RECOMMENDATION PCRA 009

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CEFRACOR
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Committee for Cathodic Protection and Associated Coatings

Telemetry system for cathodic protection equipment of underground metal pipelines

1. Scope

Buried metal pipelines can be fitted out with cathodic protection equipment in order to protect them from corrosion by reducing the corrosion rate to an acceptable limit as well as from a technical as an economical standpoint (cf. EN 12954, Cathodic protection of buried or immersed metallic structures - General principles and application for pipelines). The proper operation of the equipment and the effectiveness of the protection are periodically assessed over the entire structure under the responsibility of each network operator. These inspections are periodically carried out by cathodic protection specialists within a framework defined in standard EN 12954.

In order to optimize his internal organization, each network operator can install a remote monitoring system on the cathodic protection equipment.

The purpose of the present recommendation is to define what a remote monitoring system for cathodic protection of underground metal pipelines is and to provide the main characteristics of such a system. The rules defined in this Recommendation are in accordance with those of standard EN 12954.

2. Interest of a remote monitoring system

Standard EN 12954 edition 2001 (cf. table 2) defines the periodical functional field checks to be carried out on different equipment of the cathodic protection system unless a telemetric system is used.

Moreover, it defines the main principles of a telemetric system:

> *Functional checks:*
>
> *If the cathodic protection system is monitored by remote control, such that equipment malfunctions can be immediately detected, then the frequency of functional checks laid out in Table 2 do not apply.*
>
> *Effectiveness of cathodic protection:*
>
> *It is possible to have a better overview of the cathodic protection system if the effectiveness of*
>
> *cathodic protection is monitored by remote control. In this case potential and current measurements*
>
> *may be performed on demand, automatically at pre-set intervals, or when an alarm condition exists.*

However, the standard does not define the periodicity of functional field checks of the cathodic protection equipment in the case that a telemetric system is installed.

The installation of a telemetric system on its equipment provides multiple benefits for the operator of the protected structure:

- Ensure that his cathodic protection equipment are operational ,
- Ensure that his cathodic protection equipment provide the regulatory required level of cathodic protection of his structure,
- Increase the reactivity in case of failure of a cathodic protection equipment,
- Enhance the historical knowledge of the cathodic protection system of the structure,
- In general, reduce the operation and maintenance costs by allowing less frequent field checks and measurements.

3. Definitions and symbols

3.1 Definitions

Cathodic protection equipment can be:

- Remotely monitored,
- Remotely measured,
- Remotely controlled,
- Remotely adjusted,
- Remotely operated.

These five actions above comprise the telemetry.

Remote monitoring: Remote transmission of information regarding the state of operation or the trip of a system by means of a telecommunication system .

Remote measurement: Remote transmission of one or more measured values.

Remote control: remote control, by a binary signal, of operation of cathodic protection equipment.

Remote adjustment: remote modification of the setting of a cathodic protection equipment.

Remote operation (or remote management): remote measurement + remote monitoring + remote control.

Manager of the cathodic protection: entity responsible for the cathodic protection activities.

3.2 Symbols

The designation of the symbols used in this document is according to standard EN 12954.

a.c. : alternating current

d.c. : direct current

MC : metallic coupon[1]

U_p : voltage over the terminals of a direct current generator[1]

I_p : protection current supplied by a direct current generator

E_{on} : On potential

E_{off} : Off potential

U_{diode} : voltage over the terminals of a diode[1]

I_{diode} : current flowing through a diode[1]

[1] This symbol does not feature in standard EN 12954 neither in standard ISO 8044.

I_{anode} : current flowing through a galvanic anode[1]

I_{bond} : current flowing through a bond[1]

4. Cathodic protection equipment that can be fitted out with telemetry

The cathodic protection equipment that can be associated with a tele monitoring system includes:

- impressed current station,
- polarized bond including current drainage station,
- electrical bonds between structures,
- grounding systems for the drainage of induced or conducted alternating current on the structure,
- protection systems (such as lightning arresters, voltage surge arresters) against accidental dc or ac voltage surges,
- galvanic anode,
- potential test point, possibly associated with equipment (such as a coupon, a metal casing …).

5. Data to be tele-transmitted

Data to be transmitted can be carried by different means of communication: telephone networks, GSM, specialized links, ADSL, satellite, pipeline, GPRS…. The table below shows a non exhaustive list of data to be considered in a telemetry system. However, for each device, the cathodic protection manager will determine those he whishes to implement for his system.

