

CEOCOR CR2 "C.D."

FINAL REPORT

(december 1987)

TITLE: Cathodic Disbonding of Steel Pipe Coatings

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1. INTRODUCTION

Steel pipelines and other steel structures are susceptible to corrosion by the action of corrosive substances in their environment. To reduce access of substances such as water, oxygen and carbon dioxide to the steel surface, an organic coating is generally applied. A coating has to reduce the rate of corrosion to a negligible level, so that corrosion damage is prevented.

Since there is always the possibility that the coating on a pipeline contains defects such as holidays or damaged areas, additional protection of the steel is usually applied, ie cathodic protection. The object of cathodic protection is to polarise the steel surface at coating defects (where the steel is in direct contact with the soil) to a sufficiently negative potential, such that the corrosion rate becomes negligible and oxygen reaching the steel surface is reduced at the steel cathode.

The coating and cathodic protection act together giving overall corrosion protection.

Under the influence of negative polarisation of steel, a loss of coating adhesion can occur, starting from the edge of a coating defect. This type of adhesion loss is known as cathodic disbonding. It must be clearly distinguished from other types of coating adhesion loss, such as that caused by permeation of water through the coating, eg osmosis or electro-osmosis. This report therefore deals mainly with coating disbonding as the result of applying cathodic protection.

A reason for considering cathodic disbonding is the possibility that conditions beneath cathodically disbonded coatings may lead to stress corrosion cracking. However, other relevant conditions need also to be satisfied, eg elevated temperatures and pressure, appropriate environment, presence of millscale and rust, etc, (Reference 35) before stress corrosion cracking can occur.

In the next chapter a brief description is given of the various types of disbonding that can occur and the most probable mechanism of cathodic disbonding.

2. MECHANISM OF ADHESION LOSS OF COATINGS

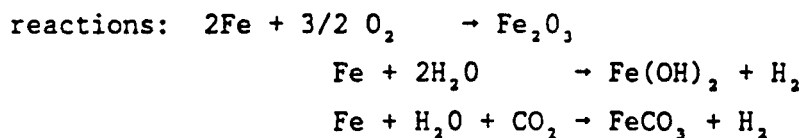
2.1 Permeation

Organic coatings on steel restrict the access of corrosive substances to the steel surface and prevent corrosion damage by significantly reducing the corrosion rate of the steel. However, corrosion reactions will not be completely prevented in the long term since all organic coatings are permeated by oxygen, water and carbon dioxide. Corrosive substances can permeate through a coating to the steel surface. The driving force of permeation is the difference in the partial pressure on either side of the coating. In the case of water, it is the difference between its vapour pressure in the wet environment and the water vapour partial pressure at the steel/coating interface.

The partial vapour pressure of water at the steel surface is generally sufficient to support the oxygen-nourished corrosion of the steel especially in a wet environment where the concentration gradient maintains an equilibrium between diffusing water and water consumption in the corrosion reactions.

An illustration of this phenomenon is the observation of dry, brown powdery rust which forms below polyethylene coatings in a wet environment with no temperature difference between the steel surface and the environment. The permeation of water and oxygen is gradual, and eventually results in total loss of coating-adhesion.

If it is assumed that the corrosive substances O_2 , H_2O and CO_2 (when they reach the steel surface) react completely according to the reactions:



then the maximum weight losses from corrosion due to permeation can be calculated as shown in Table 1 (Reference 17).

TABLE 1

Maximum Weight Loss by Permeation Through Intact Coatings

COATING	PERMEATION cm ³ /(cm ² .s.bar)	CORROSION- PRODUCT	Δ (BAR)	CORROSION RATE STEELWALL REDUCTION (μm/year)
PE (3 mm)	O ₂ : 2.9 x 10 ⁻⁸	Fe ₂ O ₃	0.2	2.6
	H ₂ O: 6.0 x 10 ⁻⁷	Fe(OH) ₂	0.02	2.0
	CO ₂ : 6.9 x 10 ⁻⁸	FeCO ₃	0.01	0.2
Epoxy (0.3 mm)	O ₂ : 2.3 x 10 ⁻⁹	Fe ₂ O ₃	0.2	2.1
	H ₂ O: 1.5 x 10 ⁻⁶	Fe(OH) ₂	0.02	50
	CO ₂ : 2.7 x 10 ⁻⁶	FeCO ₃	0.01	0.9

Real weight loss figures of coated steel pipes after 10 years underground are even lower, as shown in table 2 (Reference 17).

