan perbaikan</p> <p>10) Interaksi <i>non toxic</i> dengan lingkungan.</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Typical factors should be considered when selecting a pipe coating :

- 1) Type of environment
- 2) Accessibility of pipeline
- 3) Operating temperature of pipeline
- 4) Ambient temperatures during application, storage, shipping, construction and installation.
- 5) Geographical and physical location
- 6) Type of coating on existing pipeline
- 7) Handling and storage
- 8) Installation method
- 9) Costs
- 10) Pipe surface preparation requirements

The followings are the types of pipeline coatings and their characteristics:

- pipa
- Faktor-faktor yang umumnya harus dipertimbangkan ketika memilih *coating* pada pipa :

- 1) Tipe/ jenis lingkungan
- 2) Kemudahan akses *pipeline*
- 3) Temperatur operasi dari *pipeline*
- 4) Temperatur lingkungan sekitar selama aplikasi, penyimpanan, pengiriman, konstruksi dan pemasangan.
- 5) Lokasi geografis dan fisik
- 6) Jenis *coating* pada pipa *existing*
- 7) *Handling* dan penyimpanan
- 8) Metoda pemasangan
- 9) Biaya
- 10) Persyaratan *surface preparation* pada pipa

Berikut ini adalah jenis-jenis *coating* pada pipa dan karakteristiknya:


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Table 1.0 Types of Pipeline Coatings
Tabel 1.0 Jenis-jenis Coating pada Pipeline

No.	Pipe Coating Type Jenis Pipe Coating	Characteristic Karakteristik	Limitations Batasan
1.	Mill-applied tape systems. Sistem <i>tape</i> yang diterapkan di pabrik	<ul style="list-style-type: none"> 30+ years of use Pemakaian diatas 30 tahun Minimum holiday susceptibility Minimum kepekaan terhadap <i>holiday</i> Ease of application Mudah diterapkan Good adhesion to steel Daya rekat yang baik terhadap <i>steel</i> Low energy required for application Dibutuhkan energi yang rendah untuk aplikasinya 	<ul style="list-style-type: none"> Handling restrictions Kendala <i>handling</i> <ul style="list-style-type: none"> - Shipping and installation Pengiriman dan pemasangan UV and thermal blistering UV dan <i>thermal blistering</i> <ul style="list-style-type: none"> - Storage potential Potensi penyimpanan Shielding CP from soil Proteksi CP terhadap tanah Stress disbondment Pelepasan stres
2.	Fusion-bonded Perekatan proses fusi	<ul style="list-style-type: none"> 35+ years of use Pemakaian diatas 35 tahun Low current requirements Kebutuhan arus listrik rendah Excellent resistance to cathodic disbondment Daya tahan yang sangat baik terhadap lepasnya daya ikat secara <i>cathodic</i> Excellent adhesion to steel Daya rekat yang sangat baik terhadap <i>steel</i> Excellent resistance to hydrocarbons Daya tahan yang sangat baik terhadap <i>hydrocarbon</i> 	<ul style="list-style-type: none"> Exacting application parameters Parameter aplikasi yang tepat High application temperature Temperatur tinggi saat aplikasi Subject to steel pipe surface imperfections Tunduk pada ketidaksempurnaan permukaan pipa <i>steel</i> Lower impact and abrasion resistance Daya tahan abrasi dan benturan lebih rendah. High moisture absorption Penyerapan kelembaban tinggi.


Dokumen sesuai dengan aslinya, dicetak pada tanggal 11/06/2026 17:23:07 oleh

No.	Pipe Coating Type Jenis <i>Pipe Coating</i>	Characteristic Karakteristik	Limitations Batasan
3.	Layer of polyethylene (LPE) Lapisan <i>polyethylene</i> (LPE)	<ul style="list-style-type: none"> • Good clarity Kejelasan yang baik • Good moisture barriers Penahan kelembaban yang baik. • Can be heat sealed Bisa di <i>seal</i> dengan proses panas. • Strong and highly flexible Kuat dan sangat fleksibel • Low cost Biaya rendah • Easily processed films are soft and clear Lapisan <i>film</i> yang diproses dengan mudah, berkarakter lembut dan jernih • Lowest softening and melt point (good for heat-sealing) Titik pelunakan dan titik leleh terendah (baik untuk <i>sealing</i> dengan proses panas). • Compatible with most foods and household chemicals Kompatibel dengan sebagian besar makanan dan bahan kimia rumah tangga • Very high elongation (desirable for stretch wrap) Elongasi yang sangat tinggi (diinginkan untuk <i>stretch wrap</i>) 	<ul style="list-style-type: none"> • Fair gas barriers Penahan gas yang cukup • Very poor oxygen Oksigen yang sangat buruk.

