We need better standards for paint systems protecting buried tanks in conjunction with cathodic protection

Marcel ROCHE

CEFRACOR, France, marcel.roche@orange.fr

Abstract

The French regulatory and professional context for buried industrial or domestic tanks storing LPG (*Liquefied Petroleum Gas*) or liquefied flammable products is reminded. Avoiding or reducing periodical external inspection for requalification is allowed based on a comprehensive policy of coating and cathodic protection. A "*high durability*" and "*Im3*" type protective paint system is generally selected for coating.

It is recommended to implement a certification process for the paint systems used and for the persons acting for their application and for their inspection. In France, the *Association pour la Certification et la Qualification en Peinture Anticorrosion* (ACQPA) is in charge of these three aspects of certification but it does not currently certify paint systems for the *Im3* category.

It is first necessary to implement a relevant referential as current standards are not adapted enough. Revision of EN ISO 12944-6 specifying laboratory performance test methods is necessary for introducing a cathodic disbondment test, the present reference to ISO 15711 being not adequate. It is proposed to base the qualification and quality control tests for cathodic disbondment on ISO 21809-3 "*Petroleum and natural gas industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 3: Field joint coatings*" and to adopt the acceptable values for coatings types 4A and 4B (epoxy and polyurethane liquid applied coatings) specified in this standard.

Keywords: paint systems; cathodic protection; buried tanks; standards

Introduction

Two types of buried *Liquefied Petroleum Gas* (LPG) storage tanks are currently used:

- Industrial tanks, cylindrical or spherical (35 to 3,500 m^3), buried under “embankment” or inside reinforced concrete enclosures open on their upper faces ("sarcophagus");
- Domestic "small bulk" cylindrical tanks (<12 m^3) buried at the premises of customers.

Corrosivity of their electrolytic external environment can be estimated between 5 to 30 µm/yr when river sand with a low soluble salt content (chlorides and sulfates) is used for their installation. Based on the higher side of this range, a 1.5 mm corrosion allowance could be consumed in 50 years. However, this low general corrosion rate can be locally exceeded due to accelerating effects which may come from an unfavorable galvanic coupling, for example through contact with grounding copper circuits, or from contamination by salts, or from possible effects of stray currents.

Consequently, and due to some potential safety and environmental related risks, these tanks are systematically protected against external corrosion by an organic coating system completed with a cathodic protection (CP) system. This applies also to tanks storing other liquefied flammable products or dangerous liquids.

LPG storage tanks are subjected to regulations concerning pressure equipment which request periodical requalification inspections. However, it can be allowed to perform these requalifications without visual inspection of the outer wall of the tank, which avoids removal of soil and sand. This is accepted provided that specific requirements on cathodic protection and coating are observed.

Industrial LPG tanks buried under embankments or in concrete enclosures

In France, BSEI Decision N°13028 of 21 March 2013 of the *Ministère de l’écologie, du développement durable et de l’énergie* [1] allows performing periodical requalifications without visual inspection of the outer wall of the tank provided that specific requirements detailed in the following professional document are respected: « *Dispositions spécifiques applicables aux réservoirs sous talus destinés au stockage de gaz inflammables liquéfiés* » published by the *Association Française des Ingénieurs en Appareils à Pression* (AFIAP) [2]. The main provisions of this professional document are dealing with cathodic protection and coating systems; they are summarized hereafter.

Cathodic protection

Cathodic protection may be either by galvanic anodes or by impressed current systems. The principles, design and commissioning of these systems shall be defined in collaboration with a CP specialist. The criteria for service monitoring shall be established by the specialised company in charge of the design of cathodic protection. The personnel of this specialised company shall have a certification in accordance with EN 15257 [3] (e.g. certification from CEFRACOR CERTIFICATION/Protection Cathodique [4]) or an equivalent international standard (e.g. NACE International Institute).

These complementary systems are field proven (no corrosion despite some coating failures) and a modelling parametric study made for the *Comité Français du Butane et du Propane* (CFBP) has consolidated the demonstration of the efficiency of the CP system to prevent corrosion at coating defects and helped to better know the relevance of the various methods of measurements [5].

A professional guide on “*Cathodic protection of tanks under embankments for storage of LPG*” validated by CEFRACOR has been published by CFBP in July 2014 [6].

Coating systems

The AFIAP professional document stipulates that the choice and quality of application of the coating system are crucial for its durability. The manufacturer of the coating products and the

coating applicator shall be involved in the definition of a quality plan including specifications or procedures related to the composition, application, testing and reception of the coating system. Inspection and testing of the coating shall be made according to the relevant standards by qualified personnel.
The critical points to ensure are:

- compatibility of the coating with cathodic protection,
- consideration of climatic conditions,
- control of steel surface conditions: geometry of the weld seams, profile, cleanliness, contamination by dust...,
- control the time duration between cleaning and application of the first coating layer,
- respect of time durations and sequences,
- competence of personnel,
- measurement of dry film thickness,
- control the electrical continuity by holiday detection.

