CATHODIC PROTECTION

ENGINEERING TECHNICAL STANDARDS & PROCEDURES

PT KILANG PERTAMINA INTERNASIONAL

DIREKTORAT PROYEK INFRASTRUKTUR

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DAFTAR ISI

1. INTRODUCTION

1.1 This General Specification establishes the minimum requirements for safe and reliable Electrical Distribution Board that meets the needs of the Project.

1. PENGANTAR

1.1 Spesifikasi umum ini menetapkan persyaratan minimum untuk *Electrical Distribution Board* yang aman dan mempunyai nilai keandalan serta memenuhi persyaratan dari Proyek.

2. SCOPE

2.1 This specification defines minimum requirements for Cathodic Protection design which will be applied in the Directorate of Infrastructure Project PT Kilang Pertamina Internasional (PT KPI).

2. LINGKUP

2.1 Spesifikasi ini mendefinisikan persyaratan minimum untuk *Cathodic Protection design* yang akan diterapkan dalam proyek di Direktorat Proyek Infrastruktur PT Kilang Pertamina Internasional (PT KPI).

3. CONFLICTS AND DEVIATIONS

3.1 Any conflicts between this standard and other applicable Engineering Technical Standards & Procedures (ETSP), or OWNER standard, codes, and forms 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.

3. KONFLIK DAN DEVIASI

3.1 Apabila terdapat konflik antara standar ini dengan *Engineering Technical Standards & Procedures* (ETSP) yang berlaku lainnya, atau standar PEMILIK, *codes* dan formulir, maka harus diselesaikan secara tertulis oleh PEMILIK.

3.2 Semua permintaan penggunaan standar yang berbeda dari standar ini (ETSP), harus diajukan kepada PEMILIK secara tertulis dengan mengikuti prosedur *internal* PEMILIK untuk mendapatkan persetujuan.

4. ABBREVIATIONS

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

AC	Alternating Current
DC	Direct Current
NACE	National Association of Corrosion Engineers
CP	Cathodic Protection
EVA	Ethylene-Vinyl Acetate

4. SINGKATAN

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

AC	*Alternating Current*
DC	*Direct Current*
NACE	*National Association of Corrosion Engineers*
CP	*Cathodic Protection*
EVA	*Ethylene-Vinyl Acetate*

ICCP	Impressed Current Cathodic Protection
IEC	International Electro technical Commission
IP	Ingress Protection
PVC	Polyvinyl Chloride
SACP	Sacrificial Anode Cathodic Protection
XLPE	Cross-linked polyethylene

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
PURCHASER/ BUYER	Defined as the Company / Organisation that placed the material requisition for equipment, materials or services
VENDOR/SUPPLIER/MANUFACTURER	Defined as the company selected to supply the equipment and service detailed in this

ICCP	*Impressed Current Cathodic Protection*
IEC	*International Electro technical Commission*
IP	*Ingress Protection*
PVC	*Polyvinyl Chloride*
SACP	*Sacrificial Anode Cathodic Protection*
XLPE	*Cross-linked polyethylene*

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
PEMBELI/ PEMBELI	Didefinisikan sebagai Perusahaan/ Organisasi yang menempatkan *material requisition* untuk peralatan, *material* atau servis
VENDOR/ PEMASOK/ PEMBUAT	Didefinisikan sebagai perusahaan yang dipilih untuk memasok peralatan dan *service*

specification.

Sub VENDOR/ Sub SUPPLIER: Is defined as any SUPPLIER of equipment and support services for a particular piece of equipment/ package to a VENDOR/ SUPPLIER.

yang dirinci dalam spesifikasi ini.

Sub *VENDOR*/ Sub PEMASOK: Didefinisikan sebagai PEMASOK peralatan dan layanan dukungan untuk bagian tertentu peralatan/ paket ke *VENDOR*/ PEMASOK.

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 Applicable Codes and Standards

NACE SP0572	Standard Practice "Design, Installation, Operation and Maintenance of Impressed Current Deep Ground Beds"
NACE SP0177	Standard Practice "Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems"
NACE SP0285	Standard Practice "Corrosion Control of Underground Storage Tank Systems by Cathodic Protection"

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 Kode dan Standar yang Berlaku

NACE SP0572	*Standard Practice "Design, Installation, Operation and Maintenance of Impressed Current Deep Ground Beds"*
NACE SP0177	*Standard Practice "Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems"*
NACE SP0285	*Standard Practice "Corrosion Control of Underground Storage Tank Systems by Cathodic Protection"*

