Polyguard

RD-6™ PIPELINE COATING SYSTEM

NON-SHIELDING COATING

INTRODUCTION

If you are reading this page, you probably have questions about non-shielding pipeline coatings. First some definitions of "***shielding***":

Shielding of cathodic protection currents is a major problem today in pipeline coatings. During October, 2006, no less than five articles mentioning the shielding problem appeared in the pipeline trade press. The five articles are:

1) S.Papavinasam, M. Attard, and R. W. Revie, ***External Polymeric Pipeline Coating Failure Modes***, Materials Performance, October 2006, published by NACE International, Houston, TX 77084-4906, p. 27.
2) M. Roche, D. Melot, and G. Paugam, ***Recent Experiences with Pipeline Coating Failures***, Journal of Protective Coatings and Linings, October 2006, published by Technology Publishing Company, 2100 Wharton St, Suite 310, Pittsburgh, PA 15203-1951.
3) T. Fore, and K. Varughese, ***FBE Found Effective After 30 Years of Service***, published by Pipeline and Gas Journal, October 2006, Houston, TX 77079, p.64.
4) R. Norsworthy, ***Is Your Pipeline Coating 'Fail/Safe'?***, Pipeline and Gas Journal, October 2006, Houston, TX 77079, p.62.
5) ***Detecting Coating Disbondment,*** Materials Performance, October 2006, published by NACE International, Houston, TX 77084-4906, p.33.

Shielding is hardly a new problem. Concerns were published about shielding starting in the early 1980's..

But in spite of the growing body of evidence concerning the seriousness of the shielding problem, a large percentage – we estimate as much as 70% - of pipelines worldwide still use corrosion coatings with shielding potential.

How can this be? We at Polyguard believe that there are many reasons for the continued wide usage of shielding coatings, but the largest reason may be the fact that shielding is a difficult and highly technical subject.

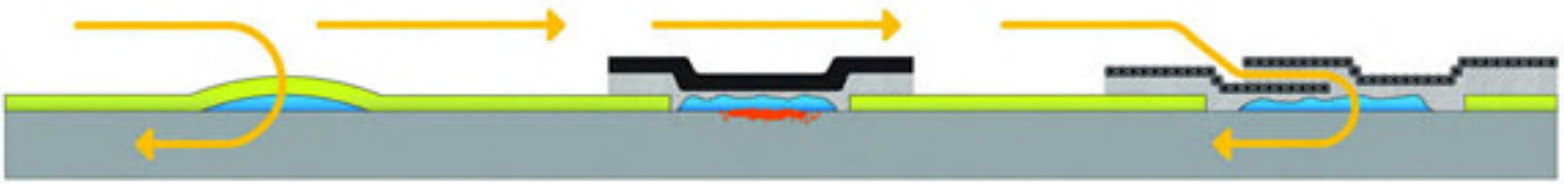
Polyguard is attempting to give concerned engineers a simplified explanation of the shielding problem. We apologize for the fact that we risk oversimplifying this issue. NACE has a full six day course concerning this area entitled the CP Protection Program. Polyguard's purpose here is to sound the alarm, to get people talking to those who are working with this problem, and to point to some sources of information and solutions. http://www.nace.org/

We hope that if you begin looking for answers to the shielding problem, you will evaluate Polyguard's RD-6 coating system as one of the available solutions. Polyguard's RD-6 product has been in wide use for over 20 years now. RD-6 is a proven solution.

• NACE defines shielding as;

"Preventing or diverting the cathodic protection current from its intended path"

NACE Standard RP0169-2002, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems,* NACE International, Houston Texas 77084-4906, p3.
www.nace.org/nacestore/dept.asp?Cat%5FID=2905



FBE

- Current reaches water
- pH raised >9
- No significant corrosion
- **Non-shielding**

Shrink Sleeve

- Current shielded from water
- pH remains <9
- Corrosion
- **Shielding**

RD-6

- Current reaches water
- pH raised >9
- No significant corrosion
- **Non-shielding**

Background of the Shielding Problem:

When underground pipelines are constructed today for transmission of oil, products, or natural gas, and even water or sewage, the pipeline design almost always includes corrosion coating with a cathodic protection system. The cathodic protection system is intended to act as backup corrosion protection in the event that the corrosion coating system were to fail.

