PAINT SQUARE WEBINAR

QUALITY CONTROL OF SURFACE PREPARATION AND COATING INSTALLATION ON PIPELINE GIRTH WELDS

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WEBINAR CONTENT

- Purpose of girth weld coatings
- Performance expectations of girth weld coatings
- Types of girth weld coatings in current use
- Field installation of girth weld coatings
- Field inspection techniques for girth weld coatings
PURPOSE OF GIRTH WELDS

- Girth welds allow the connection of standard 40’ or 80’ long sections of coated pipe into longer lengths required to build a pipeline.
- Longer sections create transportation problems.
- Each 100 miles of pipeline can contain up to 13,200 girth welds.
WHY MUST GIRTH WELDS BE COATED?

- Girth welds must be coated because the welds are made in areas that are bare steel.
- The bare area at the end of each pipe section is called the “cut back” area. It can be up to 12” wide.
- All girth welds must be coated before the line is buried.
- Federal and state corrosion mandates require protection of all coated surfaces, including girth welds.
PERFORMANCE EXPECTATIONS OF GIRTH WELD COATINGS

- Girth weld coatings should provide the same level of corrosion protection as the coating applied to the rest of the pipeline.

- The girth weld coating must also be compatible with cathodic protection.
PURPOSES OF FIELD COATING INSPECTION

- Field inspection takes place before, during, and after girth weld coating application.
- The purpose of the inspection is to verify that the coating work meets the specification requirements for:
  - Surface cleanliness
  - Surface profile
  - Allowable ambient conditions
  - Dry film thickness (DFT)
  - Absence of coating holidays (pinholes)
  - Adhesion to steel substrate
  - Degree of cure
SSPC SP-1 SOLVENT CLEANING OF THE GIRTH WELD AREA

- Prior to the roughening of the metal surfaces, all contaminants shall be cleaned in accordance with SSPC SP-1, “Solvent Cleaning”.

- Solvent cleaning provides a method for removing all visible oil, grease, soil, magnetic particle inspection products, ultrasonic couplant, and other soluble contaminants from steel surfaces to be coated.

- Solvent cleaning is a required initial step to clean girth welds before any other surface preparation work is applied to the area.
CLEANING MEDIA CONSISTENT WITH SSPC SP-1

- Emulsion or alkaline cleaners may be used in place of hydrocarbon-based cleaners.
- After treatment, the surfaces should be washed with fresh water or steam to remove detrimental residues.
- Alternatively, steam cleaning can be applied, using detergents or cleaners and follow by steam or fresh water wash to remove detrimental residues.
DEALING WITH SOLUBLE SALT SURFACE CONTAMINATION

- Soluble salt contamination on a steel surface can lead to reduced coating performance.

- Soluble salts can attract moisture through an applied girth weld coating resulting in blistering and adhesion loss.

- Soluble salts, in the form of chlorides and nitrates can exist in a trench environment from brackish water and soil fertilizers.

- Soluble salts can be removed by an SSPC SP-1 solvent cleaning operation using an aqueous solvent or steam. Soluble salts are not removed by hydrocarbon solvents.
ALLOWABLE LEVELS OF SOLUBLE SALT CONTAMINATION

- There are no consensus standards providing guidance regarding allowable levels of salt contamination.
- The project specification or coating manufacturer should be consulted to provide guidance regarding soluble salt contamination.
- Both qualitative and quantitative methods exist for determining contamination levels in the field.
- These methods either: (1) measure the conductivity of the wash water, or (2) identify the concentration of specific contaminating ions.
- A description of these methods can be found in SSPC Guide 15.
THE GOALS OF PREPARING GIRTH WELDS FOR COATING APPLICATION

- The degree of preparation of girth welds for coating application will depend on the specification requirements for cleanliness and profile (surface roughness).

- The levels of cleanliness and profile called for in the specification should reflect the values recommended by the coating manufacturer.

