A rating system was developed for several coating types used for underground pipeline systems. Consideration included soil stress, adhesion, surface preparation, cathodic protection (CP) shielding, CP requirements, handling and construction, repair, field joint system, bends and other components, and the application process. Polyethylene- and polyvinyl chloride-backed tapes, woven polyolefin geotextile fabric (WGF)-backed tapes, hot-applied tapes, petrolatum- and wax-based tapes, and shrink sleeves were evaluated. WGF-backed tapes had the highest rating.

Coatings often are considered the first line of defense against corrosion in the pipeline industry. Many factors must be considered when selecting a coating for a pipeline system. In this article, several coating types are rated on a scale of 1 to 10 in several categories, with 10 being the highest rating. The ratings are from the author's nearly 20 years of pipeline coating and corrosion control experience, involving hands-on participation, numerous test programs, specification writings and reviews, coating inspections, field applications and evaluations, literature reviews, and plant applications.

**Tape Coatings**

Hand- and plant-applied tapes are used for corrosion protection on many underground and submersed pipelines and components. Though some systems were developed earlier, most of the development was in the 1950s and early 1960s. Tapes have been widely used as a quick, easy method of coating pipes in the field. Some have been and continue to be plant-applied.

Tapes have had varied success as coatings in the pipeline industry. Although past problems reduced their use, there are new and different products on the market that have overcome some of the problems and should be considered for testing and future use.

A liquid adhesive (primer) normally is applied to the pipe before tape application. These primers wet the pipe surface and, in some cases, chemically bond the tape adhesive compound to the pipe. Primers usually are thinly applied to clean, dry metal and should be allowed to dry properly before the tape is applied. They usually are made from rubber-based materials or resin-modified bituminous materials mixed in a solvent solution.

Selection of the proper tape for the environment is critical. In severe soil stress areas, tapes that stretch can wrinkle (Figure 1). Loss of adhesion because of poor application, poor surface preparation, or soil stress can cause corrosion to occur on the pipe under tapes that shield cathodic protection (CP). There continue to be many pipeline corrosion problems caused by these failures (Figure 2). Outer wraps that do not bond and do not shield CP can help to alleviate soil stresses on tape coatings by providing a “slip plane.” In a Canadian accident, a tape coating was discovered to be
broken, with the adhesive gone. An unlikely culprit was believed to have supplied the necessary nutrients: the adhesive from the pipe’s polyethylene (PE) tape coating. Most tapes are hand-applied by spiral wrapping, although cigarette wrapping may be used. Proper tension must be maintained on the tape during the application process. Some tapes are flexible enough to apply to bends and other irregularly shaped components. For long pipe segments, tape machines (Figure 3) are recommended for a consistent spiral, with proper tension and overlap. Tape machines also avoid some of the mistakes made during hand applications.

**PE- and Polyvinyl Chloride-Backed Tapes**

These tapes normally consist of one or two layers of PE or polyvinyl chloride (PVC) backing with an adhesive layer bonded to the backing. The PE backing layer in most cases is a low-density, or blend of high- and low-density, PE. Adhesive compounds usually consist of elastomer butyl rubber, natural rubber, rubberized bitumen, or coal tar derivates. Processing oils, fillers, tackifiers, and stabilizers are added to provide adhesion, shear resistance, thermal stability, and chemical resistance. Pigments and stabilizers are added to the PE to provide color, ultraviolet resistance, thermal stability, and to improve aging. PE and PVC tapes come in several thicknesses, usually from 20 to 60 mils (500 to 1,500 µm). These tapes usually are made by extrusion, co-extrusion, or calendaring.

Even with proper application, some tapes can have problems with soil stress because the backing and compound will stretch easily. The solid backing normally will shield CP currents, and if water penetrates, corrosion can occur.

**Woven Polyolefin Geotextile Fabric**

Some tapes use a woven polyolefin geotextile fabric (WGF) for the backing. WGF products have several advantages over solid PE- or PVC-backed tapes. These tapes normally use the same type compounds and primers for adhesion. The woven fabric provides the mechanical protection, and the compound provides the corrosion protection. WGF tapes have much better soil stress characteristics than PE tapes. PE backings can have as much as a
in the adhesion and performance of WGF tapes, and one must test them to determine which gives the properties mentioned (Figure 4).

**Hot-Applied Tapes**
Most hot-applied tapes are composed of a bituminous base coating material supported on a fabric of organic or inorganic fibers. The fabric is covered on both sides by the coating material. These tapes have to be pliable enough to unwind from the roll during application. Hot-applied tapes are applied to the structure by heating the tape (usually with an open flame) on the structure side surface until the surface melts and becomes semi-liquid. The tape then is wrapped around the primed surface. Some are hand-applied using a torch. Others use a machine that includes a torch to heat the tape indirectly.