TABLE 2

Long Term Behaviour of Coated Steel

COATING	CORROSION RATE (μm/year)	SPECIFIC RESISTIVITY OF COATING, OVER 10 YEARS
Bitumen 9 mm	0.03	3.10 ⁷ → 2 x 10 ⁶ ohm.m ²
PE 4 mm	0.2	3.10 ¹¹ , no change
Coaltar Epoxy 2 mm	0.24	5.10 ⁷ → 4 x 10 ⁵ ohm.m ²

2.2 Permeation Due to a Temperature Gradient

A more severe case of water permeation is that of water through a coating due to a temperature gradient (lower temperature at the steel surface than in the wet environment).

Examples of this are the observed loosening of bitumen linings in long water mains, and the observed blistering in internally coated warm water settling tanks.

These blisters contain neutral water which has permeated the coating. This type of water permeation is inevitable with all organic coatings but its rate depends on coating type, thickness, temperature gradient, etc.

2.3 Osmosis and Electro-Osmosis

The presence of water soluble material on the steel surface (due to improper cleaning of the surface, or to the application of unsuitable primers) can give rise to water permeation through a coating due to osmosis. Osmosis occurs with every type of organic coating, but at different rates, depending on the coating.

Ions can enter certain materials with polar molecular groups and especially so if there are coherent phase boundaries within the material. An electric field across the coating thickness encourages migration, not only of ions, but also of water through the film. This process is generally known as electro-osmosis. In most cases water migrates to the cathode resulting in the formation of blisters and sometimes the destruction of the coating. Where cathodic polarisation of the steel occurs, the blisters contain an alkaline solution, whereas anodic polarisation produces an acidic solution and pits in the steel.

2.4 Cathodic Disbonding

All previously described types of adhesion loss are due to permeation of substances through intact coatings. In contrast to this, cathodic

disbonding starts from coating holidays and is characterised by moisture creeping along the interface between the coating and the steel, thus causing loss of coating adhesion. The resultant pH of the interfacial liquid can be 13 or higher.

The alkalinity of the moisture is the result of cathodic polarisation either due to the formation of a corrosion cell, or to stray-current influence or to cathodic protection of the steel. Pipelines without cathodic protection may be cathodically polarised at certain local spots, such as the cathodic surface in a (galvanic) corrosion cell, and at the point of entrance of DC-stray currents. On cathodically protected pipelines the entire steel surface is cathodically polarised.

Figure 1 illustrates a corrosion cell at a coating holiday where the following reactions occur:

At the anode, metal is consumed and iron ions are formed:



At the cathode, hydroxide ions can be produced by the reduction of oxygen



and normally to a negligible extent by the reduction of water accompanied by hydrogen evolution.



The hydroxide ions, produced at the cathode, are responsible for the observed alkaline behaviour.

The electrons liberated in the anodic partial reaction I remain within the bulk metal and migrate towards cathodic sites where electrons are consumed by the cathodic partial reaction III.

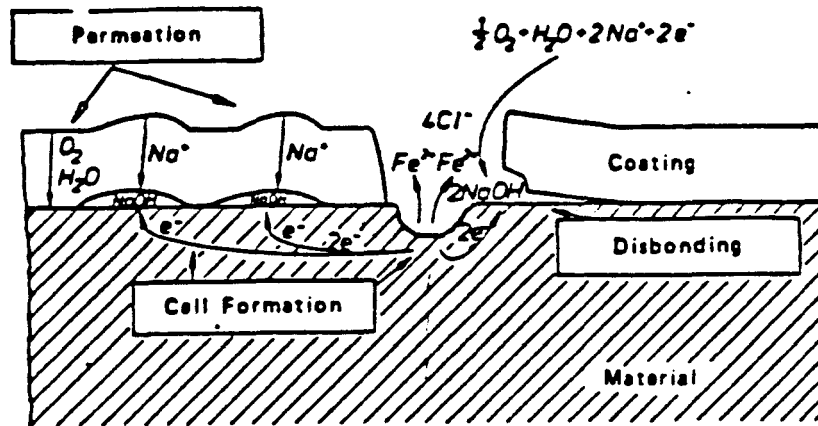


Fig. 1 (Ref.18): Corrosion interactions at a coated steel surface which is not cathodically protected.