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No.	Pipe Coating Type Jenis <i>Pipe Coating</i>	Characteristic Karakteristik	Limitations Batasan
4.	Layer of polypropylene (LPP) Lapisan <i>polypropylene</i> (LPP)	<ul style="list-style-type: none"> • Excellent moisture barrier characteristics Karakteristik penghalang kelembaban yang sangat baik • Good clarity Kejelasan yang baik • Good tensile strength Kekuatan Tarik yang baik • High melting point, which makes it desirable in packages that require sterilization at high temperatures Memiliki titik leleh tinggi, sehingga diperlukan pada kemasan yang memerlukan sterilisasi pada temperatur tinggi • Low cost Biaya rendah • Easily processed Prosesnya mudah • Good chemical compatibility Kompatibilitas yang baik terhadap bahan kimia. • Oriented PP (OPP) film is clear, stiff and glossy. Film Oriented PP (OPP) jernih, kaku dan mengkilap. • Forms best "integral hinge" when moulded Membentuk "engsel integral" terbaik saat dicetak • Higher softening point than PE (can be hot filled) Titik pelunakan lebih tinggi dibandingkan PE (dapat diisi media panas) 	<ul style="list-style-type: none"> • Average gas barrier properties Sifat penahan gas rata-rata • Three dimensional parts translucent, so colorants added Baggian 3 dimensi tembus pandang, sehingga pewarna ditambahkan • Brittle at low temperature Rapuh pada temperatur rendah • Poor oxygen barrier Penahan oksigen yang buruk

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Fusion Bonded Epoxy (FBE) based external anti corrosion coating for onshore or offshore carbon steel pipelines shall be plant applied and suitable for operating temperatures from -20°C up to +95°C. Manufacturing of the FBE based external anti corrosion coating shall be as per Project Specification for Fusion Bonded Epoxy (FBE) External Coating for Pipelines.

3 Layer Polyethylene (3LPE) based external anti corrosion coating for onshore or offshore carbon steel pipelines shall be plant applied and suitable for operating temperature from -40°C up to +80°C. Manufacturing of the 3LPE external anti corrosion coating shall be as per Project Specification for 3 Layer Polyethylene (3LPE) External Coating for Pipelines.

3 Layer Polypropylene (3LPP) based external anti corrosion coating for onshore or offshore carbon steel pipelines shall be plant applied and suitable for operating temperature from -20°C up to +95°C. Manufacturing of the 3LPP external anti corrosion coating shall be as per Project Specification for 3 Layer Polypropylene (3LPP) External Coating for Pipelines.

Lapisan anti korosi eksternal berbasis *Fusion Bonded Epoxy* (FBE) untuk *onshore* atau *offshore carbon steel pipeline* harus dipasang di pabrik dan cocok untuk temperatur operasi dari -20°C hingga +95°C. Pembuatan *coating* anti korosi eksternal berbasis FBE harus sesuai dengan dokumen "*Project Specification for Fusion Bonded Epoxy (FBE) External Coating for Pipelines*".

3 (tiga) lapisan *polyethylene* (3LPE) berdasarkan *coating* anti korosi eksternal pada *carbon steel pipeline* di *onshore* atau *offshore* harus diaplikasikan di pabrik dan cocok untuk temperatur operasi dari -40 °C hingga +80 °C. Pembuatan *coating* anti korosi eksternal 3LPE tersebut harus sesuai dengan dokumen "*Project Specification for 3 Layer Polyethylene (3LPE) External Coating for Pipelines*".

3 (tiga) lapisan polypropylene (3LPP) sebagai *coating* anti korosi eksternal pada *carbon steel pipeline* di *onshore* atau *offshore* harus diaplikasikan di pabrik dan cocok untuk temperatur operasi dari -20 °C hingga +95 °C. Pembuatan *coating* anti korosi eksternal 3LPP tersebut harus sesuai dengan dokumen "*Project Specification for 3 Layer Polypropylene (3LPP) External Coating for Pipelines*".

10. CATHODIC PROTECTION SYSTEM


10.1 Onshore Pipelines Cathodic Protection System

Cathodic protection system for onshore pipeline shall be in accordance with ISO 15589-1, "Petroleum, Petrochemical and Natural Gas Industries – Cathodic Protection of Pipeline Transportation Systems – Part 1 On-Land Pipelines and Project Specification for External Cathodic

10. SISTEM CATHODIC PROTECTION

10.1 Sistem Cathodic Protection pada Onshore Pipeline

Sistem *cathodic protection* untuk pipa *onshore* harus sesuai dengan ISO 15589-1, "*Petroleum, Petrochemical and Natural Gas Industries – Cathodic Protection of Pipeline Transportation Systems – Part 1 On-Land Pipelines and Project Specification for External Cathodic Protection of Onshore*

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Protection of Onshore Pipelines.”

In general, cathodic protection system design shall include the following activities:

- Site survey
- Design hypothesis, insulation assessment and surface calculation
- Detailed design calculation and installation drawing
- Installation procedure

As a minimum, the site survey shall include the list of low voltage power lines (to feed an impressed current DC source) and high voltage lines (that may have a detrimental influence), the list of existing cathodic protection equipment on other buried structures/pipelines, soil resistivity measurements, the list of anode ground bed possible locations, the list of test points location, list of permanent reference electrode location.

The onshore pipeline’s cathodic protection system shall be segregated from other metallic structures by the installation of insulating joints, especially at the followings:

- An area that is protected by impressed current from an area that is not protected
- Facilities arrival (plant, station, tank, etc.)
- Stations grounded to earth
- Shoreline interface
- Between pipeline sections with different owner

The onshore pipeline’s cathodic protection system shall be segregated from other

Pipelines.”

