

PETRONAS TECHNICAL STANDARDS

TECHNICAL SPECIFICATION

INSTALLATION AND COMMISSIONING OF CATHODIC PROTECTION SYSTEMS

PTS 30.10.73.33

OCTOBER 2011



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This revision of PTS **30.10.73.33 - Installation and Commissioning of Cathodic Protection Systems (October 2011, Revision 0)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The previous version of this PTS **30.10.73.33 (January 2000)** will be removed from PTS binder / e-repository from herein onwards.

The custodian of this PTS is:

Name : Jamalee B Ahmad

Tel. No : 03 – 2783 6186

Please direct any questions regarding this PTS to the above-named.

Document Approval

	Name	Designation	Date	Signature
Prepared	M Aswadi B Ton Alias	Engineer MCI (Corrosion)	27.10.2011	
Reviewed	Jamalee B Ahmad	Staff Engineer MCI (Corrosion)	27.10.2011	
Approved	Zamaluddin B Ali	Technical Authority Materials, Corrosion & Inspection	27.10.2011	
Verified	Ir. CW Ibrahim B CW Sudin	Senior Manager, Materials, Corrosion & Inspection, Engineering, GTS	31.10.2011	
Verified	Saifol Mualim B Ahmad Yahaya	General Manager, Engineering, GTS	4/11/11	
Endorsed	Ir. Pau Kiew Huai	Senior General Manager, GTS	4.11.11	

Revision History

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0	Jamalee B Ahmad	Zamaluddin B Ali	Oct 2011

PREFACE

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The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

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1 INTRODUCTION

1.1 SCOPE

This new PTS specifies requirements and gives recommendations for the installation and commissioning of onshore and offshore cathodic protection systems and gives test procedures for pre-commissioning, commissioning and monitoring of such systems.

This PTS should be read in conjunction with the relevant design documents of the cathodic protection system(s), which should include specific installation and commissioning procedures.

This PTS is a revision of the PTS of the same title and number dated April 2003. A summary of changes from the previous edition is given in (1.7).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS, and to Contractors nominated by them.

This PTS is intended to be used for new construction projects, retrofitting and the operation and maintenance of cathodic protection systems in relation to exploration and production facilities, oil refineries, chemical plants, gas plants and supply/marketing installations. When PTSs are applied, a Management of Change (MOC) process should be implemented. This is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards to safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

For the purpose of this PTS, the following definitions shall hold:

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

cathodic protection	process of reducing or preventing corrosion of metal structures in contact with an electrolyte by the flow of direct current from the electrolyte into the structure surface
cathodic protection station	combination of equipment installed to provide cathodic protection to the structure to be protected
current density	amount of current per unit area of the steel surface, coated or uncoated, in contact with the electrolyte
drain point	point on the pipeline or structure where the connection of the negative terminal of the cathodic protection voltage source is made to conduct (drain) the returning current from the pipeline to the voltage source
electrolyte	conductive liquid or material such as soil or water in which an electric current can flow
deep groundbed	one or more anodes installed vertically at a nominal depth of 15 m (50 ft) or more below the earth's surface in a drilled hole for the purpose of supplying cathodic protection. Sometimes referred to as deep anode bed (NACE SP 0572)
foreign structures/pipelines	metal structures or pipelines other than the structure or pipeline under consideration, in contact with the same electrolyte, and which are or may fall under the influence of the cathodic protection system; they may be owned by the Principal or other companies and may or may not be equipped with cathodic protection
groundbed	system of buried or submerged electrodes, to conduct the required current into and through the electrolyte to the steel surface to be protected
isolating flange	set of two flanges assembled with an insulating gasket and insulating sleeves and washers, for the purpose of electrically isolating two metallic pipe sections
isolating joint	factory assembled pipe fitting provided with insulating gaskets and resins, to be welded into a pipeline or piping for the purpose of electrically isolating two metallic pipe sections
midpoint	point on a pipeline between two cathodic protection stations where the influence of the two cathodic protection stations is expected to be equal and the protection levels are usually lowest
natural potential	pipe-to-soil potential measured when no cathodic protection is applied and polarisation caused by cathodic protection is absent
"OFF" potential	pipe-to-soil potential measured immediately after the cathodic protection system is switched off and the applied electrical current stops flowing to the pipeline surface, but before polarisation of the pipeline has decreased
"ON" potential	pipe-to-soil potential measured while the cathodic protection system is continuously operating