In the case of cathodic protection no iron ions leave the metal surface, and no pitting results. The electrons are then furnished by cathodic protection.

Reactions I and II depend on each other and need to proceed in balance as follows:

If the electrons released in reaction I are not consumed by reaction II the surface is polarised to a potential negative enough to stop reaction I.

The anodic partial reaction I, ie "oxidation", and the cathodic partial reaction II, ie "reduction", sustain each other. The access of oxygen to a place where it may be reduced, controls the progress of the actual corrosion reaction I.

It can be shown that in a corrosion cell developing on a steel surface exposed by coating damage, the edge of the holiday acts as the cathode, whereas the anode is stabilised in the centre*). If the coating is electrically conductive, and allows the migration of ions and permeation of water/oxygen, the coated area near the holiday can act as a cathode and as a consequence of ion migration and eletrosmosis this area of the coating may develop blisters.

The destruction of adhesion due to alkaline moisture creeping under the coating, starting from the edge of the holiday is symbolised in the right hand section of figure 1 (most coatings do not bend up this way, so disbonding may remain undetected).

*) This can be demonstrated as follows:

Dissolve ~ 1 g NaCl and ~ 30 mg K₃[Fe(CN)₆] in 20 ml water and add two droplets 1% - phenolphthalein solution.

Remove about 1 cm² of coating from a coated steel surface without loosening the edge of the remaining coating and fill the defect with the above solution. After about 15 minutes the central parts of the liquid turns blue, indicating the dissolution of iron (anode), whilst the edge of the droplet turns red, indicating the formation of alkali (cathode).

With cathodic protection, (CP), ie artificial negative polarisation of the steel to $U_{\text{Cu/CuSO}_4} \leq -0.85 \text{ V}^*$ enough electrons are furnished for the consumption of all the available oxygen in reaction II and almost totally eliminating reaction I. Lowering the potential promotes reaction III, which may become dominant. (At $U_{\text{Cu/CuSO}_4} \leq -1.15 \text{ V}$ hydrogen evolution can be observed.)

Experiments show that cathodic polarisation per se does not necessarily lead to Cathodic Disbonding (CD). Specific ions which form strong, soluble alkalis such as the alkali metals and barium must be present. Apparently the cathodically produced strongly alkaline reaction enables moisture to creep under the coatings. With ammonium and calcium cations CD is markedly slower.

Cathodic polarisation in acid solutions does not usually lead to disbonding.

It is observed that:

1. Alkali metal hydroxide solutions remove coatings from steel even where cathodic polarisation is not applied.
2. Increased Alkalinity lowers the surface tension of water appreciably.
3. In tests on PE coatings, lowering the surface tension of water by a non-ionic surfactant may enable it to creep under the coating.

Although these observations lead to the supposition that CD is mainly a matter of surface tension, chemical sensitivity of certain coating materials to strong alkali may also be important. The widespread assumption that cathodically formed H_2 -gas lifts the coating and thus

*) the potential measured without IR drop, ie 'off' potential in CP measurements

causes cathodic disbonding, no longer seems valid for two reasons, viz.

1. CD occurs at negative potentials, even where hydrogen is not discharged.
2. A negative potential which is sufficient to discharge H₂ will not extend into the liquid under a tightly fitting coating.

Thus, cathodic disbonding may be considered a type of alkaline cleaning of the metal surface.

In all of these cases, including CD, adhesion loss is a consequence of the appearance of new phases below the coating; a previous lack of adhesion, even at "points", is not a precondition for these to form or migrate. The strength of adhesion and mechanical properties of the coating itself may, however, influence the ease or velocity with which these processes take place.

