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Cathodic protection of LPG mounded vessels – The current distribution problem

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Abstract

Cathodic Protection of LPG Tanks is quite a special application. Previous experience with sacrificial anodes has led to individuate localized surface areas where the required protection potential could not be obtained.

The use of impressed current, allowed by the recent Standards and recommendations, can solve the problems, provided that the distribution of the protection current is such as to be successfully regulated through a great diligence during the various phases of design, installation, commissioning and operation of such system.

The wise choice of number and location of the groundbeds and the reference electrodes during the design phase is therefore the most important issue.

The paper describes the problems encountered during the site erection of two 2000 m^3 LPG mounded tanks in Madinah (KSA) area, and the commissioning results.

Commissioning has confirmed that in such complex structures the presence of specific and sometimes unforeseen unprotected areas can only be healed thanks to the preventative measures taken in the various phases of the CP design and installation.

1 – Introduction

LPG large tanks are often placed in existing, old LPG plants where new needs have led to implement the stock capacity of LPG Gas. Mounded LPG Bullets are large, buried, horizontal cylindrical steel tanks with dished ends of size ranging between 3.5 to 7.0 meter diameter and lengths of 35 to 70 meters or more. Mounded bullets allow storage of large quantities of LPG - up to 2,000 MT or more in a single location.

The area of land required to locate a mounded system is minimal compared to conventional storage. In these kinds of reservoirs, the construction of the Tanks is made first, and then a large quantity of soil is used to cover the whole construction.

The typical construction of mounded Tanks involves some new findings: the first one is that the soil is usually compacted over the tanks after their construction; the second one is that around the usually very large steel surfaces to be protected there is a little amount of soil. Besides, the Tanks are usually placed among other structures already cathodically protected. This involves possible interference problems to be solved. It is too simplistic to try to protect cathodically such structures by using typical vertical deep or horizontal groundbeds placed at large distances. In these cases, problems usually arise that may result in dangerous electrical interferences and, above all, in order to properly protect some part of these structures, a large amount of current is to be fed to the entire system, contributing to cause even worst interference conditions elsewhere in the plant.

According to the appropriate European Standards, this kind of structures must be considered as a “Complex Structures” and then are to be dealt with specific knowledge of this type of structures. Their special geometry, especially when multiple tanks are installed, involves the choice of particular arrangement of the groundbeds in order to obtain an even distribution of CP currents coupled with the possibility of its fine regulation around and across the structures to be protected, according to the needs.

2 – **Complex Structures**

In many industrial applications the use of distributed groundbeds is to be considered either very useful or unavoidable. This is typically the case of Complex Structures where impressed current cathodic protection systems are generally used.

According to EN Standard 14505, a "Complex Structures" is a : *"structure composed of a structure to be protected and of one or more foreign electrodes which, for safety or technical reasons, cannot be electrically separated from it."*

In the case of Mounded Tanks, for safety reasons, they are also provided with an autonomous grounding system which must also be cathodically protected together with the metallic surfaces of the Tanks. Besides, due to the complexity of the plant, many pipes are connected to the existing pipeline network and grounding. Besides, a large reinforced concrete platform is necessary to sustain the whole structure.

The complexity of this kind of structures is due to:

- presence of other structures, usually cathodically protected;
- critical distribution of CP current around and across the vessels also due to the geometry of the mound;
- possible screen effect;
- need of a separate grounding.

As usual, in these cases, a "global" or "local" Cathodic Protection System must be applied.

2 – Cathodic Protection System of Mounded Tanks – Requirements

In the case of mounded tanks, the amount of soil surrounding the metallic tanks is rather small (see Figure 1) and therefore particular care should be taken with either impressed current or sacrificial anodes systems: the scarce amount of electrolyte requires in fact a particular design since the current distribution is strongly influenced by the soil thickness. Besides, soil resistivity has carefully to be taken into account for the calculation of groundbed design.

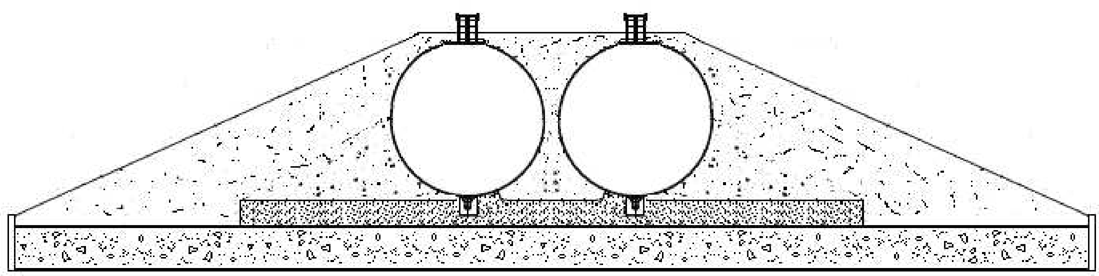

Figure 1 – Cross section of the mounded tanks

In order to allow the best possible distribution, once the current requirements have been calculated, a sufficient number of groundbeds has to be distributed along and between the structures to be protected.