NACE SP0286	Standard Practice "The Electrical Isolation of Cathodically Protected Pipelines"	NACE SP0286	*Standard Practice "The Electrical Isolation of Cathodically Protected Pipelines"*
NACE SP0193	Standard Practice "External Cathodic Protection of On-Grade Metallic Storage Tank Bottoms"	NACE SP0193	*Standard Practice "External Cathodic Protection of On-Grade Metallic Storage Tank Bottoms"*
NACE TM0497	Standard Test Method "Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems"	NACE TM0497	*Standard Test Method "Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems"*
BS EN 14505	Cathodic protection of complex structures	BS EN 14505	*Cathodic protection of complex structures*
API STD 651	Cathodic Protection of Aboveground Petroleum Storage Tanks	API STD 651	*Cathodic Protection of Aboveground Petroleum Storage Tanks*
ASTM B265	Standard Specification for Titanium and Titanium Alloy Strip, Sheet and Plate	ASTM B265	*Standard Specification for Titanium and Titanium Alloy Strip, Sheet and Plate*
ASTM B418	Standard Specification for Cast and Wrought Galvanic Zinc Anodes	ASTM B418	*Standard Specification for Cast and Wrought Galvanic Zinc Anodes*
ASTM G57	Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method	ASTM G57	*Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method*
ASTM B843	Standard Specification for Magnesium Alloy Anodes for Cathodic	ASTM B843	*Standard Specification for Magnesium Alloy Anodes for Cathodic*

	Protection		*Protection*
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable	ASTM D1248	*Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable*
UL 506	UL Standard for Safety Specialty Transformers	UL 506	*UL Standard for Safety Specialty Transformers*
IEC 60076	Power Transformers, Part 1 and 3	IEC 60076	*Power Transformers, Part 1 and 3*
IEC 60079	Explosive atmospheres - All Parts	IEC 60079	*Explosive atmospheres - All Parts*
IEC 60146	Semiconductor Converters, Part 1-1	IEC 60146	*Semiconductor Converters, Part 1-1*
IEC 60364	Electrical Installations for Buildings	IEC 60364	*Electrical Installations for Buildings*
IEC 60529	Degree of Protection Provided by Enclosures (IP Code)	IEC 60529	*Degree of Protection Provided by Enclosures (IP Code)*

6.2 This specification shall also be read in conjunction with all other specifications and data sheets attached to the material requisition. Any conflicts between the referenced documents shall be identified to the PURCHASER in writing for resolution. In general, when resolving conflicts the following order of precedence shall apply:

a. Data Sheets
b. Material Requisition
c. This Specification
d. Referenced Standards

6.2 Spesifikasi ini juga harus dibaca bersama dengan semua spesifikasi dan *data sheet* lain yang dilampirkan pada *material requisition*. Setiap konflik antara dokumen yang dirujuk harus diidentifikasi kepada PEMBELI secara tertulis untuk diselesaikan. Secara umum, ketika menyelesaikan konflik, urutan prioritas berikut akan berlaku:

a. *Data Sheet*
b. *Material Requisition*
c. *This Specification*
d. *Referenced Standard*

7. ENVIRONMENTAL CONDITIONS

7.1 Equipment shall be suitable for the relative humidity conditions as stated in IEC standards.

7. KONDISI LINGKUNGAN

7.1 Peralatan harus sesuai dengan kondisi kelembaban relatif seperti yang dinyatakan dalam standar IEC.

7.2 The atmosphere is to be considered saliferous and dusty.

7.2 Atmosfer harus dianggap *saliferous* dan *dusty*.

8. VENDOR QUALIFICATION

8.1 Design and Commissioning of CP systems shall be undertaken by experienced personnel certified by NACE International as an accredited CP Level 4 or equivalent.

8. KUALIFIKASI *VENDOR*

8.1 Desain dan *commissioning* sistem CP harus dilakukan oleh personel berpengalaman yang disertifikasi oleh NACE *International* sebagai CP *Level* 4 terakreditasi atau setara.

9. GENERAL

9.1 Cathodic protection (CP) shall be provided, as necessary, for the external surfaces or underground piping and selected equipment and structures, as follows:

a. external surface of underground piping systems;

b. external bottom plates of on-grade steel storage tanks.

9.2 The contractor shall be responsible for the detailed CP system design, layout, installation and commissioning including, but not limited to the following deliverables:

a. site survey to collect design data, including the soil resistivity as needed for design;

b. system design, including engineering calculations;

c. preparation of construction drawings and material specifications;

d. provide construction supervision;

e. pre-commissioning, commissioning and post commissioning surveys and reports.

9.3 Cathodic Protection System shall be Impress Current System (ICCP) for

9. UMUM

9.1 *Cathodic protection* (CP) harus disediakan, sebagaimana diperlukan, untuk permukaan eksternal atau pipa bawah tanah dan peralatan dan struktur yang dipilih, sebagai berikut:

a. permukaan eksternal sistem perpipaan bawah tanah;

b. pelat bawah eksternal dari tangki penyimpanan baja diatas tanah.

9.2 Kontraktor harus bertanggung jawab atas detail desain sistem CP, tata letak, instalasi dan termasuk juga *commissioning*, tetapi tidak terbatas pada hal-hal berikut:

a. *site survey* untuk mengumpulkan data desain, termasuk resistivitas tanah sesuai kebutuhan untuk desain;

b. desain sistem, termasuk; perhitungan *engineering*

c. persiapan gambar konstruksi dan spesifikasi *material*;

d. menyediakan pengawasan konstruksi;

e. *pre-commissioning*, *commissioning* dan *post commissioning survey* dan *report.*

9.3 Sistem *cathodic protection* harus *Impress Current System* (ICCP) untuk melindungi

protecting underground Fire Line and external bottom plates of on-grade steel storage tanks at the process area ISBL, Other area Sacrificial Anode (SACP) shall be used.