3. TEST METHODS FOR CATHODIC DISBONDING OF PIPE COATINGS

One of the first test methods for studying cathodic disbonding of pipe coatings was the ASTM G8 method, published in 1968 as a tentative method, and in 1972 as a standard test method.

The method standardises sample size, defect size, immersed area, electrolyte, potential against a reference electrode, the duration of the test-period, and procedures for measuring current demand and disbonded area. The latest revision (1985) is more specific in temperature of testing ($23 \pm 2^\circ\text{C}$ instead of 20 to 30°C), and allows a sacrificial magnesium anode, as an alternative to the use of an impressed current system.

The repeatability quoted in G8-85 is lower than that in the previous version, and is given as maximum 6 mm difference between duplicate results of disbonding (Δr) on two specimens, taken from the same coated pipe from commercial production.

The ASTM G8 method is meant as an accelerated procedure, for comparing one coating with another. Paragraph 4 "Significance and Use" explains that disbondment in this test is not necessarily an adverse indication of performance. All pipeline coating now in common use will disbond to some degree, but the same measured disbondment for two different coating systems may not represent equivalent loss of corrosion protection.

A similar method, often used in Europe, is the British Gas CW/6 cathodic disbonding method, on which the British Standard BS 39 00 F11 (1985) is based.

It does not differ basically from the ASTM G8 but; sample size and electrolyte are different, and only an impressed current system is prescribed.

There are many variations of these two standards in existence which specify particular requirements of individual end-users. The most important differences concern the time of testing, temperature and potential.

Since the introduction of the ASTM G8 method, many investigations have been made to evaluate the influence of the various test conditions and to study the mechanism of cathodic disbonding.

3.1 Effect of Various Test Parameters

The effect of the various test-parameters on cathodic disbonding can be summarised as follows:

3.1.1 Effect of Test Duration

In ref (6) various industrial pipe coating samples have been tested using the ASTM G8 method with a potential of -1.0 V for periods up to 1 year.

This work showed that after about 6 months, the rate of disbonding decreased and its extent levelled off to a constant value after about 1 year.

The maximum disbonding was about 40-50 mm for a PE coating and about 60mm for bitumen coated samples. Other investigations however, show disbonding of bitumen coatings at levels much less than 60mm.

3.1.2 Effect of Potential

Cathodic disbonding tests at potentials between -0.85V and -1.2V showed that the disbondment increased when the potential was lowered from -0.85 to -1.2V (4).

Decreasing the potential from -1.5 V to -3.0 V does not result in an increase of disbondment, although H₂ gas evolution increases. Apparently, at lower potentials more hydroxide ions are formed, but below ca. -1.2V, due to hydrogen evolution, the increased turbulence of the electrolyte prevents a further increase in alkalinity. Within very small holidays gas bubbles can prevent the flow of current, thus reducing electrochemical activity.

3.1.3 Effect of the Electrolyte

For cathodic disbondment to occur it is necessary that the electrolyte is strongly alkaline at the steel surface. This can only develop if alkali-ions are present for balancing the hydroxyl ions formed at the steel surface. If no alkali-ions are present (eg if ZnCl₂ is used instead of NaCl), virtually no cathodic disbondment occurs (9).

3.1.4 Effect of Defect Size

Laboratory experiments by Heim et al (6) showed, that the rate of disbonding is markedly influenced by the size of the defect when thick coatings (PE Bitumen) are tested.

With a 100mm² hole in the coating, the disbonding level (measured in mm radius extension or "under creepage"), was 4 times greater than with a 1 mm² hole.

Thinner coatings such as FBE-coating however, showed no difference when the defect size was changed from 1 to 11 mm diameter, with the disbonding rates being only very small (<5mm after 1 year).

3.1.5 Effect of Polarization Current

In the course of cathodic disbonding testing at 25°C and at a constant voltage the electrical current does not significantly change (17) with time, provided the coating does not disintegrate. With the presently known factory applied coatings, signs of deterioration or blistering are unusual. In disbonded areas the coating normally rests close to the steel surface with only a thin film of moisture in between and extended current carrying capacity is low.

