Technical Seminar for Cathodic Protection to GOGC Design Unit Specialists

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WITHIN THE JURISDICTION OF THE MINISTRY OF ENVIRONMENT, ENERGY & CLIMATE CHANGE

MINISTRY OF ENVIRONMENT ENERGY & CLIMATE CHANGE

Photo of a typical T/R cabinet

Impressed Current Stations

Impressed current stations should be located where they are easily accessible and where they are protected against environmental damage, electrical damage and vandalism

Impressed Current Stations

The following should be considered when selecting locations:

- proximity of an a.c. power source or possibility to use another power supply (battery, solar panel with battery);
- suitable electrolyte conditions and suitable site for the groundbed system;
- distances from the pipeline and from other metallic structures (buried structures or metallic buildings), mainly in urban areas;
- distances from other cathodic systems or a.c. or d.c. sources;
- hazardous areas.
- Usually the installation work is undertaken as soon as possible after the completion of the main structure. If required by design, temporary cathodic protection systems should be installed and activated.

Impressed Current Stations

The following labels should be on the housing:

a) safety signs concerning the dangers of electricity;

b) identification signs concerning the owner/operator and the installation.

Impressed Current Stations

Power supply

The following shall be taken into account when specifying d.c. voltage sources:

- availability and type of connection to a.c. supply;
- type of rectifier;
- measuring devices, e.g. voltmeters, ammeters;
- number of output terminals;
- type of cooling (air or oil);
- type of output control (voltage, current or potentiostatic);
- removable link to allow insertion of cyclical current interrupter;
- requirement for the permanent installation of a cyclical current interrupter;
- electrical and safety requirements for the equipment;
- protection measures against possible high voltage interference;
- requirement for a.c. and/or d.c. surge protection

Impressed Current Stations

Power supply

- requirement for environmental protection and housing;
- a.c. content of the d.c. output (acceptable ripple factor);
- identification and rating plate details;
- environmental protection (e.g. IP rating);
- remote monitoring / control equipment.

Impressed Current Stations

Voltages higher than 50 V d.c. (rectifier output) should be avoided.

High voltage gradients in the electrolyte in the vicinity of groundbeds can be a hazard to animals, persons or buildings with metallic structures.

Transformer/rectifiers shall be specifically designed for CP service and shall be suitable for continuous operation under the prevailing service conditions.

Impressed Current Stations

Groundbeds

- deep-well
- shallow type

- Quantity of the groundbed materials (anode and backfill) shall be compatible with the groundbed size and design life of the cathodic protection system.
- The resistance to remote earth of each groundbed shall allow the maximum predicted current demand to be met at no more than a value defined during the design (e.g. 70 % of the voltage capacity of the d.c. source) during all seasons of the year and throughout the design life of the cathodic protection system. Calculation shall be based on the resistance of the anode groundbed at the end of its design life.
- Harmful interference on neighbouring buried structures, including fences, foreign pipelines, facility piping, and earthing systems, shall be avoided.

Impressed Current Stations

Groundbeds

In selecting the location and type of groundbeds for installation, the following local conditions shall be taken into account:

- electrolyte conditions and the variation in resistivity with depth;
- groundwater levels;
- any evidence of extreme changes in electrolyte conditions from season to season;
- nature of the terrain;
- shielding (especially for parallel pipelines);
- likelihood of damage due to third-party intervention.

Impressed Current Stations

Groundbeds

The basic design shall include a calculation of the groundbed resistance based upon the most accurate electrolyte resistivity data available.

If multiple groundbeds are necessary to deliver the current demand, then the current output from each groundbed should be independently adjustable.

Impressed Current Stations

Shallow Groundbeds

- electrolyte resistivity near the surface is far more suitable than at the depths of a deep-well groundbed:
- there is no risk of shielding by adjacent pipelines or other buried structures:
- space is available for a shallow groundbed:
- the current being generated does not create unacceptable corrosion on adjacent buried structures.