The surprising thing is the frequency that coating systems are used which can partially or completely block the effectiveness of the cathodic protection system.

In recent years, knowledgeable engineers and scientists have begun to try to highlight this incompatibility. Beavers and Thompson summarized the shielding incompatibility in the newly released Volume 13 of the ASM Handbook:

"Ultimately, the effectiveness of a coating system in preventing corrosion is related to two primary factors: (a) the resistance of a coating to degradation over time and (b) the ability of the coating to conduct CP current should the coating fail (minimize shielding). For SCC resistance, these factors as well as the type of surface preparation used with the coating are important."

Beavers, J.A. and Thompson, N.G., *External Corrosion of Oil and Natural Gas Pipelines,*
ASM Handbook, Volume 13C, Corrosion: Environments and Industries (#05145), ASM International, Materials Park Ohio 44073-0002, p1021.
www.asminternational.org

The above definition of an effective coating system is what some people have started to call ***"non-shielding coating systems". Others call it a "fail/safe coating system"***.

Plenty of research and papers are available on the topic of shielding and non-shielding coating systems.

We have organized the frequently asked questions about shielding and non-shielding coatings below, drawing on the conclusions found in the research and papers. Where possible a citation with a link is included.

FREQUENTLY ASKED QUESTIONS ABOUT SHIELDING AND FAIL/SAFE COATINGS

1. What are some other things NACE says about shielding?

a. NACE SP0169, Standard Recommended Practice for underground or submerged piping, says:

"Materials and construction practices that create electrical shielding should not be used on the pipeline."

Nace Standard SP0169-2002, *Control of External Corrosion on Underground or submerged Metallic Piping Systems*,
NACE International, Houston, Texas 77084-4906, Section 4.2.3, p4.
www.nace.org/nacestore/dept.asp?Cat%5FID=2905

b. NACE has initiated a course entitled; *"Coatings in Conjunction with Cathodic Protection"*. This 6 day course "was developed for corrosion control personnel who must deal with the selection and application of protective coatings that will also be exposed to cathodic protection."

For more information on the CCCP course, go to www.nace.org/

2. What is the shielding behavior of various pipeline coatings in use throughout the world?

a. Fusion Bond Epoxy (FBE)
In the early 1990's PRCI (Pipeline Research Committee International) funded a research program to investigate three factors which prevent SCC failure. One of the factors was *"the ability to pass CP current should the coating fail"*. In this research, single layer FBE coatings were found to conduct CP current in the absence of holidays.

Therefore FBE may be considered a "fail/safe" coating. If disbondment of FBE occurs (a failure), cathodic protection currents probably will be able to reach the disbonded area.

Beavers, J.A. 1992. *Assessment of the Effects of Surface Preparation and Coating on the Susceptibility of Line Pipe to Stress Corrosion Cracking.*
PRCI, Arlington, VA, Report L51666
www.prci.org

This disbonded FBE had no corrosion underneath. The pH of the water under the blister was elevated (made more alkaline) as the result of the CP currents being able to reach underneath the disbondment.

b. Shrink Sleeves

Shrink sleeves were included in research by CC Technologies on shielding behavior of pipeline coatings which was published in 2006. But they were included as the extreme "complete shielding". In the words of the study; *"Shrink sleeves and polyethylene tape wrap coatings for girth welds are known to cause problems with cathodic protection shielding. Polyethylene is an excellent water barrier and absorbs virtually no moisture, making it an excellent packaging material for food (Glad Wrap, Ziploc bags, garbage bags, etc.) but promoting CP shielding by not allowing ionic conductivity. The small pores and cracks which may be present in heterogeneous coatings are not present in polyethylene based coatings. When combined with polyethylene's naturally hydrophobic chemistry, the result is a water impermeable coating without defect pathways for ionic migration".*

As expected, *"No evidence of CP was seen in the shrink sleeve coating…..although destructive testing found that it was not well bonded in all locations on the panel."*

Ruschau, G.R. and Chen, Y. 2006 *Determining the CP Shielding Behavior of PipelineCoatings in the Laboratory.* NACE International, Houston, TX 77084, Paper No. 06043
www.nace.org/nacestore/default_0.asp

Therefore shrink sleeves should be considered to shield cathodic protection currents. If disbondment of shrink sleeves occurs, cathodic protection currents probably will not be able to reach the disbonded area.

c. Polyguard RD-6

Polyguard Products RD-6 is designed to be non-shielding in two ways:

1. The geotextile backing is invisible to CP currents because of its open weave. Therefore if the coating compound underneath the backing is damaged, and a holiday is created in the corrosion coating, the backing will not shield the passage of protective currents.