3.1.6 Effect of Temperature on Cathodic Disbonding

The temperature of testing has a strong effect on the rate of cathodic disbonding, as it has on mechanical properties and on other properties such as water absorption and electrical conductivity.

Only a few systematic investigations have been carried out on the maximum service temperature of coatings in relation to properties such as electrical resistivity, blistering and cathodic disbondment.

At the BHRA-conference 1981 (report h1) results of cathodic disbonding tests and electrical resistivity tests were published. Various coatings such as coaltar-epoxy, coaltar-polyurethane, liquid and powder epoxy, polyethylene and polyamide were first subjected in stage 1 to a blistering test (immersion of coated pipe samples in an electrolyte at 70°C, with no defects in the coatings and with a cathodic protection potential of -1.5V).

In stage 2, after making an artificial holiday in the coating,

testing was continued for cathodic disbonding at 70°C on the same piece of coated pipe.

The results of this work showed, that in stage 1, blistering occurred on most coatings with a specific electrical resistivity of $< 10^4$ ohm m².

After stage 2 (cathodic disbonding test at 70°C) all coatings were completely disbonded and some samples developed blisters.

Examination of the blisters showed their contents to be alkaline with a pH of 12.5.

A similar series of tests, but with an electrolyte with less sodium chloride, resulted in much less cathodic disbondment, but again in this series many samples showed blistering in stage 2, or signs of deterioration (swelling). The lower level of cathodic disbondment can be explained by the reduced concentration of the strong alkali-forming cations Na⁺ or K⁺.

The formation of blisters in stage 1 and stage 2, can be explained by electro-osmosis and water-permeation, accelerated by higher temperatures.

3.2 Cathodic Disbonding Test-Requirements

Many standards and specifications specify a C.D. test method and also a maximum level of disbonding.

In Table 3 a selection of these requirements is given for epoxy coatings and for polyethylene coatings.

The table shows, that there is a large variation in test duration, temperature of testing and in maximum accepted disbondment value.

The fact, that some companies require one test to be carried out per 100 pipes, (which can mean one test per day production) makes it obvious that there is a lot of misconception in the applicability of

TABLE 3:

VARIOUS C.D. TEST REQUIREMENTS

Specification	Basic Test Method 1)	Time (days)	Temperature °C)	Specified Value 2)
A) Epoxy Coatings:				
NEN 6905 (Dutch Standard)	G8	90	20-30	max. 20 mm
British Gas PS/CW6	CW6	28	20	max. 5 mm
DIN 30671 (draf nov'83)	CW6	30 2	23 65	max. 10 mm max. 15 mm
Elf-Aquitaine, SNEAP-OM-07-G-00A-301 (Jan.'82)	CW6	30	R.T.	max. 12 mm
Phillips Petrol.Comp P/L/S61 (Oct.'80)	-	28	R.T.	max. 5 mm
Shell Cormrant 5/85	G8/G42	2	60	max. 1 mm
PDO-Oman ENG/01/80 Nov.'82	G8	2	65	max. 16 mm
B) Polyethylene Coatings:				
NAM, END/6-4	G42 G8	- -	- R.T.	to be agreed " " "
British Gas CW4	CW1	56	R.T.	max. 10 mm
Russian Specification	G8	60	R.T.	max. 10 mm
Sydgas (Sweden)	CW6	30	R.T.	max. 10 mm
ONGC (India)	G42a	30	60	max. 30 mm
Gaz de France R06	CW6	56	20	max. 31 mm
Norm Francaise A49-704	CW6	28 56	20 20	- max. 46 mm

1) ASTM G8/G42 or Br.Gas/CW6

2) Disbonded area, expressed as radius extension Δr (mm).

the test, since in many cases it lasts for a minimum of 30 days. From the large variation in requirements it can be concluded that the specified values were arbitrarily established.

4. FIELD EXPERIENCE WITH DISBONDED COATINGS

Most literature on cathodic disbonding of pipe coatings relates to laboratory testing. The number of publications on disbonding coatings (cathodically or otherwise) under field conditions is rather limited.