9.4 The following documents shall be submitted for approval as a minimum:

a. Soil resistivity survey and analysis, water analysis reports

b. Design calculations

c. Dimensional drawings for all equipment/ material, plot plan drawings, circuitry drawings, rectifier schematic and drawings

d. Material and equipment specifications, data sheets, and MSDSs

e. Shop and field-test/commissioning procedures

f. Installation Procedures, Operation and Maintenance Manual

g. Commissioning Report(s) and data

h. As-builts

10. DESIGN BASIS

10.1 The cathodic protection systems shall be designed for a minimum 20-year service life, except for sacrificial anode systems that will have shorter service lives if used for seawater immersion equipment.

10.2 The design CP current density shall not be less than 10 mA/m^2 for buried steel bare steel, including the external bottom plates of on-grade storage tanks.

10.3 -950mV to -1100mV polarized instant-off with respect to copper sulfate electrodes in general. If the potential cannot achieve -950mV, one of the following criteria shall be

fire line di bawah tanah dan pelat bawah eksternal dari tangki penyimpanan baja diatas tanah di area proses ISBL, untuk area lain *Sacrificial Anode* (SACP) harus digunakan.

9.4 Dokumen-dokumen berikut harus diserahkan untuk disetujui minimal:

a. Survei dan analisis *soil resistivity*, laporan analisis air.

b. Perhitungan desain

c. Gambar dimensi untuk semua peralatan/ *material*, gambar *plot plan,* gambar *circuit*, skema dan gambar *rectifier.*

d. Spesifikasi *material* dan peralatan, *data sheet*, dan MSDS

e. Prosedur *shop* dan *field-test/ commissioning*

f. Prosedur instalasi, operasi dan manual pemeliharaan

g. Laporan *commissioning* dan data

h. As-built

10. DASAR DESAIN

10.1 Sistem *cathodic protection* harus dirancang untuk *service life* minimal 20 tahun, kecuali untuk sistem *sacrificial anode* yang akan memiliki *service life* yang lebih pendek jika digunakan untuk peralatan *sea water immersion*.

10.2 Desain densitas arus CP tidak boleh kurang dari 10 mA/ m^2 untuk *buried steel bare steel*, termasuk pelat bawah eksternal tangki penyimpanan diatas tanah.

10.3 -950mV hingga -1100mV terpolarisasi *instant-off* dengan elektroda tembaga sulfat pada umumnya. Jika potensi tidak dapat mencapai -950mV, salah satu kriteria

achieved:

a. 100mV formation of polarization

b. 100mV decay of polarization

10.4 The minimum coating breakdown for externally coated buried structures shall be 1%.

10.5 Transformer rectifiers shall supply current for impressed current cathodic protection systems.

10.6 Conventional or specialty impressed current anodes may be used.

10.7 ICCP shall be used for the following:

a. Extensive underground piping systems that are electrically common with the buried copper earthing system

b. External bottom plate protection for tanks

10.8 Transformer rectifiers with a DC power shall be supplied with 3 phase, 380V/400 volt, 50 Hz AC power.

10.9 Rectifier and junction box enclosures shall be 316L stainless steel, in accordance with the specific project requirements. As a minimum, the enclosures shall be rated as IP 55, sized appropriately, and located in a non-hazardous area. Rectifier enclosures exposed to direct sun shall have sunshades or extended tops.

10.10 Standard bar tap adjustment constant voltage transformer rectifiers shall be used for all applications.

10.11 Transformer rectifiers and junction boxes shall be located in non-hazardous areas. If it becomes necessary to locate rectifiers or junction boxes in Hazardous classified locations appropriately rated explosion proof enclosures and fittings shall be used.

10.12 Transformer rectifiers shall be oil

berikut harus tercapai:

a. Pembentukan polarisasi 100mV

b. Kehilangan polarisasi 100mV

10.4 Kerusakan *coating* minimum untuk struktur yang dilapisi secara eksternal harus 1%.

10.5 *Transformer rectifier* akan mensuplai arus untuk sistem *impressed current cathodic protection.*

10.6 *Impressed current anodes* konvensional atau khusus dapat digunakan.

10.7 ICCP harus digunakan untuk hal-hal berikut:

a. Sistem perpipaan bawah tanah yang luas yang secara elektrik terhubung dengan sistem *buried copper earthing*.

b. Perlindungan pelat bawah eksternal untuk tangki

10.8 *Transformer rectifier* dengan DC *power* harus disuplai dengan 3 *phase*, 380V/ 400 *volt*, 50 Hz AC *power*.

10.9 *Rectifier* dan *junction box enclosure* harus 316L *stainless steel*, sesuai dengan persyaratan spesifik proyek. Minimal, penutup harus memiliki *rating* IP55, berukuran tepat, dan terletak di *area non-hazardous*. *Rectifier enclosure* yang terpapar matahari langsung harus memiliki *sunshade* atau *extended top.*

10.10 Pengaturan/ penyetelan standar *bar tap voltage transformer rectifier* tetap harus digunakan untuk semua aplikasi.

10.11 *Transformer rectifier* dan *junction box* harus terletak di *area non-hazardous*. Jika perlu untuk menempatkan *rectifier* atau *junction box* di lokasi yang diklasifikasikan *hazardous* harus menggunakan yang memiliki *rating explosion proof enclosure* dan *fitting.*

10.12 *Transformer rectifier* harus tipe *immersed*

immersed units.