2. If the corrosion coating becomes disbonded, and water penetrates between the coating and the substrate underneath the overlap, CP current can penetrate underneath the overlap to the disbonded area. This has been proven in three ways:

a. Lab testing has shown that current can pass from the outside of the overlap to the steel substrate under a disbonded area.
b. Lab testing has shown that pH of water in disbonded areas (voids) at overlaps is raised to a level of 9 or higher. A high (alkaline) pH has been shown to minimize corrosion activity.
c. Over the 19 year field history of RD-6, Polyguard Products personnel have been present to observe numerous of digups where RD-6 was used as the corrosion coating. Only six areas have been found where any coating was disbonded. *Disbondment was attributed to failure to strip weld seams, insufficient tension being applied during application of the RD-6, and/or application to wet pipe*

In the above instances where disbondment was found, there has been no significant surface corrosion. On occasions where the pH of the water underneath the disbondment was measured, pH was 9 or above.

The above testing is described in Richard Norsworthy's 2004 article, referenced below.

Norsworthy, R., June 2004, *"'Fail/safe' System Used in Conjunction with Cathodic Protection",* Materials Performance, p. 34-38
www.polyguardproducts.com/match/publishedpapers/FailSafe.pdf

Water underneath a disbonded area of this improperly applied RD-6 had a pH of 9-10, as compared to water under nearby disbonded coal tar coating, which has a pH of 5-6. The CP current had increased the alkalinity of the water under the RD-6 to a level which does not support corrosion.

Therefore RD-6 may be considered a non-shielding coating. If disbondment of RD-6 occurs - cathodic protection currents probably will be able to reach the disbonded area.

d. 3 Layer Systems:

Three layer systems are covered in detail by a 2005 NACE paper by Argent and Norman;

"The universal strategy for external corrosion protection on buried or sub-sea pipelines accepts that coating damage will occur and CP is built into the pipeline design to prevent metal loss at these sites of coating damage. If the failed coating does not impede the flow of CP current onto the pipe steel then normal CP monitoring will ensure continued pipeline integrity.

When a PE based coating loses adhesion from the metal substrate then a condition of CP shielding can be created. The corrosion risk created by CP shielding can only be eliminated by excavation and recoating. Coatings that can fail to create conditions of CP shielding include cold applied tapes, heat shrink materials (particularly mastic backed heat shrink), 2LPE, 3LPE, and 3LPP."

Argent, C.A. and Norman, D., 2005, *"Fitness for Purpose Issues Relating to FBE and Three Layer PE Coatings"*, David Norman Corrosion Control, Cornwall, TR8 5SA, England
www.davidnormancorrosioncontrol.com/html/papers/PDF/DavidNormanNACE2005.pdf

Therefore three layer systems should be considered shielding coatings. If disbondment of three layer systems occurs (a failure), cathodic protection currents may not be able to reach the disbonded area.

e. Liquid Coatings

Four types of liquid coatings (epoxy, epoxy-polyurethane, polyurethane, and wax) were investigated for their ability to allow CP current to be transmitted. Results showed that; *"the liquid coatings, when applied extra thin to accelerate the kinetics of absorption and current transmission…..all allowed CP current to be transmitted."*

Ruschau, G.R. and Chen, Y. 2006 *Determining the CP Shielding Behavior of PipelineCoatings in the Laboratory.* NACE International, Houston, TX 77084, Paper No. 06043
www.nace.org/nacestore/default_0.asp

From a practical viewpoint this result is inconclusive at best regarding non-shielding properties of liquid coatings. "Extra thin" coatings are achievable in the lab, but in field application can be difficult to achieve. When liquid coatings were applied thick in the lab, no evidence of pH change or CP current was noted.

Thus, it appears that liquid coatings will need some work to obtain and prove non-shielding and fail/safe properties.

f. Polyethylene Backed Tapes

Polyethylene backed tapes were the first shielding culprit to be identified. In 1988, the Pipeline Research Committee concluded that shielding of cathodic protection currents was a problem for over half of the 27 gas industry members surveyed.

