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Shielding effect of delaminated pipe coatings

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Introduction

In the context of cathodic corrosion protection, the shielding effect of delaminated coatings is frequently discussed. Especially in Anglo-Saxon countries, the use of non-shielding coating systems is prescribed for certain pipelines. This increasingly leads to the supersession of polyethylene-based coating systems in these countries. In recent years, discussions with regard to shielding are also increasingly taking place in Europe, accompanied by the increasing marketing of allegedly non-shielding products. However, the use of coatings with significantly poorer dielectric properties contradicts Central European practice.

The relevant aspects are dealt with taking into account the work of Professor Schwenk and the statements of DIN 30670:2012.

Corrosion protection of pipelines

The corrosion protection of pipelines in Central Europe is usually achieved by a high-quality factory coating with three-layer polyethylene (3LPE) and a field-coating with three-layer butyl rubber PE tapes or three-layer PE shrink sleeves in combination with cathodic corrosion protection (CCP). This principle has proven very successful in practice. Despite the positive experience with the combination of high-quality dielectric coatings and CCP, outside the German-speaking region repeated discussions about the shielding effect of delaminated polyethylene coatings on the protective current access to the steel ensue. In each case, reference is made to the significance of the adhesion of the coating, the delamination through the so-called over protection (see DIN EN ISO 15589-1:2017) as well as the excellent dielectric properties of these products. This discussion has led to fundamental differences in corrosion protection concepts between North America and Central Europe. In the USA, for example, the use of non-shielding coatings is mandatory for certain pipelines (see DOT CFR 192.112). This leads to the use of comparatively thin (approx. 0.5 mm) fusion bonded epoxy (FBE) coatings, which are generally described as non-shielding [1]. By contrast, the use of comparatively thick (at least 1.8 mm) polyethylene-based coatings has proved very successful in Central Europe, although these have clearly pronounced insulating and thus - in the sense of the above-mentioned DOT CFR 192.112 - shielding properties. In this context, it is important to note that in Europe, despite shielding coatings, there were hardly any reports of damages caused by delaminated coatings. The problem of delamination and the resulting shielding is described in the current DIN 30670:2012 "Polyethylene coatings of steel pipes and fittings - Requirements and testing" as follows:

“Extensive testing and practical observations have shown that, independent of the manufacturing process, the polyethylene coating can be permeated, depending on the salt content of the soil water and the level of cathodic polarisation caused by defects. This process, however, neither involves subsurface corrosion nor an increase in the protective current requirement.”

This information is fundamentally at odds with the non-shielding coatings required in North America. There are therefore fundamental differences in the choice of coating system and the assessment of the risk of corrosion under delaminated coatings between Europe and North America.

Corrosion of the steel under delaminated coating

The effectiveness of the CCP under delaminated coating was thoroughly investigated by Schwenk. Schwenk draws the following conclusion from these investigations [2]:

Chapter 4.5. and 5.2.1.5: “Based on theoretical considerations, laboratory tests and field experience there is no risk of corrosion in the infiltrated area itself.” and “Furthermore, an increase in the protective current requirement of CCP is not to be expected.”

The term “dimensionally stable coating” is often used in this context. As long as the delaminated coating rests tightly on the steel surface in the form of a tube, no corrosion problems occur. Based on the above statements by Schwenk, it must be concluded that the shielding effect of the coating is neither a question of the product, its electrical resistance nor its adhesion. Rather, the geometry of the gap, i.e. the dimensionally stable and tubular contact, is the prerequisite for the non-shielding behaviour. This conclusion fundamentally challenges today's widespread international view and the linking of non-shielding properties with specific product classes (FBE vs. 3LPE). Similarly, the approach of using so-called 2-layer polymeric mesh backed coatings, which is often used in Anglo-Saxon countries, proves to be a wrong track. Apart from the open question of whether the protection current is in principle sufficient, this solution can only actually be effective in a small number of idealised possibilities.

An essential prerequisite for corrosion protection underneath the coating is the so-called dimensional stability. If this is not given, a larger volume of electrolyte can form between the coating and the pipe and in extreme cases even lead to flowing water between the coating and the pipe. Corrosion can therefore only occur under delaminated coating if a relevant volume is able to form between the coating and the pipe surface.

It becomes clear that the discussion regarding shielding and non-shielding properties has so far not been conducted in a sufficiently differentiated manner. An argumentation based solely on specific electrical resistances without consideration of the relevant mass transport processes and dimensional stability represents an inadmissible simplification. It is therefore not surprising that the term «shielding» has not yet been clearly defined either in standardisation or in the literature.

Conclusions

The experiences of the last decades have shown that the alleged shielding with the products used today is non-existent in Central Europe and also does not represent an integrity problem, since the dimensional stability is guaranteed with most products. From a corrosion protection point of view, coating systems that have demonstrably not led to any corrosion problems in practical use are therefore preferable, for example high-quality factory coatings with three-layer polyethylene (3LPE, e. g. ISO 21809-1) and field-coatings with three-layer butyl rubber PE tapes (e. g. DIN EN 12068).

References

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