Table 1: Data to be tele-transmitted

Remote monitoring	Remote measurement	Remote adjustment	Remote control
Rectifiers			
Parameters that can be remotely monitored by a on/off contact include : - open door, - burnt fuse, - a threshold to be defined (e.g. I_p, U_p, E_{on} or E_{off}). Duration of failure can be associated with the monitored parameter (delayed alarm).	Parameters that can be remotely measured: - I_p - U_p - E_{on} - E_{off}	Parameters that can be remotely adjusted as a reference value: - I_p, - U_p - E_{on}, - E_{off}.	Putting into or out of operation of a rectifier, a cyclical circuit breaker.
Polarized bonds			
Parameters that can be remotely monitored by a on/off contact include : - open door, - burnt fuse, - a threshold to be defined (e.g. I_{diode} , E_{on} ,….). Duration of failure can be associated with the monitored parameter	Parameters that can be remotely measured: - I_{diode}, - U_{diode}, - $E_{on\ structure}$, - $E_{off\ structure}$, - E foreign structure / soil or E foreign structure / structure (E rail road/soil or E rail road/structure in	Not applicable	Putting into or out of operation of a bond

(delayed alarm).	the case of a current drainage station).		
Galvanic anodes			
Parameters that can be remotely monitored by a on/off contact on a threshold to be defined (e.g. I_{anode}, E_{on} or E_{off}).	Parameters that can be remotely measured: - I_{anode}, - E_{on}, - E_{off}	Not applicable	Not applicable
Bond with foreign structure (resistive or direct)			
Parameters that can be remotely monitored by a on/off contact on a threshold to be defined (e.g. I_{bond}, E_{on}, E_{off}, …). Duration of failure can be associated with the monitored parameter (delayed alarm).	Parameters that can be remotely measured: - I_{bond}, - E_{on}, - E_{off}.	Not applicable	Putting into or out of operation of a bond
a.c. grounding system			
Parameters that can be remotely monitored by a on/off contact include : - open door, - a threshold to be defined (e.g. $I_{bond\ a.c.}$, $I_{bond\ d.c.}$[2], $U_{ac\ pipeline}$, E_{on}, …). Duration of failure can be associated with the monitored parameter (delayed alarm).	Parameters that can be remotely measured: - $I_{bond\ a.c.}$, - $I_{bond\ d.c.}$, - $U_{a.c.\ pipeline}$, - E_{on}, - E_{off}.	Not applicable	Not applicable
Potential test point			
Parameters that can be remotely monitored by a on/off contact on a threshold to be defined (e.g ; E_{on}, I_{TM}, E_{off}). Duration of failure can be associated with the monitored parameter (delayed alarm).	Parameters that can be remotely measured: - E_{on}, - I_{MC}, - $E_{off,}$ - $U_{a.c.}$, - Parameter related to additional equipment.	Not applicable	Putting into or out of operation of a cyclical circuit breaker

6. Description

A remote monitoring system shall enable to:

- record at least once per day the proper operation from parameters (cf. table 1) and selected equipment,

- in case of confirmed malfunction of the cathodic protection equipment (cf. table 2), transmit information to the cathodic protection manager within the by him defined maximum timeframe,

[2] In normal operation, the $I_{bond\ d.c.}$ equals zero. In case of short circuit of the filter, a d.c. current will flow in the bond, which is very detrimental for the cathodic protection of the buried pipeline.

- in case of normal operation, transmit information of proper operation to the cathodic protection manager within the by him defined maximum timeframe,

A remote measurement system shall enable to:

- record all selected variables (cf. table 1), within the maximum lapse of time defined by the cathodic protection manager, on networks not subject to stray currents. The remote measurement system originates data that can be either directly accessibly or indirectly by means of statistical values calculated over a defined period of recording (at least: the minimum, maximum and average values),

- record, during a sufficiently long period, and with a suitable scan rate, all selected variables, within the maximum lapse of time defined by the cathodic protection manager, on networks subject to stray currents. The remote measurement system originates data that can be either directly accessibly or indirectly by means of statistical values calculated over a defined period of recording (at least: the minimum, maximum and average values),

- transmit recorded information to the cathodic protection manager within a by him defined maximum delay,

A remote measurement system may be associated with a remote monitoring system. The transmission of the measurements can be carried out either directly through the remote measurement system, or on request (automatically or manually) by the cathodic protection manager.

A remote control system shall enable to remotely change the operational state of a cathodic protection equipment (start/stop of a rectifier, remotely start/stop of a cyclical switching device,…).