pipeline	pipeline and associated equipment as defined in the scope of the cathodic protection design contract
pipe-to-soil potential	difference in electrochemical potential between a pipeline or foreign structure/pipeline and a specified reference electrode in contact with the electrolyte. Similar terms such as structure-to-soil potential, pipe-to-electrolyte potential and pipe-to-(sea)water potential are sometimes used as applicable in the particular context
polarisation	change of the pipe-to-soil potential caused by the flow of DC current between an electrolyte and a steel surface
polarisation cell (Kirkcell)	device inserted in the earth connection of a structure that isolates for DC in the cathodic protection range
reference electrode	potential is accurately reproducible and which serves as a reference for pipe-to-soil potential measurements
stray currents	electrical currents running through the electrolyte, originating from a foreign DC source and causing interaction with the corrosion and cathodic protection processes of the structure or pipeline. Stray currents may also originate from the pipeline's cathodic protection system and act upon foreign structures/pipelines
structure	structure and associated equipment as defined in the scope of the cathodic protection design contract

1.4 ABBREVIATIONS

Ag/AgCl	Silver/Silver Chloride as used for the Silver/Silver Chloride type of reference electrode
Cu/CuSO ₄	Copper/Copper Sulphate as used for the Copper/Copper Sulphate type of reference electrode
AC	Alternating Current
DC	Direct Current
PVC	Poly Vinyl Chloride
ROV	Remotely Operating Vehicle (underwater)
SBM	Single Buoy Mooring

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (6).

1.6 PROPRIETARY NAMES

The names "Wenner", "Shepard", "Kirkcell" and "Swain" are used in this PTS to indicate measuring techniques or equipment types, commonly understood by those names in cathodic protection engineering. They are not intended to indicate a requirement to apply equipment of that particular brand name.

1.7 CHANGES FROM PREVIOUS EDITION

The previous edition of this PTS was dated January 2000. Other than editorial changes, the following are the main changes since that edition:

Section	Change
1.3.2	Include definition for deep groundbed
2.2	Include reference to ISO 15589-1 and ISO 15589-2
3.1	New addition to include inspection requirement
3.3.1	Improve requirements for communication on any change of construction
3.3.3.1	Include reference to NACE Standard SP0572
3.5.2	Include recommendation for installation of "spare" test cables for buried structures
3.5.2.5	Provide guidance for placement of permanent reference electrode
3.7.2.3	More elaboration on testing through potential measurement and include isolation checker as another alternative method
4.2.1	Include reference to BS EN 50162
6	Include reference to PTS 30.48.00.31-P, NACE SP0572, BS EN 50162, ISO 15589-1 and ISO 15589-2

2 GENERAL

2.1 HOW TO USE THIS PTS

The installation of cathodic protection systems is an important step during the execution of a cathodic protection project. Most components of a cathodic protection system are buried or immersed and therefore not accessible for inspection after installation, costly to replace (if at all possible) and prone to deterioration by electrochemical effects if not installed properly.

During installation of a cathodic protection system several (pre-commissioning) checks have to be carried out to show that the design requirements are met, before the system or parts of it are backfilled.

Upon completion of the installation of the cathodic protection system, the system shall be commissioned in accordance with written commissioning procedures to give evidence that the system operates or can operate in accordance with the design and that the protection criteria can be met.

It is assumed that the design of the cathodic protection system has been made in accordance with the recommended standards (2.2). The design documents shall include the design protection criteria, a materials schedule, all relevant drawings and installation and commissioning procedures. This documentation shall be available during installation and commissioning.