Impressed Current Stations

Anode materials

- high-silicon iron alloy, including with appropriate chromium concentrations if used in electrolytes with high chloride content and if allowed by regulations
- magnetite
- graphite
- mixed-metal-oxide-coated titanium
- conductive polymers
- steel.

Alternative materials may be used if reliable performance for the specific operating conditions can be demonstrated and is documented.

Impressed Current Stations

Output control

- constant output rectifier voltage
- potential control
- current control

Impressed Current Stations

Current distribution for multiple pipelines

When more than one pipeline is being cathodically protected by one rectifier, the parameters below shall be considered:

- pipelines routes
- pipelines owner/operator
- electrical influence
- current demand for each pipeline
- cathodic protection shielding effect (position of the groundbed versus different pipelines).

Impressed Current Stations

Current distribution for multiple pipelines

Resistors should be installed in the negative drains to balance the current to each of the adjacent pipelines individually. Each negative drain may be provided with a shunt and diode preventing mutual influence of pipelines during ON-potential and OFF-potential measurements

Impressed Current Stations

Current distribution for multiple pipelines

All cables, diodes and current measurement facilities should be installed in a distribution box or transformer-rectifier cabinet.

Cathodic protection on multiple pipelines from a single transformer rectifier may be achieved by the use of equipotential bonding if cathodic protection effectiveness is achieved. This, however, limits the possibility of measuring the potentials of individual pipes.

Impressed Current Stations

Potential control

The d.c. voltage source can be required to maintain a constant pipeline potential to compensate for changes in the external circuit conditions. Changes can be caused by stray or telluric current interference.

Fault detection of impressed-current systems during operation

Observation	Possible cause
a) pipe-to-electrolyte potential becomes more positive as protection system is switched on	1) reversed connections at the transformer-rectifier, which is a very serious fault that could result in severe damage to the pipeline in a relative short period of time
b) applied voltage zero or very low, current zero	1) failure of a.c. fuse or tripping of other protective device 2) failure of a.c. supply 3) failure of transformer-rectifier
c) applied voltage normal, current low but not zero	1) deterioration of anodes or groundbed 2) drying out of electrolyte around groundbed 3) accumulation of electrolytically produced gas around the anodes (gas blocking) 4) disconnection of individual anodes in a groundbed or anode system 5) disconnection of part of the protected pipeline from the negative side of the transformer-rectifier
d) applied voltage normal, but current zero	1) severance of anode or cathode cables 2) failure of d.c. fuse or ammeter of transformer-rectifier 3) complete failure of groundbed or anode system
e) applied voltage and current zero	1) control on transformer-rectifier unit set too low 2) transformer or rectifier fault 3) electricity supply fault
f) applied voltage and current both high	1) control on transformer-rectifier set too high 2) drift of permanent reference electrode in positive direction 3) disconnection of permanent reference electrode

Fault detection of impressed-current systems during operation

Observation	Possible cause
a) applied voltage and current normal but pipe-to-electrolyte potential insufficiently negative, i.e. too positive	1) break in a continuity bond, or increased resistance between point of connection and point of test due to a poor cable connection
	2) greatly increased aeration of the electrolyte at or near the point of measurement due to drought or increased local ground drainage
	3) faulty isolation equipment, e.g. the short-circuiting of an isolating joint at the end of the pipeline being protected
	4) protected pipeline shielded or otherwise affected by new pipelines
	5) failure of CP system on an adjacent section of the pipeline or on a secondary pipeline bonded to it
	6) deterioration of, or damage to, the pipeline protective coating
	7) addition or extension to the buried pipeline, including contact with other metallic structures
	8) interaction with the CP system on an adjacent or neighbouring pipeline
	9) effects of interference current on the pipeline
b) applied voltage and current normal but the pipe-to-electrolyte potential abnormally negative	1) break in the continuity bonding at position further from the point of application than the point of test
	2) secondary pipelines have been disconnected or disbonded from the pipeline being protected, or have received additional protection via a new CP system
	3) effects of interference current on the pipeline
c) applied voltage and current normal but pipe-to-electrolyte potential fluctuates	1) presence of interference earth currents, e.g. interference from d.c. traction systems or telluric/geomagnetic effects