A remote adjustment system shall enable the remote modification of the settings of a current rectifier. It shall enable to carry out remote measurements. Any reference to periodicity, scan rate or measured value is irrelevant.

Table 2: Examples of failures according to the type of equipment

Type of equipment	Examples of failures
Rectifier	- Protection current not in accordance with a preset threshold, - Protection potential Eon not in accordance with a preset threshold, - Voltage over the terminals of the rectifier not in accordance with a preset threshold.
Polarized bond	- Bond current not in accordance with a preset threshold during a preset period, - Inversion of the current flow direction in the bond.
Galvanic anode	Protection current not in accordance with a preset threshold.
Bond with foreign structure (resistive or direct)	Cathodic protection current not in accordance with a preset threshold, possibly during a preset period.
a.c. grounding system	- A.c. current in the ground bond not in accordance with a preset threshold during a preset period, - D.c. current not equal to zero.
Selected potential test point [3]	- Protection potential E_{on} not in accordance with a preset threshold, - Current in an internal bond not in accordance with a given threshold.
Not selected potential test point	- Protection potential E_{on} not in accordance with a preset threshold, - Current in an internal bond not in accordance with a given threshold, - Protection potential E_{off} not in accordance with a preset threshold, during a preset period.

[3] This involves test points selected as meant in standard EN 12954 (cf. 10.3.3.2 a 1).

7. Delay of information transmission

The delays of transmission of data and alarms vary according to the telemetry system and the internal organization of the company using the system. On should distinguish the delay of transmission of data (such as measurements) from that of an alarm (signaling the failure of equipment of the cathodic protection system). In all cases the maximum transmission delay shall be defined by the cathodic protection manager as specified in § 5.

The possible or probable severity of a failure of the remotely monitored equipment may also affect the choice of the transmission delays. For the choice of the transmission delay one shall also take into account the capability of responding to the alarm: e.g. it is inconsistent to collect data in real time if an intervention cannot be scheduled in less than a month.

In the case that the on-site monitoring campaigns are totally or partially substituted by the remote measurement systems, the transmission delays shall be comply with the minimum requirements in the regulation.

Note : It is recommended to take into account the delays of intervention which will be added to the delays of transmission . However, the present document does not address the delay of intervention further to the notification of an anomaly by the telemetry system.

8. Periodicity of field measurements and checks of cathodic protection equipment

Standard EN 12954 (cf. table 2) defines the periodicities of field checks on cathodic protection equipment in absence of a telemetry system.

Several philosophies are possible. The cathodic protection manager can implement either exclusively remote monitoring or exclusively remote measurement or remote monitoring with associated remote measurement. This can be completed with remote control and/or remote adjustment.

If the telemetry involves exclusively remote monitoring, then it can only substitute the verification of proper operation of the cathodic protection equipment. However it will not replace the detailed and comprehensive assessments to be carried out on-site. In this case it is recommended to comply with the periodicities defined in standard EN 12954 for these detailed and comprehensive assessments.

If the telemetry involves remote measurement (with or without associated remote monitoring), the periodicities of the assessments to be carried out on site can be increased with regard to those defined in standard EN 12954. The operator who decides to increase the field checks of a network or part of a network shall be able to justify this decision.

The justification shall particularly take into account:

- the number and type of measurement points equipped with remote measurement (rectifier, potential test point,…..),
- the characteristics of the network (length of the involved pipelines, defined limits of the network, absence of foreign electrical influence on the network,…..),
- the level of effectiveness of the CP which shall comply with the criterion defined in standard EN 12954,
- the control of the level of the cathodic protection.

9. Characteristics to consider for the choice of a telemetry system

Table 3 synthesizes the different parameters to be considered in order to guide the choice of a telemetry system.

Table 3: Parameters to be considered and the related description for selecting a telemetry system