This PTS has been written to provide common installation and commissioning procedures and specifies the minimum tests which should be executed during and after installation. It may assist the designer of a cathodic protection system in writing specific procedures in line with Group practice. Because of the general nature of this PTS, a mere reference to this PTS is usually insufficient and specific instructions to cover specific equipment and local conditions are usually required.

2.2 CATHODIC PROTECTION DESIGN STANDARDS

This PTS shall be used in conjunction with the following cathodic protection design standards and with the relevant design documents:

Onshore pipelines	: PTS 30.10.73.31 ISO 15589-1 ^(see note)
Offshore pipelines	: PTS 30.10.73.32 ISO 15589-2 ^(see note)
Offshore structures	: PTS 37.19.30.30
Mounded storage vessels	: PTS 34.51.11.30
Bottoms of vertical tanks	: API RP 651
Ships	: BS 7361-1

General guidelines for cathodic protection are given in PTS 30.10.73.10

Note: The design requirement specified in ISO 15589-1 and ISO 15589-2 might differ than the PTS requirements. The more stringent requirements shall be followed.

2.3 CATHODIC PROTECTION CONTRACTORS

The installation and commissioning of cathodic protection systems shall be under the supervision of qualified and experienced cathodic protection specialists, preferably the design consultant's representative. In particular the installation of groundbeds and permanent monitoring facilities shall be closely supervised.

3 INSTALLATION

3.1 INSPECTION

Careful inspection during entire installation process, both of the cathodic protection system and of the structures to be protected are vital to the successful application of cathodic protection.

Inspection should focus on ensuring that coatings are properly applied and not damaged during construction, and that proper isolation and bonding are achieved. For buried structures, these inspections must be performed before backfilling. Once the structure or other system components are buried, identification and correction of any discrepancies is difficult. If the coating on a structure is damaged (or absent) cathodic protection requirements will increase dramatically. Open bonds and shorts to other structures are common causes of inadequate protection and the resulting interference can cause accelerated corrosion damage.

Coatings inspection shall be performed following [PTS 31.40.30.31](#), [PTS 31.40.30.32](#), [PTS 31.40.30.33](#) and [PTS 31.40.30.34](#) depending on type of coating. Electric Holiday Detectors should be used for all coating inspections. If properly used they can detect flaws in the coating which may not be visible. In addition to the use of the Holiday Detector, the inspector shall also make detailed visual inspection of the coatings and occasional measurements of the bond strength. Visual inspection should also include observation of the following:

- surface preparation and coating
- handling of the pipe
- lowering of the pipe into the ditch or seabed
- backfilling operations

Packaged galvanic anodes shall be inspected and steps taken to ensure that backfill material completely surrounds the anode. The individual container for the backfill material and anode shall be intact. If individually packaged anodes are supplied in waterproof containers, the containers shall be removed before installation. Lead cable shall be securely connected to the anode and be inspected for assurance that it is not damaged.

Other galvanic anodes, such as the unpackaged "bracelet" or ribbon type, shall be inspected to ensure that dimensions conform to design specifications and that any damage during handling does not affect application. If a coating is used on bands and the inner side of bracelet anode segments, it shall be inspected and, if damaged, repaired before the anodes are installed.

The rectifier or other power source of an impressed current system shall be inspected to ensure that internal connections are mechanically secure and that the unit is free of damage. Rating of the DC power source shall comply with the construction specification.

Impressed current anodes shall be inspected for conformance to specifications concerning anode material, size, length of lead cable, anode lead connection, and integrity of seal. All cables shall be carefully inspected to detect defects in insulation. Anode backfill material shall conform to specifications.

3.2 POWER SOURCES

3.2.1 Transformer rectifier stations

Transformer rectifiers and control and monitoring equipment shall be installed at locations as directed by the design document. Prior to the installation the area classification shall be checked and the unit shall meet this PTS.

The installation checklist for transformer rectifiers stations ([Appendix 1](#)) should be used.