The *Association pour la Certification et la Qualification en Peinture Anticorrosion* (ACQPA) offers a complete scheme for certifying coating systems vs. referentials, as well as competence of application personnel and the one of inspectors on the basis of FROSIO scheme [7]. However, ACQPA does not operate certification of coating systems for cathodically protected buried structures so far.

Domestic "small bulk" LPG tanks buried at premises of the customers

In France, Decision DM-T/P No.32325 dated 9 December 2002 [8] exempts from external verification the tanks operated by one of the companies members of CFBP and protected, installed and monitored in accordance with its Professional Specification dedicated to the manufacture and operation of small bulk LPG tanks MA.PV/Cc.01 (Edition 5 of 30/03/2009) and all associated documentation (procedures, technical specifications, application guides) [9].
This is applicable to buried equipment:

- coated and cathodically protected,
- or installed in plastic casings
- or coated with "Bitulatex".

Coating systems
MA.PV/Cc.01 stipulates that:
§ 7. 1. Surface preparation is achieved by abrasive blast cleaning at SA 2.5 according to ISO 8501-1 or equivalent, or cleaning resulting in an equivalent surface condition.
§ 7. 3. Surface protection of cathodically protected buried tanks with sand backfill shall be in accordance with technical specification CFBP MA.PV/ST.05 [10].
§ 7. 4. Surface protection of cathodically protected buried tanks with backfilling using the native material shall be in accordance with the technical specification CFBP MA.PV/ST.06 [11].
Technical specifications CFBP MA.PV/ST.05 and MA.PST.06 request:

- A liquid or powder applied paint system controlled with holiday detector as per NF E86-901 settled at 2.5 kV
- Requirements of qualification tests carried out on samples taken from actual conditions of application, by an independent lab, including:
    - Adhesion > 7 MPa,
    - 1000 hours salt spray resistance,
    - cathodic disbondment in accordance with BG PS/CW6 at 28 days <20 mm [12].

Technical specification CFBP MA.PV/ST.06 requires an additional mechanical protection fulfilling:

- impact tests with 15 kg concrete cubes at 230 J: No breakdown at 2.5 kV
- static penetration test 4 t on 40 cm^2 for 10 min.

Cathodic protection

Cathodic protection shall ensure, at all times, a "OFF" potential more negative than -850 mV vs. saturated Cu-$CuSO_4$ (CSE) or -950 mV in soils with sulfate-reducing bacterial activity.
At least 2 galvanic anodes shall be used, located in the native soil outside the filling material at a minimum distance of 60 cm from the tank.
Impressed current system is possible in locations where it is already installed (e.g. in filling stations).
It is necessary to limit the risk of "cathodic disbonding" (actually loss of adhesion) of the coating under the action on the adhesive bond between the coating and steel around a coating defect of alkaline pH (about 12 to 13) created by the cathodic polarisation, which increases when the potential becomes more negative or when the temperature increases.
It is also necessary to avoid that the coating undergoes open disbondments that may lead to penetration of low conductive electrolyte (soil or sand) locally creating an attenuation of cathodic protection current density that could prevent protection ("shielding effect").

Improvement of reliability of coating systems of cathodically protected buried tanks through standardisation and certification

Coating standards

The essential requirements and recommendations of corrosion protective paint systems are based on the respect of EN ISO 12944. For paint systems used for protection of buried tanks it is necessary to select a "*high durability*" (>15 years without intermediate maintenance operation) paint system as defined by EN ISO 12944-1 [13] for a category of environment "*Im3*" (buried in the ground) according to EN ISO 12944-2 [14].
However EN ISO 12944-2 very vaguely refers to cathodic protection (only in a general note).
Qualification tests of paint systems at the laboratory are defined by EN ISO 12944-6 [15]. For a category of environment *Im3* (buried in the ground) and "*high durability*" coating this standard specifies 3000 hours resistance to 5% NaCl salt water immersion test according to ISO 2812-2 [16] and 1440 hours resistance to salt spray test according to ISO 7253 [17]. These tests are not representative of a buried environment and moreover there is no cathodic disbonding test required. It is therefore essential to revise this standard for introducing a cathodic disbonding test. ISO 15711 standard relative to *Determination of resistance to cathodic disbonding of coatings exposed to sea water* should itself be revised to be improved and, in addition, it is not applicable to soil [18].