As a consequence, a substantially high number of groundbeds is necessary (in this particular case 32 groundbeds).

The high number of groundbeds also implies the necessity of calibrating the current relevant to each groundbed.

A sufficient number of reference electrodes have to be placed around the structure to calibrate and verify the potential of the whole surfaces (in this particular case, 26 Permanent Reference Electrodes).

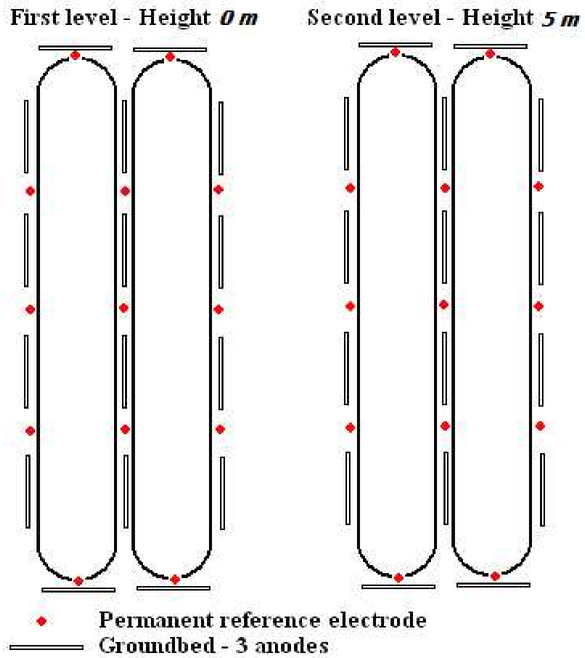

Figure 2 – Arrangement of the groundbeds and the permanent reference electrodes

The groundbeds are made of high silicon-iron anodes. Each groundbed is composed of three high silicon anodes connected together. The different groups of groundbeds have been placed at various levels. The position of the groundbeds and permanent reference electrodes around the tanks has been selected in relationship to an optimised distribution of current and determination of the potential around the surfaces to be cathodically protected and is schematically shown in the Figure 2.
In the following Figure 3 the Power supply system and the distribution of different circuits for each groundbed is shown.

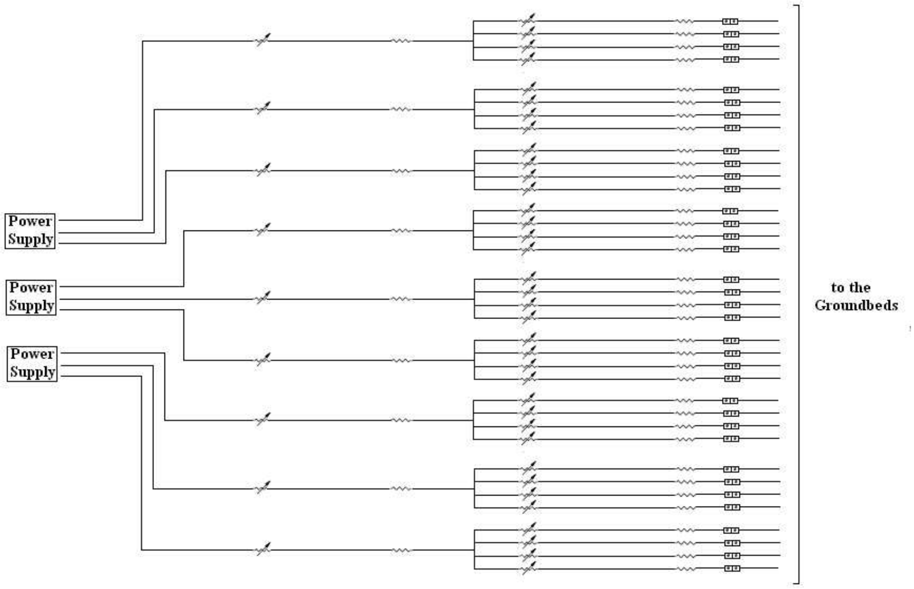

Figure 3 – Power distribution

Figure 4 shows the Measurement and Control Panel, which allows the measurement of all the permanent Reference Electrodes.
Some of them (E1, E2, E3) are chosen to drive the three CP Stations automatically maintaining the potential at the "critical" positions, where the potential is less negative.