10.13 Suitable earthing lug and lifting eye bolts or lugs shall be provided for each transformer rectifier unit.

10.14 The impact of the grounding system shall be accounted for when designing an ICCP system for buried piping networks that are electrically common with the earthing grid. CP current losses to the buried bare copper conductors, fence posts, metallic conduits etc., shall be accounted for in the design.

10.15 Zinc anodes shall conform to ASTM B418 and Magnesium anodes shall conform to ASTM B843.

10.16 Mixed metal oxide on titanium substrate anodes (MMO) in wire, mesh, grid, prepackaged, etc configurations, or conventional impressed current high silicon-chromium cast iron anodes shall be used for undergroound and external bottom plate CP systems.

10.17 The pipeline facilities shall be electrically isolated above grade from the plant facilities at the transition tie-ins by others.

10.18 Insulating joints or flanges shall be protected by overvoltage protectors (OVP) or DC decouplers.

10.19 All CP systems shall be designed to ensure they will adequately protect the intended structure.

10.20 Design calculations shall be performed to verify adequate anode life, the ground bed resistance, rectifier outputs, etc.

10.21 The initial design of any buried impressed current anode beds shall be directed to remote earth where practical. Maximum DC Voltage shall not exceed 50

oil.

10.13 *Earthing lug* yang cocok dan *lifting eye bolt* atau *lug* harus disediakan untuk setiap *unit transformer rectifier.*

10.14 Dampak dari sistem *grounding* harus dapat diperhitungkan ketika desain sistem ICCP untuk jaringan perpipaan bawah tanah yang secara elektrik terhubung dengan jaringan *earthing*. Kerugian arus CP ke konduktor *buried bare copper conductor*, *fence post, metallic conduit,* dll harus diperhitungkan dalam desain.

10.15 Anoda *zinc* harus sesuai dengan ASTM B418 dan anode *magnesium* harus sesuai dengan ASTM B843.

10.16 Mixed metal oxide (MMO) pada anoda substrat titanium dalam *wire, mesh, grid, prepackaged*, dll, konfigurasi, atau anoda *conventional impressed current high silicon-chromium cast iron* harus digunakan untuk sistem CP pelat dasar eksternal dan *underground.*

10.17 Fasilitas pipa harus terisolasi secara elektrik di atas permukaan tanah dari fasilitas kilang pada transisi *tie-ins* oleh yang lain.

10.18 Sambungan insulasi atau *flange* harus dilindungi oleh *Overvoltage Protector* (OVP) atau DC *decoupler*.

10.19 Semua sistem CP harus didesain untuk memastikan mereka akan melindungi struktur yang dimaksudkan secara memadai.

10.20 Perhitungan desain harus dilakukan untuk memverifikasi kecukupan umur anoda, *ground bed resistance*, *output rectifier*, dll.

10.21 Desain awal dari setiap *impressed current anoda bed* harus diarahkan ke *remote earth* jika memungkinkan. Tegangan DC maksimum tidak boleh

VDC.

10.22 The DC output capacity of the transformer rectifiers shall be a minimum of 25% greater than the design requirements.

10.23 Permanent reference electrodes shall be installed with all CP systems.

10.24 The other criteria listed in the applicable NACE Recommended Practices may be utilized, with sound engineering practices during the commissioning of the CP systems.

11. EQUIPMENT AND MATERIAL

11.1 The equipment and materials shall include, but are not limited to, the following:

a. Impressed Current Anodes;
b. Coke Breeze Backfill;
c. Junction Boxes;
d. Direct Burial DC Cable;
e. Rectifier Units;
f. Electrical Isolation Devices;
g. Insulated Conductors;
h. Test Stations;
i. Magnesium Anodes;
j. Zinc Ribbon;
k. Sacrificial Anode Backfill;
l. Shunts, Resistors;
m. Surge Protection Devices;
n. DC Decoupler Units.

11.2 Impressed Current Shallow Anodes - Conventional and Distributed for Underground Precious metal type mixed

melebihi 50 VDC.

10.22 Kapasitas *output* DC dari *transformer rectifier* harus minimal 25% lebih besar dari persyaratan desain.

10.23 Elektroda referensi permanen harus dipasang dengan semua sistem CP.

10.24 Kriteria lain yang tercantum dalam NACE *Recommended Practices* yang berlaku dapat digunakan, dengan praktik *engineering* yang baik selama *commissioning* sistem CP.