Still there are a few articles dealing quite thoroughly with disbonded coatings and their behaviour under cathodic protection but almost all of these are concerned with metal loss from corrosion.

One of the first reports on field experience with PE-coatings is from Pickelmann (Ref 5). Field studies, conducted in 1968 and 1974, proved that some PE coatings showed loss of adhesion after 3 years underground service. However, the amount of corrosion products underneath the disbonded coatings was very low, and equivalent to only a few microns steel loss. Furthermore, it seemed not to increase even after longer service periods of up to 10 years.

The observed corrosion products were dry, brown powdery materials: obviously they had been formed by water vapour and oxygen diffusion through the intact coating.

After 6 years service other pipe samples showed neither adhesion loss, nor signs of corrosion beneath PE coating. The initial coating quality (thickness, surface preparation, adhesion) also has some influence on the rate of adhesion loss, and on the extent of corrosion underneath the coating.

In spite of adhesion loss, high specific coating resistivities were measured on disbonded coatings with values of up to 10^{11} ohm.m² on single buried pipes and $3 \cdot 10^9$ ohm.m² on long pipeline sections of PE-coated pipe without any indication of corrosion damage.

The cathodic protection performs very well, due to the high coating resistances.

After 11 years in service a bitumen coating (Ref 5) showed no corrosion underneath the coating and no apparent loss of adhesion, despite the higher diffusion-rate of moisture through bitumen. In a field test on single pipes, buried in soil or immersed in a water basin, with various types of coating (Ref 17), only a very low steel loss due to corrosion was measured (appr. 1-4 μ m in 10 years).

After 10 years in soil, electrical resistances of 2-3 x 10¹¹ ohm.m² for PE coatings and 2 x 10⁶ ohm.m² for a holiday free bitumen coating were measured.

Nevertheless some cases are reported of completely disbonded bitumen coatings, probably caused by cathodic disbonding, starting at cracks in the coating or damaged areas and possibly associated with lower quality steel surface preparation or coating application. It is reported from Italy that more recently applied, higher quality coatings show less disbonding.

A typical example of cathodic disbonding on a bitumen coated pipeline is reported from Holland. A few years after installation, a loss of adhesion was observed, with alkaline moisture between coating and steel.

Investigations showed that the cathodic disbonding had occurred due to a number of reasons:

- Steel surface preparation by acid pickling followed by dipping in hot 3% phosphoric acid solution. In laboratory testing over a 3 month period a phosphated surface gave ten times more cathodic disbonding than blast cleaned or acid pickled steel.
- Cracks had been induced in the bitumen at the overlap of the asbestos outerwrap due to expansion and contraction under alternating wet and dry soil conditions.

Despite these coating failures and because of an effective C.P. system, corrosion damage had not occurred.

Based on these experiences the Dutch standard for bitumen coatings has been adapted, by prescribing a better (moisture resistant) reinforcing of fully impregnated woven glass, and a steel surface preparation without phosphate treatment, if cathodic protection is to be applied.

Only a few publications are available on the long term behaviour of FBE coatings. A number of test specimens were taken for examination from 150mm and 200mm pipelines which had been coated with FBE in Holland and had been in service for 5 and 7 years.

On testing the samples showed good adhesion and almost no disbonding in a cathodic disbonding test. The electrical resistance was quite good, with a measured value of $5 \cdot 10^8$ ohm.m².

Corrosion or disbonding were not observed in the region of coating pinholes.

Ref 29 reports on a pipe sample with appr. 200µm epoxy powder coating after 10 years in service in a wet marshy type soil. Despite the rather thin coating with respect to present standards of minimum 300 to 350 µm and the presence of small blisters (3 to 12 mm Ø) and pinholes, corrosion had not occurred. Cathodic disbonding was up to 12 mm after 10 years in service. No electrical resistance figures are mentioned but according to the observations, cathodic protection had performed effectively.

The significance of cathodic disbonding in relation to the occurrence of stress corrosion cracking was investigated in large scale experiments by Ruhrgas AG (35).