Item	Parameters	Description	Remarks
1	Type of telemetry	Remote monitoring, remote measurement, remote control, remote adjustment, remote operation ,	Permanent or temporary telemetry according to the type of equipment (rectifier, test point, …).
2	Type of cathodic protection equipment	- Rectifier, - Drainage station, - Potential test point with or without equipment (test coupon), - Electrical bond, - Galvanic anodes, - Electrical grounding (for a.c. current drainage).	
3	Dimensions of the telemetry devices	To be agreed up on between the client and the supplies.	Dimensions compatible with the equipment to be monitored.
4	Parameter to be measured or monitored	See Table n°1.	
5	Type of power supply	- mains, - battery, possibly associated with solar panels, - turbo generator - turbines powered by a fluid.	- Accumulator life time, - Autonomy of the accumulators or batteries, - Vandalism, geographical et environmental situation for the location of solar panels.
6	Environmental conditions	- ATEX area or not, - Ambient relative humidity, - Allowable operating temperatures, - Corrosive environment or not, - Degree of Ingress Protection by enclosure (IP).	The allowable operating temperatures shall be compatible with the ambient temperatures
7	Information communication system	- GSM or GPRS, - PSTN network - Pipeline, - ADSL (PSTN or optical fiber), - Wi-Fi, - Radio waves, - Satellite.	- Problem of area coverage, - Existing network, - Loss of signal depending on the distance, - Existing network, - Limited range of the signal, - Limited range of the signal and reliability issue, - Cost of transmission.

8	Technical characteristics of the remote measurement channels	- Required number of channels, - a.c. or d.c. data to be acquired for each channel, - Range of each channel, - Scan rate, - Input impedance of each channel, - Insulation of the channels.	- Suitable range for the measurement of the involved parameter, - Scan rate compatible with the requirements of the CP manager - Typically : 10 MΩ for a spot potential measurement, 100 MΩ for a permanent potential measurement. Very low for a current measurement. - Typically : 200 to 1000 V between two channels in order to avoid interference on the measurements, - Increase the electrical power consumption.
9	Technical characteristics of the remote monitoring or remote control channels	- Discrete binary input - Discrete binary output	- Voltage threshold at the input of the remote monitoring circuit board, - Interruption capacity of the remote control relay or circuit board.
10	Memory	- Volatile or permanent memory of the recorded data, - Memory size, - Type of support of the memory.	- A permanent memory allows avoiding loss of information in case of malfunction. - Depending on the chosen management process, a removable support enables reading the recorded data on another device
11	External communication ports	The type and number of external parts shall comply with the requirements of the CP manager	- Ethernet ports for network access, - Serial ports for communication, - Bus for extensions, of digital and analogical inputs for connection of a laptop (not exhaustive),
12	Details regarding the acquisition of the measurements	- Accuracy to be defined with the CP manager, - Metrological follow-up to be defined with the CP manager.	- Typically: 1 % of full scale of the channel, - Self auditing system possible.
13	Data management	- Processed directly by the CP manager by means of an information processing software installed at his premises,	- Requires backup and archiving of data

		- Processed by the telemetry system supplier. In this last case information is accessible through Internet. - Possibility to secure the transmitted data.	- Possibility to remotely modify, via internet, the threshold settings, the frequency of retrieval of the measurements. - Defer to the supplier the responsibilities for data storage, backup, and protection
14	Data export format	The software shall allow exporting data by means of a format usable by the cathodic protection manager.	Examples of formats: XML, ASCII, SQL, CSV, XLS.
15	Technological developments	Compatibility of existing hardware and software with technological developments.	
16	Configuration of retrieved data	- Complete transmission of recorded data. - Statistical processing over a defined lapse of time (e.g. one day) : minimum, maximum, average, standard deviation, out of range time. - Archiving of statistical values, number of alarms, out of range time …	The configuration shall be defined with respect to the means of data analysis of which the CP manager disposes - Possibility to obtain spot records and zooms.
17	Protection against accidental potential surges	- Interest to dispose of his own protection device - Compatibility with that of the equipment on which it will be installed	The installed telemetry equipment shall comply with standards EN 62305-3 (Protection against lightning-Damage to structures) and 62305-4 (Protection against lightning-Electrical and electronic systems). NOTE: the telemetry equipment shall have an adequate protection against lightning and a good CEM in order to allow its installation (low failure frequency).
18	Maintenance	- Maintenance contract established with the supplier or the service provider, - Maintenance carried out by the client.	
19	Guaranty	- Duration of the guaranty, - Guaranty conditions (hardware, software, data transmission, data backup, guaranty exclusions, …).	

20	Training	To be detailed in the contract if needed.	
21	Type of contract regarding the hardware	- Proprietary system, - Leased system.	- Follow up of the equipment by the CP manager, - Rely on the service provider.
22	After sales service	- Sustainability of spare parts supply over a defined period, even after ceasing the manufacturing of the equipment.	
23	Supplier references	- Number of equipment already installed, - Client portfolio	
24	Miscellaneous	- Technical assistance from the supplier to be defined in the customer-supplier contract.	