11. PERALATAN DAN *MATERIAL*

11.1 Peralatan dan *material* harus ada, tetapi tidak terbatas pada, berikut:

a. Impressed Current Anodes;
b. Coke Breeze Backfill;
c. Junction Boxes;
d. Direct Burial DC *Cable;*
e. Rectifier Units;
f. Electrical Isolation Devices;
g. Insulated Conductors;
h. Test Stations;
i. Magnesium Anodes;
j. Zinc Ribbon;
k. Sacrificial Anode Backfill;
l. Shunts, Resistors;
m. Surge Protection Devices;
n. DC *Decoupler Units.*

11.2 *Impressed Current Shallow Anodes - Conventional* dan *Distributed* untuk *Underground Precious metal type mixed*

metal oxide (MMO) on titanium substrate, or high silicon-chromium cast iron anodes shall be used.

11.3 Sacrificial Anode Backfill shall consisting of the following composition:

a. Ground Hydrated Gypsum: 75%;

b. Powdered Bentonite: 20%;

c. Anhydrous Sodium Sulfate 5%.

11.4 The backfill shall have a grain size such that one hundred percent (100%) is capable of passing through a 20-mesh screen and a 100-mesh screen shall retain fifty percent (50%). The prepackaged anode backfill mixture shall be firmly prepared around the anodes/ electrode(s) within a cotton bag.

11.5 Junction boxes shall be minimally rated at IEC, IP-55 and furnished with a continuous stainless steel piano hinge and a stainless steel draw pull latch with padlock hasp. The door shall open downward, with a lid retainer bracket (90 degrees). Junction boxes located in hazardous areas shall be stainless or galvanized steel enclosures rated for a Class I, Zone 2, Group IIA and IIB environment. Provisions for trimming resistors of suitable resistance and wattage shall be included on each branch circuit.

11.6 Conductors

10.6.1. All lead wires shall normally be of sufficient length to avoid the necessity of underground splices, except for sacrificial anode installations. If splicing becomes necessary, a suitable hydraulic press tool shall be used with an appropriate compression fitting. The splice shall be waterproofed with epoxy splice kits

metal oxide (MMO) pada *titanium substrate*, atau *high silicon-chromium cast iron anode* harus digunakan.

11.3 *Sacrificial anode backfill* harus terdiri dari komposisi berikut:

a. *Ground Hydrated Gypsum*: 75%;

b. *Powdered Bentonite*: 20%;

c. *Anhydrous Sodium Sulfate* 5%.

11.4 *Backfill* harus berukuran *grain*/ butiran sedemikian rupa sehingga seratus persen (100%) mampu melewati 20-*mesh screen* dan 100-*mesh screen* harus menahan lima puluh persen (50%). Campuran *anode backfill* yang sudah dikemas sebelumnya harus disiapkan dengan baik di sekitar anoda/ elektroda dalam *cotton bag.*

11.5 *Junction box* harus memiliki *rating* minimal IEC, IP-55 dan dilengkapi dengan *continuous stainless steel piano hinge* dan *stainless steel draw pull latch* dengan *padlock hasp*. Pintu harus terbuka ke bawah, dengan *lid retainer bracket* (90 derajat). *Junction box* yang terletak di *area hazardous* harus merupakan *stainless* atau *galvanized steel enclosure* yang memiliki *rating* untuk lingkungan *Class* I, *Zone* 2, *Group* IIA dan IIB. Ketentuan untuk *trimming resistor* dengan resistansi dan watt yang sesuai harus disertakan pada setiap sirkuit cabang.

11.6 Konduktor

11.6.1. Semua *lead wire* biasanya memiliki panjang yang cukup untuk menghindari kebutuhan *underground splice*, kecuali untuk instalasi anoda yang akan dikorbankan. Jika *splicing* menjadi perlu, perkakas *hydraulic press* yang sesuai harus digunakan dengan kompresi yang sesuai. *Splice* harus tahan air dengan

manufactured by 3M, such as Type 90-B1 for eye splices and Type 82-A1 for in-line splices, or equal products, including a manual wrap combination system of 3M electrical insulation putty tape/23 splicing tape/PVC tape/Scotchkote Electrical Coating FD.

10.6.2. Impressed current anode and permanent sacrificial anode leads shall be stranded copper with Kynar primary insulation and high molecular weight polyethylene (no armouring), or with XLPE/PVC insulation (no armouring).

10.6.3. Reference electrodes, temporary sacrificial anode and coupon leads shall be stranded copper with XLPE/PVC, HMWPE or other suitable insulations for direct burial (without armouring).

10.6.4. Main DC positive and negative (i.e., header) cables shall be armoured, with XLPE/PVC or other equivalent insulations for direct burial. Single core cables shall be aluminium wire armoured. All armouring on DC cables shall be electrically isolated from the glands prior entry/exit junction boxes, test boxes, and rectifiers, and shall not contact any other metallic structure.

10.6.5. All conductors shall be properly sized for ampacity and resistance. Cables shall be sized for current rating in accordance with IEC 60287.

epoxy splice kit yang dibuat oleh 3M, seperti Tipe 90-B1 untuk *eye splice* dan Tipe 82-A1 untuk *in-line splice*, atau produk yang sama, termasuk sistem *manual wrap combination* dari 3M *electrical insulation putty tape*/ 23 *splicing tape*/ PVC *tape*/ *scotchkote electrical coating* FD.