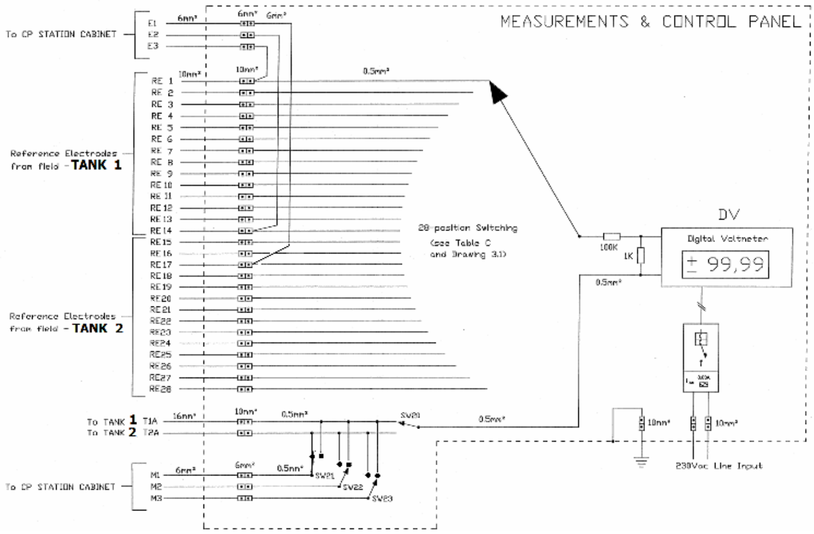

Figure 4 – Measurements and Control Panel

Figure 5 shows the global arrangement of the CP System, including Transformer/Rectifiers, Measurement and Control Panel and the Power Distribution Panel.

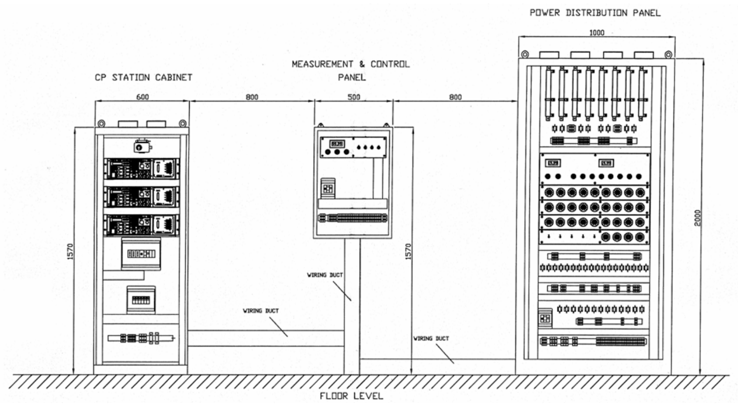

Figure 5 – Cathodic Protection System – Overall view

Thanks to the flexibility of this kind of CP System, it has been quite easy to reach satisfactory potentials all over the structures to be protected. Three permanent reference electrodes (the least negative ones) are automatically driving the current outputs from the three electronic transformer rectifiers. The entire System is allocated in a fireproof room which also assures enough ventilation and is temperature controlled. The rectifiers themselves are in a cabinet self controlled in terms of temperature.

3 – Conclusions

The choice of a cathodic protection system, such as the one described above is justified by the fact that it will be very difficult indeed, or even impossible, to make any kind of intervention once the GPL Tanks will be in operation; any further soil movement (excavation, re-burial, etc.) could in fact imply slight movements of the well settled tanks and therefore danger of mechanical failures which certainly could strongly jeopardize the service life of the important service operation of these tanks.
The use of the so-called “continuous anodes”, much easier to be put in place, would not give the possibility of a careful and localised control of all parts of the tank’s surface and would not therefore, in our opinion, allow a correct distribution of the CP current where it is really needed.
Pre-commissioning and commissioning have confirmed the validity of the design and the capability of the system for obtaining the best distribution of the current in order to reach the correct protection potential everywhere.
A further development of this idea has been already put in practice, by means of the realisation of multiple CP Stations where a modular device supplies many smaller external circuits. Each of these circuits is self controlled with constant current or constant potential mode. All the relevant parameters such as voltage applied, current, potential, groundbed resistances and, indirectly, any variation of electrical characteristics of the entire CP circuit and System (short circuits, undue connections, soil resistivity, damages to the coating etc.) will be continuously monitored with a Remote Control System, included in the design, and relevant automatic alarm signals.

References

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[2] G. Raoli, R. Cigna, M. Di Berardino, O. Fumei – "Cathodic Protection of LPG Mounded Storage Systems", Conference on "Cathodic protection and associated coatings" (EFC event n. 254), June 6th – 7th 2002, Aix en Provence.

Standards and Recommendations

- EN 14505 – 2005 Cathodic Protection of Complex Structures
- EN 13636 – Cathodic protection of buried metallic tanks and associated piping
- UNI 10832 – Aug. 1999 – LPG mounded storage systems - Design, construction and control - Safety requirements
- EN 13509 – Cathodic protection measurement techniques
- EN 12954 – Cathodic Protection of buried or immersed metallic structures – General principles and application for pipelines
- EN 50162 – Protection against corrosion by stray current from direct current system
- ISO/FDIS 15589-1: 2003 (E) Petroleum and natural gas industries – Cathodic protection of pipeline transportation systems – Part 1 : On land pipelines
- NACE RP 0285/95 - Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
- NACE - RP-0188-90 – International Standard - Recommended Practice, "Discontinuity Testing of Protective Coatings"