**Petrolatum and Wax-Based Tapes**
Petrolatum (PET) tapes are made from a non-woven synthetic fabric that is impregnated with neutral compounds that are based on saturated PET and inert fillers. Wax tapes are made from plastic fiber felt that is saturated with a blend of PET waxes, plasticizers, and corrosion inhibitors. These tapes are sometimes backed with PVC or PE to provide mechanical protection to the compound. A paste material made from PET, plasticizers, and corrosion inhibitors is applied to the pipe as a primer. Moisture-displacing and corrosion-inhibiting compounds sometimes are added to the paste. The paste adds to the adhesion and provides a moisture barrier under the tape. Although these coatings sometimes are assumed to displace water when applied, this process is limited.

**Shrink Sleeves**
Shrink sleeve (SSL) technology was developed in the early 1960s and continues to be developed today. SSLs are used for field joint and repair coatings,
TABLE 1

RATINGS SUMMARY FOR TAPES AND SSLS\(^{(A)}\)

<table>
<thead>
<tr>
<th></th>
<th>Soil Stress</th>
<th>Adhesion</th>
<th>Surface Preparation</th>
<th>CP Shield</th>
<th>CP Requirements</th>
<th>Handling/Construction Damage</th>
<th>Repair</th>
<th>Field Joint</th>
<th>Bend Components</th>
<th>Application</th>
<th>Overall</th>
<th>Total Points</th>
<th>RANK(^{(B)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE &amp; PVC (w/o primer)</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>51</td>
<td>7</td>
</tr>
<tr>
<td>PE &amp; PVC (w/primer)</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>7</td>
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<td>58</td>
<td>2</td>
</tr>
<tr>
<td>Hot-applied tapes</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>53</td>
<td>6</td>
</tr>
<tr>
<td>WGF</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>69</td>
<td>1</td>
</tr>
<tr>
<td>PET</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>7</td>
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<td>4</td>
<td>57</td>
<td>5</td>
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<td>4</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>4</td>
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<td>7</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>56</td>
<td>3</td>
</tr>
</tbody>
</table>

\(^{(A)}\) Ratings are from 1 to 10 (10 being highest).
\(^{(B)}\) Ranking determined by adding overall points to total points (1 being highest).

but some have been used for larger repairs or are being used for a more continuous application system.

SSLS coatings normally are made from cross-linked, heat-shrinkable thermoplastic backing (usually PE) that serves as a tough permanent outer layer. Radiation crosslinking gives these materials an elastic memory that allows the product to be supplied to the customer in an expanded state. When heated, the material will shrink and tightly cover the structure. Special adhesives, from soft sealant to highly crystalline hot melts, are applied to the backing material in a manner that is similar to tapes.

Early SSL applications had adhesion problems, but latter versions have made major improvements. Even with recent improvements, application procedures are very critical to their performance. They have to be heated evenly with the correct heating device to shrink properly and perform. Infrared heater coils are available to apply SSLS. During the inspection, poor adhesion at the dual epoxy/sleeve interface was detected, and judged to be the result of the insignificant amount of heat applied to the sleeve. Most SSLS require that the pipe surface be preheated before the sleeves are applied. Preheating is difficult, if not impossible, for in-service systems with cold flowing product.

One type of SSL is an enclosure installed over a pipe end and slid into place. This type requires the sleeve to be installed before making connections. Another type is a wraparound sleeve with a closure strip that normally is pre-attached to the sleeve for easy application. The closure has an adhesive to help hold the sleeve in place until it is shrunk to the structure.

**Advantages of Tapes and SSLS**

Tapes and SSLS share several advantages over other products:
- Good for repair, field joints, and replacement for base coatings.
- Quick backfill or immersion.
- Easy to apply.
- Machines are recommended for most tapes.
- Surface preparation requirements are not usually as stringent.
- Can be applied in several layers.
- Flexible.
- High electrical resistance.
- Low CP requirements.

**Disadvantages of Tapes and SSLS**

- Soil stress.
- CP shielding.
- Use of the wrong type of primer or no primer.
- Suspected cases of bacterial attack on butyl rubber compound adhesive.
- Limited use at temperatures above 65°C (150°F).
- PET and wax tape normally limited to ambient temperature systems.
- Improper heating of SSL and hot-applied tapes.

**Ratings**

Table 1 gives the ratings for tapes and SSLS. The criteria are:

**SOIL STRESS**

Soil stress arises from the soil forces applied to the coating surface after the pipe is buried. Soil stress, or soil forces, can occur as a result of backfill settlement, pipe movement, alternating wet and dry conditions in the soil, or combinations of these. Soil stress can cause the coating to wrinkle, sag, or separate. The best-rated coatings are least affected by SS.

**ADHESION**

Strong adhesion—how well the coating sticks or bonds to the pipe steel—improves the rating. Most tapes and SSLS rely on the bond of the primer to the pipe and the bond between the primer and the compound. Primerless tapes or SSLS rely strictly on the bond of the compound to the pipe. Adhesion can be greatly affected by the operating temperature of the pipeline, especially for pipelines operating over 150°F (66°C).

**SURFACE PREPARATION**

Normally, the better the surface cleaning and preparation, the better the coating performance. A more difficult surface preparation causes a lower
rating. Surface preparation requirements normally are fewer for tapes and SSLs than for many other coatings, but most SSLs require the pipe to be heated.