Floor-mounted units shall be installed on a stable base. When installed outdoors, a concrete plinth shall be constructed with separate cable ducts for AC and DC cables. The equipment shall be fastened to the plinth or the floor using suitable fastenings. Wall mounted units shall be sufficiently supported and bolted to the wall. All units shall be installed so that sufficient ventilation is provided.

Sufficient room shall be provided around the units to allow full opening of all doors and panels and to provide access for reading meters and to carry out visual inspection, adjustments and repairs.

When installed outdoors, sufficient security shall be provided by using lockable cabinets and main circuit breakers. The enclosure shall be weather proofed to a degree of protection of at least IP 54 in accordance with IEC 529. When installed off-plot, security fencing may have to be erected all around the unit. If applicable a sunshade shall be erected above the transformer rectifier.

Oil cooled units shall be filled with the supplied transformer oil to the indicated level, leaving sufficient room for expansion after energising the unit. When a unit is supplied oil-filled, the level shall be checked and adjusted when necessary. Oil temperature gauges shall be installed or checked. Silica gel breathers shall be installed. The content of the breathers shall be dry as indicated by the (blue) colour of the crystals. Pink or white crystals indicate moisture contaminated silica gel, which shall be dried or replaced.

Transformer rectifiers shall be connected to the power supply in accordance with [PTS 33.64.10.10](#).

All functional testing of the transformer/rectifier unit shall be done with the secondary (DC) cables disconnected from the structure to be protected. Dummy load resistors or circuits shall be used for such testing.

Upon completion of the installation, the unit shall be left de-energised. The main circuit breaker shall be locked open and/or the primary or secondary fuses shall be removed and stored separately from the unit until final commissioning.

3.2.2 Solar Generator Stations

The solar generator system shall be supplied complete with supporting framework.

The location of the solar generator station shall be checked for any obstructions to insolation of the solar panels such as other buildings, trees, etc.

A suitable foundation shall be constructed, able to support the solar generator, batteries and regulators according to the generator Manufacturer's written recommendations.

The foundation shall be suitable to withstand the effect of the maximum prevailing wind forces on the solar panel structure.

The structure shall be oriented so that solar panels, when installed, face the direction of maximum insolation.

Sufficient room shall be provided around the solar panels to provide access for maintenance and cleaning of the panels and control equipment.

Battery containers or supports shall be constructed so that spillage of the full content of one battery unit can be contained in an acid resistant container.

Sufficient security shall be provided by using lockable cabinets or buildings and/or by constructing a security fence around the solar generator station.

All functional testing of the solar generator unit shall be done with the secondary cables disconnected from the structure to be protected. Dummy load resistors or circuits shall be used for such testing and may be left in place until final commissioning is required.

Upon completion of the installation, the unit may be left energised to keep the batteries charged. The secondary fuses shall be removed and stored separately from the unit until final commissioning.

3.3 IMPRESSED CURRENT GROUNDBEDS

3.3.1 General

The location and the soil resistivity of the groundbed site should be verified to confirm the design parameters. During construction, test results may require modifications in the design, e.g. anode depth, location etc. These activities should be carried out by or in close co-operation with the design contractor of the groundbed. Any modification should be clearly documented and communicated to the Principal.

Prior to installation, impressed current anodes shall be inspected for defects, conformance with the anode specification, and size and length of anode cable tails, and to ensure that anode caps, if used, are secure. Care must be exercised to avoid damaging anodes during handling and installation. Cable tails should be visually inspected for defects in insulation.

Care must be taken to avoid damage to the cables or cable insulation. Each anode shall be tagged with a unique number or code.

Anodes should never be handled, lifted or lowered using the anode cable, unless specifically allowed by the Manufacturer in the installation instructions (e.g. strunged anodes).

Impressed current anodes are usually installed in carbonaceous backfill. If the backfill material is supplied loose, it should be installed properly, so that there are no voids around the anodes. Anodes may also be delivered pre-packaged with compacted backfill in metal canisters.

3.3.2 Surface Groundbeds

Surface anode ground beds shall be constructed as directed by the design document. The installation checklist for surface groundbeds ([Appendix 2](#)) should be used.