Polyethylene coated pipe sections containing deliberate holidays were thermostatically controlled at 70°C in a bicarbonate solution to induce cathodic disbonding around the coating defects. Pipe surface preparation before coating involved:

- a) good quality blast-cleaning
- b) wire brushing leaving residual millscale on the surface
- c) untreated, millscaled surface.

The pipes were then cyclically pressurised up to 87% of pipe yield strength in such a way as to achieve critical slow strain rates. After 11,190 loading cycles (9830 hours) neither SCC nor corrosion fissures could be detected in cases a) or b) whereas incipient SCC was observed in case c). Thus, it was concluded that with polyethylene coatings on blast-cleaned surfaces, cathodic disbonding would not result in SCC, provided that the operating temperature and pipeline stress remained within the limits set by German standards.

5. DISCUSSION

From the collected information on field observations and laboratory investigations it can be concluded that generally, corrosion damage is not found under cathodically disbonded pipe coatings, as long as the disbonded coating preserves its integrity and remains close to the steel pipe surface. If the coating is deformed and detached from the pipe surface, there is a risk of a flow of corrosive agents between the surrounding electrolyte and the coating/steel interface. Corrosion may occur, in spite of applied cathodic protection.

An important property relating to corrosion protection is the electrical resistance of the coating. A high electrical resistance is required for the most efficient application of cathodic protection.

At low electrical resistance corrosion cells can form from free corrosion, or cathodic blisters may arise from water migration through the coating which is encouraged by cathodic protection (electro-osmosis).

A correlation between cathodic disbonding in laboratory testing and disbonding under field conditions is difficult to establish. Laboratory testing is generally too short to take into account disbonding other than cathodic disbonding.

Cathodic disbonding seems to level off to a constant value after a certain time for the well known factory applied pipeline coatings such as polyethylene, bitumen or fusion bonded epoxy coatings, but the maximum level of cathodic disbonding cannot be predicted from laboratory testing during a few months.

Ultimately total disbonding due to permeation of corrosive substances through the coating can occur, but the general rate at which this happens is difficult to define because of the large variations in individual observations on various pipeline samples. Nevertheless, the maximum theoretical rate of corrosion underneath intact coatings due to permeation is very low (less than 1 $\mu\text{m}/\text{year}$) and localised corrosion attack (pitting) will not occur.

6. CONCLUSIONS

6.1 Cathodic disbonding tests can give some information about the sensitivity of coatings to alkaline conditions, produced during cathodic protection.

6.2 It gives no information about the maximum rate and level of cathodic disbonding, that can occur around a defect under field conditions.

6.3 If different types of coatings are compared, a lower rate of disbondment for one type of coating in a C.D. test does not necessarily mean a better performance in practice.

6.4 C.D. testing may be used in a comparative way, to study similar types of coatings, or to optimise application parameters, but not as a quality control test.

6.5 Cathodic disbondment does not necessarily result in a loss of general corrosion protection, provided that the coating does not disintegrate in the caustic environment resulting from cathodic protection (Ref. DIN).

6.6 Cathodic disbonding is only one of many factors which lead to stress corrosion cracking. If specific conditions of stress, temperature and environment are not achieved stress corrosion cracking will not occur even though a coating may be cathodically disbonded.

6.7 To study the sensitivity to the occurrence of cathodic blistering, it is likely that C.D. testing should be extended beyond one month. Additionally the electrical coating resistance should be measured, to provide information on the corrosion prevention properties of a coating.

6.8 For a suitable test procedure, the following parameters are suggested.

Duration	:	1 month minimum
Temperature	:	room temperature
Potential	:	-1.5V (vs sat. Cu/CuSO ₄), impressed current
Electrolyte	:	1% each NaCl/Na ₂ SO ₄ /Na ₂ CO ₃ in distilled water
Anode	:	Pt-wire, or platinised titanium
Exposed surface:	:	ca 50 cm ² (cell of approximately 8 cm Ø sealed onto the surface of sample).
Defect size	:	6 mm, minimum
Current	:	Provision made for measuring current.

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Maassluis, February 22nd, 1988.