11.6.2. *Impressed current anode* dan *permanent sacrificial anode lead* harus berupa *stranded copper* dengan insulasi primer *kynar* dan *high molecular weight polyethylene* (tanpa pelindung), atau dengan insulasi XLPE/ PVC (tanpa pelindung).

11.6.3. Referensi elektroda, *sacrificial anode* yang bersifat sementara dan *coupon lead* harus terbuat dari *stranded copper* dengan XLPE/ PVC, HMWPE atau insulasi lain yang sesuai untuk ditanam langsung (tanpa penutup).

11.6.4. Kabel DC utama positif dan negatif (yaitu, *header*) harus berlapis baja, dengan XLPE/ PVC atau insulasi setara lainnya untuk ditanam langsung. *Single core cable* harus dilindungi kabel aluminium. Semua *armour* pada kabel DC harus diisolasi secara elektrik dari *gland* sebelum masuk/ keluar *junction box*, *test box* dan *rectifier*, dan tidak kontak dengan struktur logam lainnya.

11.6.5. Semua konduktor harus berukuran tepat untuk *ampacity* dan resistensi. Kabel harus diukur untuk *rating* arus sesuai dengan IEC 60287.

10.6.6. The minimum rating for all cables and wires shall be 600V.

10.6.7. All cables shall be able to withstand the prevailing chemical and mechanical (soil) conditions.

10.6.8. All cables shall be sized such that the voltage drops that occur do not reduce the capacity of the system.

10.6.9. All above ground cables shall be suitably identified with stainless steel tags to show their origin and function.

10.6.10. Colour coding for cables shall be as follows:

a. Main DC Positive – Red

b. Main DC Negative – Black

c. Bond cables – Black

10.6.11. All anode cables (except when they are Kynar/ HMWPE) Red Coupon cable – White

10.6.12. Silver/ silver chloride reference electrode - Blue Copper/ copper sulphate reference electrode – Yellow

10.6.13. Where the specified colour is not available for the outer jacket, the end of the cables may be marked with coloured tape.

11.7 Rectifiers

11.7.1. All DC power supplies for the CP systems shall be oil immersed transformer-rectifier units with pad mounting provisions.

11.6.6. *Rating* minimum untuk semua kabel dan pengkabelan harus 600V.

11.6.7. Semua kabel harus mampu menahan kondisi kimia dan mekanik (*soil)* yang berlaku.

11.6.8. Semua kabel harus didesain sedemikian rupa sehingga jika *voltage drop* terjadi tidak mengurangi kapasitas sistem.

11.6.9. Semua kabel di atas *ground* harus dapat diidentifikasi dengan *stainless steel tag* untuk menunjukkan asal dan fungsinya.

11.6.10. Kode warna untuk kabel adalah sebagai berikut:

a. *Main* DC *Positive* – merah

b. *Main* DC *Negative* – hitam

c. *Bond cable* – hitam

11.6.11. Semua kabel anoda (kecuali ketika kabel adalah *Kynar*/ HMWPE) *red coupon cable* - Putih

11.6.12. *Silver/ silver chloride reference electrode - Blue Copper/ copper sulphate reference electrode* – kuning

11.6.13. Jika warna yang ditentukan tidak dapat digunakan untuk *outer jacket*, ujung kabel dapat ditandai dengan *tape* berwarna.

11.7 *Rectifier*

11.7.1. Semua DC *power supply* untuk sistem CP harus menjadi *oil immersed transformer-rectifier unit* dengan ketentuan *pad mounting.*

11.7.2. All rectifiers shall be equipped with surge protection on the AC input and DC output and on silicon diodes (e.g., selenium clip cells), AC secondary and DC high speed fuses, independent transformer and stack assemblies, engraved phenolic panel, hinged doors, fully magnetic circuit breaker, heavy duty transformer with 20% over design capacity, tap adjustments (6 coarse, 6 fine), separate DC volt and amp meters (± 2% accuracy). All single-phase units shall be equipped with a DC efficiency filter choke.

11.7.3. Rectifiers should not be installed in "Hazardous Locations." However, any unit installed in such locations shall be oil cooled and rated for "explosion proof service" (e.g., Class I, Zone 2, Groups llA and llB).

11.8 Test Points

11.8.1. Test stations shall be accessible at frequent intervals and at mandatory points such as isolation joints (if any), buried structure crossings, etc., so that the system integrity can be verified on a periodic basis. Test stations shall consist of post mounted test boxes for termination of leads from the protected structure with terminals suitable for outdoor installations. A test lead and permanent reference electrode lead(s) shall be terminated in all auto-potential controlled transformer rectifiers.

11.7.2. Semua *rectifier* harus dilengkapi dengan *surge protection* pada AC *input* dan DC *output* dan pada *silicon diode* (misalnya, *selenium clip cell*), AC *secondary* dan DC *high speed fuse*, *independent transformer* dan *stack assemblies*, *engraved phenolic panel, hinged door*, *fully magnetic circuit breaker, heavy duty transformer* dengan kapasitas 20% *over design*, *tap adjustment* (6 *coarse*, 6 *fine*), ampere meter DC dan *voltmeter* terpisah (± 2% *accuracy*). Semua *single phase unit* harus dilengkapi dengan *choke filter* efisiensi DC.