3.3.2.1 Vertical Groundbeds

For vertical anode installation, holes shall be excavated in appropriate diameters and depth. Power auger equipment may be used where available and where local conditions permit.

Pre-packaged anodes shall be lowered into the holes and backfilled with the original soil. The soil around the anodes shall be compacted by fluidizing the soil with water.

Non pre-packaged anodes shall be positioned in the centre of the holes on a layer of at least 10 cm of tamped backfill. The holes shall be filled with backfill, which shall be tamped in thin layers to approximately 10 cm above the top of the anode. Water may be used to fluidize the backfill. When multiple anodes are installed in one hole, the cable tails of the lower anodes shall be protected from damage during installation of the upper anode(s).

The holes shall be finished with the original soil or, if additional venting is required, with fine gravel. If required by the design, separate headworks shall be erected over each anode hole. Otherwise the original ground profile shall be restored.

Depending on the type of soil, different techniques may be used to install vertical anodes, such as by using water jets to drive the (pre-packaged) anodes into the soil. In such cases, the installation Contractor shall provide a description of the procedures to be followed.

3.3.2.2 Horizontal Groundbeds

For horizontal anode installation a trench shall be excavated to the appropriate depth and length. At the bottom of the trench a slot of about 30 cm by 30 cm shall be excavated to accommodate the anodes and backfill.

The anodes shall be laid in the trench on a layer of tamped backfill material and shall be covered with a layer of backfill material, so that the anodes are positioned in the centre of the backfill.

3.3.2.3 Anode Cable Installation

Upon installation of the anodes, the cables shall be laid in the trench, not directly above the anodes, in a layer of soft sand. For underground cable installation (see section 3.6). If a ring main feeder system is used, the anode cable tails shall be spliced into the ring cable using C-crimps or line taps without cutting the ring cable strands. The ring cable shall be connected to the feeder cable. Underground splices shall be made in accordance with (3.6.1). If a central distribution box is used, the cable tails shall be laid in the trench and shall be terminated in the distribution box.

The trench shall be finished with original soil. If needed, cable warning tape or cable protection tiles shall be used (3.6.1).

On completion of the groundbed the resistivity of the groundbed and if possible the individual anodes shall be measured to remote earth using a low resistance earth Megger.

If the groundbed resistivity is outside usable limits for operation within the design parameters, the Principal and Contractor shall investigate the cause and take remedial actions.

The location of the groundbed shall be indicated e.g. by the installation of groundbed marker posts at both extremities of the groundbed.

3.3.3 Deep Groundbeds

3.3.3.1 Groundbed Design Options

Various types of deep groundbeds are possible and any specific type is chosen to suit the local conditions and/or output requirements. Installation of deep anode systems is described in NACE Standard Practice SP0572.

Options for the bore hole include:

1. Various diameters, to facilitate the installation of large anode systems and depending on the available drilling equipment.
2. Holes cased or uncased down their entire length or part of it, depending on open hole or closed hole option and sub-soil stability. Casings, if specified, can be made of steel, (perforated) plastic or a combination of these.

Options for the anode system include:

1. Conventional anodes with individual cable tails (silicon iron, magnetite).
2. String type anodes having various active sections with one feeder cable (linear distributed anodes).

Options for the total groundbed include:

1. Open hole. Open holes can be used when anodes can be suspended in groundwater at depth.
2. Closed hole. Closed holes are required when no groundwater is present. Closed holes require low resistivity (coke) backfill and venting facilities. Coke backfill can be supplied loose or pre-packaged with the anodes in metal canisters.

The selected design options shall be detailed in the design drawings.

3.3.3.2 Construction

A deep groundbed shall be constructed in accordance with the design document and drawings.

The installation checklist for deep groundbeds (Appendix 3) should be used.

A surface casing larger than the nominal diameter of the bore hole shall be set to a depth of approximately 5 m.

A hole of the specified diameter shall be drilled to the required depth.