Certification of coating systems

For France, it is highly recommended to systematically implement the ACQPA certification process for protective paint systems, application personnel and inspectors (FROSIO system) personnel for buried tanks.
In addition, the adequacy of the paint systems and the quality of their application in view of ensuring their durability shall be systematically validated by the *Office d'Homologation et de Garantie des Peintures Industrielles* (OHGPI) [19].
However, ACQPA does not currently certify paint systems for *Im3* category and, in addition, under cathodic protection.
It is first of utmost importance to prepare a suitable referential for *Im3* category under cathodic protection, as current standards do not suit. Pending on a future adapted ISO standard, it is proposed to write an AFNOR standard for France which could be used as referential for the ACQPA certification of the coating systems adapted to *Im3 with cathodic*

protection. For this purpose, it is proposed to adopt for this standard the qualification and control tests, and the corresponding acceptable values, which are specified by EN ISO 21809-3: 2016 standard applicable to the field joint coating of buried pipelines for coating types 4A and 4B (epoxy and polyurethane liquid applied coatings) [20]. This standard precisely defines in particular a cathodic disbonding test procedure in a normative annex G. It is based on a 6 mm diameter discoid artificial coating defect, a potential of -1.5 V vs. Standard Calomel Electrode (SCE) and a duration of 28 days at room temperature. For quality control, testing at 65°C allows reducing the duration of the test to 48 hours with the same acceptable values.

References

1. Ministère de l'écologie, du développement durable et de l'énergie, Direction générale de la prévention des risques, Décision BSEI n° 13-028 du 21 mars 2013 *relative à la reconnaissance d'un cahier technique professionnel pour le contrôle en service des réservoirs sous talus destinés au stockage de gaz inflammables liquéfiés*
2. Cahier technique professionnel de l'Association Française des Ingénieurs en Appareils à Pression (AFIAP) définissant les « *Dispositions spécifiques applicables aux réservoirs sous talus destinés au stockage de gaz inflammables liquéfiés* », Révision de mars 2013 (Edition initiale juin 2004) [1] Guide professionnel CFBP « *Protection cathodique des réservoirs sous talus destinés au stockage de GPL* », 2014, http://www.cfbp.fr/
3. EN 15257: 2007, *Cathodic protection - Competence levels and certification of cathodic protection personnel*
4. CEFRACOR CERTIFICATION/Protection cathodique, French certification scheme for cathodic protection persons, http://www.protectioncathodique.net/
5. M. Roche, A. Duclos, H. François, *Efficiency of cathodic protection applied to buried LPG tanks*, Eurocorr 2016, paper 51552, Montpellier, 11 - 15 September 2016
6. Guide professionnel CFBP - *Protection cathodique des réservoirs sous talus destinés au stockage de GPL*, Ref.533, Juillet 2014, Comité Français du Butane et du Propa*ne*, 8 Terrasse Bellini, 92807 Puteaux cedex, France, http://www.cfbp.fr/
7. ACQPA Web site, http://www.acqpa.com/
8. Décision DM-T/P n° 32325 du 9 décembre 2002 relative à l'exploitation de certains réservoirs de stockage de gaz de pétrole liquéfiés dits "Petit vrac"
9. Cahier des charges professionnel pour la fabrication et l'exploitation des réservoirs GPL Petit Vrac, Comité Français du Butane et du Propane, Ma.Pv/Cc.01 Edition 5 du 30 mars 2009
10. Spécification CFBP MA.PV/ST.05, peintures des réservoirs "petit vrac" de GPL (remblayage sable)
11. Spécification CFBP MA.PV/ST.06, peintures des réservoirs "petit vrac" de GPL (remblayage matériau d'origine)
12. BG PS/CW6, *Technical specification for the external protection of steel line pipe and fittings using fusion bonded powder and associated coating systems. Part1: requirements for coating materials and methods of test*, Jan. 1993, J229 (rev 08/98), British Gas, then Tranco
13. EN ISO 12944-1, *Paints and varnishes – Corrosion protection of steel paint structures by protective paint systems – Part 1: General introduction*
14. EN ISO 12944-2, *Paints and varnishes – Corrosion protection of steel paint structures by protective paint systems – Part 2: Classification of environments*
15. EN ISO 12944-6, *Paints and varnishes – Corrosion protection of steel paint structures by protective paint systems – Part 6: Laboratory performance test methods*
16. ISO 2812-2, *Paints and varnishes – Determination of resistance to liquids - Part 2: Water immersion method*
17. ISO 7253, *Paints and varnishes – Determination of resistance to neutral salt spray (fog)*

18. ISO 15711, *Paints and varnishes - Determination of resistance to cathodic disbonding of coatings exposed to sea water*
19. OHGPI Web site, http://www.ohgpi.com/
20. EN ISO 21809-3: 2016, Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems - Part 3: Field joint coatings