11.7.3. *Rectifier* tidak boleh dipasang di "Lokasi *Hazardous*." Namun, unit apa pun yang dipasang di lokasi tersebut harus *oil cooled* dan *rated* untuk "*explosion proof service*" (misalnya *Class* I, *Zone* 2, *Group* llA dan llB).

11.8 Titik Pengujian

11.8.1. Stasiun pengujian harus dapat diakses pada *interval* yang sering dan pada titik-titik wajib seperti *isolation joint* (jika ada), *buried structure crossing*, dll sehingga integritas sistem dapat diverifikasi secara berkala. Stasiun pengujian harus terdiri dari *post mounted test box* untuk terminasi kabel dari struktur yang diproteksi dengan terminal yang sesuai untuk instalasi luar ruangan. Kabel pengujian dan kabel elektroda referensi permanen harus diterminasi di semua *transformer rectifier* yang dikendalikan *auto-potential.*

11.8.2. Permanent (i.e., stationary) reference electrodes shall be provided for buried protected piping, directly buried USTs, under the external bottom plates of protected on-grade steel storage tanks, and any application where auto-potential controlled impressed current CP systems are used. Stationary reference electrodes and access points shall be provided where necessary (except in containment areas or in electrically classified locations that would prohibit their use) for monitoring of the underground- protected systems. Stationary reference electrodes for buried piping applications within the plant shall be provided with watering tubes that are accessible at grade. These tubes may also be used to facilitate the use of portable reference electrodes. Penetrations through the surface in the containment areas shall be avoided. Internal water storage tanks that are protected with impressed current CP shall be equipped with a minimum of two permanent reference electrodes and terminated in the rectifier for automatic monitoring and potential control. Copper/copper sulfate types shall be used for underground applications. Reference electrodes for internal water tanks and any immersion applications shall be suitable for the service and in accordance with the applicable regulations. The quantities shall be in accordance with the cited

11.8.2. Elektroda referensi permanen (yaitu *stationary*) harus disediakan untuk pipa bawah tanah yang diproteksi, *direct buried* UST, di pelat bawah eksternal dari tangki penyimpanan baja diatas tanah yang diproteksi, dan aplikasi apa pun di mana sistem *auto-potential controlled impressed current* CP digunakan. Elektroda referensi *stationary* dan titik akses harus disediakan jika diperlukan (kecuali di *containment area* atau di lokasi yang dilarang penggunaannya secara elektrik) untuk *monitoring* sistem yang dilindungi di bawah tanah. Elektroda referensi *stationary* untuk aplikasi perpipaan yang ditanam di dalam kilang harus dilengkapi dengan tabung air yang dapat diakses di *grade*. Tabung ini juga dapat digunakan untuk memfasilitasi penggunaan elektroda referensi portabel. Penetrasi melalui permukaan di *containment area* harus dihindari. Tangki penyimpanan air *internal* yang diproteksi dengan *impressed current* CP harus dilengkapi dengan minimal dua elektroda referensi permanen dan diakhiri di *rectifier* untuk *monitoring* otomatis dan kontrol potensial. Jenis *copper/ copper sulfate* harus digunakan untuk aplikasi bawah tanah. Referensi elektroda untuk tangki air *internal* dan aplikasi *immersion* harus sesuai untuk servis dan sesuai dengan peraturan yang berlaku. Kuantitas harus sesuai dengan praktik standar dan penilaian *engineering.*

standard practices and engineering judgment.

11.8.3. Although not mandatory, coupons and/or electrical resistance (ER) probes may be installed as additional tools to monitor the effectiveness of the cathodic protection system. Where provided for buried applications, coupons shall be installed in accordance with NACE SP0104. ER probes shall be specified and installed in accordance with the manufacturer's recommendations.

11.8.3. Meskipun tidak wajib, *coupon* dan/ atau *electrical resistance (ER) probe* dapat dipasang sebagai alat tambahan untuk memantau efektivitas sistem proteksi katodik. Jika disediakan untuk aplikasi yang ditanam, *coupon* harus dipasang sesuai dengan NACE SP0104. *Probe* ER harus ditentukan dan dipasang sesuai dengan rekomendasi pembuat.

11.9 Reference Electrodes

11.9.1. The permanent reference electrodes shall be copper/ copper-sulfate (CSE) for buried applications, unless contamination of chlorides is anticipated. In certain situations, zinc electrodes may also be used.

11.9 Referensi Elektroda

11.9.1. Referensi elektroda permanen harus berbahan *copper*/ *copper-sulfate* (CSE) untuk aplikasi yang tertanam, kecuali kontaminasi klorida dapat diantisipasi. Dalam situasi tertentu, elektroda *zinc* juga dapat digunakan.

11.9.2. The permanent reference electrodes shall be rated for a minimum of 20 years of continuous service.

11.9.2. Referensi elektroda permanen harus dapat bekerja selama minimal 20 tahun layanan secara kontinu.

11.10 Surge Arrester

Surge Arrester or DC decouplers shall be used across insulating flanges or joints within the plant scope for any steady state AC, surge, lightning and fault grounding requirements. Arrester shall have a suitable enclosure and be properly rated electrically for the specific application and area classification.