**CP SHEILDING**

The opportunity for a coating to shield CP lowers the rating. CP shielding is a serious problem for nearly all tape products, if the tape or SSL disbands or is not properly applied and water penetrates. Disbonded coatings over pipeline steel often can lead to serious corrosion problems that cannot be controlled by conventional CP systems.⁶

**CP REQUIREMENTS**

Initial and long-term CP requirements are important. Lower CP requirements result in better ratings. Coatings that are less likely to shield CP currents may lead to higher CP requirements, but the benefits may be more significant than lower CP costs. CP requirements are minimal for most tape and sleeve products, but if deterioration, separation, or cracking occurs, the CP current will increase over the life of the system.

**HANDLING AND CONSTRUCTION**

Tapes and SSLs can be plant or shop-applied and then transported to the field, or they can be applied in the field. Most of these products perform well during handling, construction, and backfilling operations. Coatings that encounter the least damage during handling and construction are rated the highest.

**REPAIR**

The best ratings are given to systems that provide a repair coating equal to or better than the base coating. Repairs of most tape and SSL products easily are made using the same material and primer products as the base coating.

**FIELD JOINT**

Best ratings are given to coatings that provide a field joint system that is as good as or better than the base coating. The same tape or SSL product used as a base coating can be used for field joint coatings. Many companies continue to use tapes and SSL coatings as their primary field joint coating material, no matter what is applied as the base coating.

**BENDS AND OTHER COMPONENTS**

Coatings that provide a coating system that is as good as or better than the base coating are rated best. Bends, valves, and other components often can be coated with tape products. SSL and some tapes are too difficult to use on irregular shapes and may not properly seal overlap and other areas.

**APPLICATION PROCESS**

Less complicated applications produce better ratings. Application of tapes and SSLs is relatively easy, but as with any coating, manufacturer’s recommendations must be followed and care must be taken. The correct primer (if required) must be used and allowed to cure properly before the tape or SSL is applied.

**OVERALL RATING**

As mentioned, there has been mixed success with tape and SSL products. When used in the correct environment, with proper application, some have performed well. WGF tape coatings offer the best overall performance and rating for this category of coatings.

Other Considerations

There are many things to consider when choosing and using a coating system. One of the most important is to have a well-written and detailed set of specifications. To ensure the surface preparation and coating application process meets or exceeds the specified requirements, well-trained, knowledgeable inspectors are required. Inspectors must have a passion for ensuring that the coating process is the very best it can be under the conditions that exist.

When field conditions do not meet the necessary application requirements, leaving the repair area uncoated may be the best option if adequate CP is being applied. Repairing at a later date when conditions are right pro-
vides a coating repair that will perform properly. One such example is applying coating to a wet pipe. Coatings do not adhere normally to a wet pipe. Even coatings that are claimed to work on wet surfaces rarely perform as well as coatings applied to a dry, properly prepared surface. Some in the pipeline industry will question this recommendation because regulations usually require the pipe to be 100% coated. If the coating does not bond and water penetrates, most coatings will shield the CP and corrosion can become an uncontrollable problem.

Testing and experience are the best methods for choosing a coating system (Figure 5). Coatings should be tested at or above the expected operating temperature of the system.

Once a particular brand of coating is proven to work, that brand and type should be used. Each brand and type can have significant performance differences. Before an alternative coating is used, it should be tested thoroughly to ensure that it meets or exceeds the performance of the selected brand. New and different systems should be continually tested and tried, but not relied upon until they are proven.

**Recommendations**

For applied coatings, field repairs, field joints, and rehabilitation coatings, the WGF-backed tape is recommended. The WGF tape—when properly selected and applied—offers a coating that is easily applied in the field for nearly all services ≤150°F (65°C). These tapes are not affected by soil stress like most other tape and SSL products. The woven backing will not shield CP currents, and if the compound is damaged, the current can easily protect the pipe in this area.

**Conclusions**

The purpose of this article is not to force this author’s experiences and choices on the reader/user, but to challenge each reader/user to select and use coatings based on a rating system that covers the criteria that are important for a particular service.

Coating companies continually are developing new and sometimes better coating systems. These coating systems must be given the opportunity to prove their effectiveness through testing and field trials.

Testing and field experience with a particular coating type and brand, used in conjunction with well-written specifications, qualified applicators, and well-trained inspectors, will help to ensure that the coating will perform as expected. Improper or insufficient training of such workers is a major cause of failures. NACE International offers excellent courses in protective coatings and inspector training.

**Acknowledgments**

The author wishes to thank Toni Pfaff, Pfaff International, Toronto, Canada, and Robert (Bob) Nec, Polyguard Products, Inc., Ennis, Texas for their assistance in the preparation of this article.

**References**


Richard Norsworthy is a corrosion control consultant with Lone Star Corrosion Services, 2019 Enchanted Lane, Lancaster, TX 75146. He previously was a corrosion specialist with Mobil Oil, Mobil Pipeline, and Amoco Pipeline Co., and was a corrosion technician at Tenneco. He was a corrosion technology instructor at Kigole College in the mid-1980s. Norsworthy has a B.S. in mathematics and is a NACE Corrosion Specialist. He currently is active on several NACE technical committees.