Secara umum, desain sistem *cathodic protection* harus mencakup aktivitas berikut:

- Survei lapangan
- Hipotesa desain, penilaian *insulation* dan perhitungan permukaan
- Perhitungan detail desain dan gambar instalasi
- Prosedur instalasi


Sebagai syarat minimal, survei lokasi harus mencakup daftar saluran listrik tegangan rendah (sebagai sumber listrik DC bagi sistem proteksi *impressed current*) dan saluran listrik tegangan tinggi (yang mungkin memiliki pengaruh yang merugikan), daftar peralatan *cathodic protection* eksisting pada struktur/ *pipeline* terkubur lainnya, pengukuran resistivitas tanah, daftar kemungkinan lokasi *anode ground bed*, daftar lokasi titik uji, dan daftar lokasi elektroda referensi permanen.

Sistem *cathodic protection* pada *onshore* harus dipisahkan dari struktur logam lainnya dengan pemasangan sambungan insulasi, terutama pada lokasi-lokasi berikut :

- Area yang terlindung oleh *impressed current* dari area yang tidak terlindung
- Fasilitas untuk kedatangan (kilang, *stasion*, tangki, dan lain-lain)
- *Stasion* yang dipasang *grounding* ke tanah
- *Shoreline interface*
- Antara bagian *pipeline* dengan pemilik yang berbeda

Sistem *cathodic protection* pada *onshore pipeline* harus dipisahkan dari struktur

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metallic structures by the installation of insulating joints, especially at the followings:

- An area that is protected by impressed current from an area that is not protected
- Facilities arrival (plant, station, tank, etc.)
- Stations grounded to earth
- Shoreline interface
- Between pipeline sections with different owner

10.2 Offshore Pipelines Cathodic Protection System

Cathodic protection system for offshore pipeline shall be in accordance with ISO 15589-2, "Petroleum, Petrochemical and Natural Gas Industries – Cathodic Protection of Pipeline Transportation Systems – Part 2 Offshore Pipelines and Project Specification for Design of Cathodic Protection of Offshore Pipelines."

Offshore pipelines shall be protected from sub-sea corrosion using a combination of external coatings and cathodic protection. The cathodic protection system shall be designed independently of the systems used to protect other structures or facilities to which they are connected.

The cathodic protection system shall be designed to maintain the exposed pipeline metal surfaces within an electrochemical potential range which controls corrosion within acceptable limits without causing material damage.

Cathodic protection system shall be designed for the full design life of the

logam lainnya dengan pemasangan sambungan insulasi, terutama pada hal-hal berikut:

- Area yang terlindung oleh *impressed current* dari area yang tidak terlindung
- Fasilitas untuk kedatangan (kilang, *stasion*, tangki, dan lain-lain)
- *Stasion* yang dipasang *grounding* ke tanah
- *Shoreline interface*
- Antara bagian *pipeline* dengan pemilik yang berbeda


10.2 Sistem *Cathodic Protection* pada *Offshore Pipeline*

Sistem *cathodic protection* untuk *offshore pipeline* harus sesuai dengan ISO 15589-2, "Petroleum, Petrochemical and Natural Gas Industries – Cathodic Protection of Pipeline Transportation Systems – Part 2 Offshore Pipelines and Project Specification for Design of Cathodic Protection of Offshore Pipelines."

Offshore pipeline harus diproteksi terhadap *sub-sea corrosion* dengan menggunakan kombinasi *external coating* dan *cathodic protection*. Sistem *cathodic protection* harus dirancang secara independen terhadap sistem *cathodic protection* yang digunakan untuk memproteksi struktur atau fasilitas lain yang terhubung.

Sistem *cathodic protection* harus dirancang untuk menjaga permukaan logam *pipeline* yang terpapar, agar tetap berada dalam *electrochemical potential range* yang berfungsi mengontrol korosi dalam batas yang dapat diterima tanpa menyebabkan kerusakan material.

Sistem *cathodic protection* harus dirancang untuk total umur desain dari *pipeline*.

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pipeline.

The recommended cathodic protection system for offshore pipelines features bracelet-type sacrificial anodes. The use of impressed current is not recommended except where successfully in use for existing pipelines and for retrofit purposes when sacrificial systems are not feasible.

Bracelet anodes shall be installed regularly along the pipeline length. The use of anodes sleds shall be reserved to specific cases or retrofit systems.

Sistem *cathodic protection* yang direkomendasikan untuk *offshore pipeline* memiliki fitur *bracelet-type sacrificial anode*. Penggunaan proteksi jenis *impressed current* tidak direkomendasikan kecuali telah terbukti berhasil digunakan pada *existing pipeline* dan untuk untuk tujuan *retrofit* ketika sistem *sacrificial anode* tidak bisa dilakukan.

Bracelet anode harus dipasang secara teratur di sepanjang *pipeline*. Penggunaan *anode sled* harus dipersiapkan untuk tujuan khusus atau sistem *retrofit*.