11.10 *Surge Arrester*

Surge Arrester atau DC *decoupler* harus digunakan di seluruh insulasi flange atau *joint* dalam lingkup kilang untuk setiap *fault* AC, *surge*, *lightning*, dan *fault grounding* yang stabil. *Arrester* harus memiliki *enclosure* yang sesuai dan memiliki *rating* yang benar secara *electrical* untuk aplikasi dan klasifikasi di area tertentu

12. INSPECTION, TESTING, AND COMMISSIONING

12.1 Inspection

Equipment manufacturers shall allow access to their shop and offices at reasonable times for inspections and obtaining information on the progress of work.

12.2 Testing

12.2.1. Shop tests shall be carried out in accordance with the requirements specified in the codes and standards and the tests identified in Sections 11.2.2 to 11.2.5 shall be performed in addition to the manufacturer's standard tests.

12.2.2. Mechanical Tests - Equipment dimensions, construction, materials, connection, ratings, painting, etc., shall be verified in accordance with "accepted" drawings and Project Specifications and data sheets.

12.2.3. Electrical operational tests, especially for the rectifiers that determine circuit verification and sequence of operation, shall be performed.

12.2.4. Test reports for anodes shall be submitted.

12.2.5. Any limitations in test capabilities shall be indicated in the quotation.

12.3 Commissioning

12.3.1. A Commissioning Procedure, as well as an operation and maintenance manual for the cathodic protection system, shall be provided with the design

12. INSPEKSI, PENGUJIAN, DAN *COMMISSIONING*

12.1 Inspeksi

Pembuat peralatan harus mengizinkan akses ke *shop* dan kantor mereka pada waktu yang sesuai untuk inspeksi dan mendapatkan informasi tentang kemajuan pekerjaan.

12.2 Pengujian

12.2.1. *Shop test* harus dilakukan sesuai dengan persyaratan yang ditentukan dalam kode dan standar serta pengujian yang diidentifikasi dalam Pasal 11.2.2 sampai 11.2.5 harus dilakukan selain pengujian standar pembuat.

12.2.2. *Mechanical test* - dimensi peralatan, konstruksi, *material*, koneksi, *rating*, pengecatan, dll harus diverifikasi sesuai dengan gambar dan spesifikasi proyek dan *data sheet* yang "disetujui".

12.2.3. *Electrical operational test*, terutama untuk *rectifier* yang menentukan verifikasi sirkuit dan urutan operasi, harus dilakukan.

12.2.4. Laporan pengujian untuk anoda harus disampaikan/ diserahkan.

12.2.5. Setiap keterbatasan dalam kemampuan pengujian harus ditunjukkan dalam penawaran.

12.3 *Commissioning*

12.3.1. Prosedur *commissioning*, serta manual operasi dan pemeliharaan untuk sistem *cathodic protection*, harus disediakan dengan paket desain. *Commissioning* harus

package. The commissioning shall include Mechanical Completion Inspections, Pre-Commissioning and Commissioning. All inspections, native potential survey, interference testing, energized and polarized potential survey data shall be recorded and submitted in report format.

meliputi *mechanical completion inspection, pre-commissioning* dan *Commissioning.* Semua inspeksi, *native potential survey, interference testing, energized* dan *polarized potential survey data* harus dicatat dan disampaikan dalam format laporan.

12.3.2. A walk-down shall be performed and witnessed after the cathodic protection systems are mechanically complete and commissioned. During the walk down, the accessible CP equipment and components shall be inspected, and CP potentials at various locations shall be measured and recorded, to confirm that the equipment was installed and functions per the design, and to confirm the protection is in accordance with Section 11.2 and the appropriate standard for the application.

12.3.2. *Walk-down* harus dilakukan dan disaksikan setelah sistem *cathodic protection* secara mekanis selesai dan dilakukan *commissioning.* Selama *walk down*, peralatan dan komponen CP yang dapat diakses harus diperiksa, dan potensial CP di berbagai lokasi harus diukur dan dicatat, untuk mengkonfirmasi bahwa peralatan dipasang dan berfungsi sesuai desain, dan untuk mengkonfirmasi proteksi sesuai dengan Bagian 11.2 dan standar yang sesuai untuk diaplikasikan.

12.3.3. A Commissioning Report shall be prepared and submitted, that includes all native potentials, energized potentials, instant off potentials and final check out potentials, as well as rectifier voltage and currents, etc. Native and instant off potentials are not required for structures that are protected with pre-installed sacrificial anodes that are not possible to disconnect for these measurements. Any deficiencies in the CP systems shall be corrected prior to acceptance.

12.3.3. Laporan *commissioning* harus disiapkan dan disampaikan, yang mencakup semua potensial asli, potensial *energized*, potensial *instant off* dan potensi *check out* akhir, serta tegangan dan arus rectifier, dll. Potensial *native* dan *instant off* tidak diperlukan untuk struktur yang diproteksi dengan *pre-installed sacrificial anode* yang tidak mungkin terputus untuk pengukuran ini. Setiap kekurangan dalam sistem CP harus diperbaiki sebelum penerimaan.