Moreover, the report stated; *"PRC research indicates that SCC is enhanced by cathodic protection shielding at the disbonded areas..."*

As stated above in the section on Shrink Sleeves, researchers believe that: *"Shrink sleeves and polyethylene tape wrap coatings for girth welds are known to cause problems with cathodic protection shielding. Polyethylene is an excellent water barrier and absorbs virtually no moisture, making it an excellent packaging material for food (Glad Wrap, Ziploc bags, garbage bags, etc.) but promoting CP shielding by not allowing ionic conductivity. The small pores and cracks which may be present in heterogeneous coatings are not present in polyethylene based coatings. When combined with polyethylene's naturally hydrophobic chemistry, the result is a water impermeable coating without defect pathways for ionic migration".*

Pipeline Research Committee, *"A Review of Gas Industry Pipeline Coating Practices",* Pipeline Research Council International, 1988, p.3, published by Technical Toolboxes, Inc., 3801 Kirby Drive, Houston, Texas 77098
www.prci.org/

3. Tapes are widely condemned above. Isn't Polyguard RD-6 a tape?

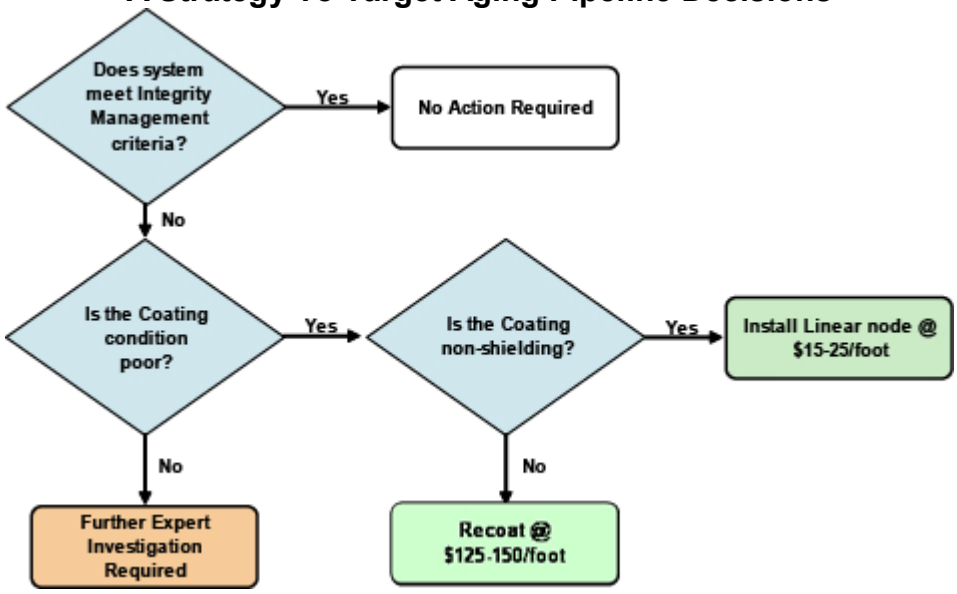
RD-6 is not a tape because it was designed to overcome the fatal flaws that have almost destroyed the North American tape market. These flaws are *shielding of cathodic protection currents* and *vulnerability to soil stress.*

4. What are the cost implications of using non-shielding coatings?

The use of non-shielding coatings will reduce the possibility of catastrophic failure. That is a benefit difficult to quantify.

The cost benefit of non-shielding coatings was estimated by one 3rd party however. In a 2006 Pipeline & Gas Journal article entitled ***A Strategy to Target Aging Pipeline Decisions***, the author says that aging pipeline systems with deteriorated coating systems can be addressed with $15-25/foot linear anodes, vs. $125-150/foot for recoating. However, as shown in the decision chart below, the lower cost CP treatment will not work if the corrosion coating is one which shields cathodic protection currents.

A Strategy To Target Aging Pipeline Decisions



Huck, T. June 2006 *"Linear Anodes Target Aging Pipeline Coating Threats"*, Pipeline & Gas Journal, pgs. 34-36.
http://www.oildompublishing.com/

5. If users knew 20 years ago that solid film backed corrosion coatings created shielding problems, how come there are so many specifications in place today for them?

It is true that many specs are in place today, although the number in North America has dropped significantly. But the other part of the answer is that engineering specifications have long tails.