- Different girth weld coating products have different surface cleanliness and profile requirements.
SURFACE CLEANLINESS STANDARDS USED FOR GIRTH WED COATING WORK

- Principal surface preparation requirements for girth weld coatings include:
  - SSPC SP-3 “Power Tool Cleaning”
  - SSPC SP-11 “Power Tool Cleaning to Bare Metal”
  - SSPC SP-10 “Near-White Metal Blast Cleaning”
REQUIREMENTS OF
SSPC SP-3 POWER TOOL CLEANING

- Following SSPC-SP1 solvent cleaning, power tools (power brush, power abrading, or power impact) shall be used to produce a level of cleanliness with the following characteristics:
  - Removal of all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter.
  - It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.
  - There is no surface profile requirement for SSPC SP-3.
WHAT EQUIPMENT IS USED FOR POWER TOOL CLEANING?

- Power tool cleaning is done with grinders, pneumatic chisels, needle scalers, rotary impact tools and other tools requiring electrical or pneumatic power.

- Most of these tools can remove both loosely and tightly adhering corrosion products, old paint and mill scale from the steel surfaces.

- The amount of material removed will depend on the specification.

POWER TOOLS - (1) ROTARY IMPACT FLAPPER (2) NEEDLE SCALER, AND (3) ABRASIVE DISC
Following SSPC-SP1 solvent cleaning, and when abrasive blasting is not required nor feasible, an alternative cleaning method, SSPC SP-11, “Power Tool Cleaning to Bare Metal” can be used.

SSPC SP-11 uses power tools to clean and profile the metal surface.

A bare metal power-tool cleaned steel surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, rust, coating, oxides, mill scale, corrosion products, and other foreign matter. If the original surface is pitted, slight residues of rust and coating are permitted to remain in the lower portions of pits.

The cleaning shall produce a minimum profile of 1.0 mil.
WHAT IS SSPC SP-11, POWER TOOL CLEANING TO BARE METAL?

- SSPC-SP11, “Power Tool Cleaning to Bare Metal” requires the removal of all mill scale, rust, and paint to expose the bare metal surface.

- It also requires that a minimum 1 mil anchor pattern or profile be etched into the bare steel surface.

- The photos are taken from the SSPC VIS 3 Visual Guides

Fig. 32 - Cleaning a 100% rusted steel weld to an SSPC-SP11 – Power Tool Cleaning to Bare Metal
POWER TOOLS FOR SSPC SP-11

- Power tools that can create the cleanliness levels of SSPC SP-11 include:
  - Rotary impact flap assemblies
  - Coated abrasive bands
  - Needle guns
  - Rotary steel brushes

- Profile will be specific to the tool used. Profiles in the range of 1.0 to 2.5 mils are possible.
WHAT IS SSPC SP-10, NEAR WHITE METAL BLAST CLEANING?

- Following SSPC-SP1 solvent cleaning, and when abrasive blasting is indicated, SSPC SP-10, “Near White Metal Blast Cleaning” shall be applied.

- SSPC-SP10, “Near White Metal Blast Cleaning requires the removal of all mill scale, rust, oxides, and paint to expose the bare metal surface.

- Random staining shall be limited to no more than 5% of the surface and may consist of light shadows, slight streaks, or minor discolorations caused by rust, mill scale, or previously applied coating.

- The photos are taken from the SSPC VIS 1 Visual Guides
MEASURING SURFACE PROFILE USING A SURFACE COMPARATOR

- ASTM D4417 Method A uses a lighted 5X magnifier and three (3) comparator discs to visually determine the surface profile on a blasted steel surface.
- Each of the comparator discs display a range of surface profiles created by sand, steel shot, or grit.
- The disc representing the blasting media used is placed on the cleaned surface to determine the profile.
MEASURING SURFACE PROFILE WITH AN ELECTRONIC DEPTH MICROMETER

- ASTM D4417 Method B uses an electronic depth micrometer for measuring surface profile.

- The gage base is fitted with a spring-loaded metal pin.

- When the gage is placed on a profiled steel surface, and the pin drops into the valley of the profile.

- The profile is measured by the pin depth and recorded into electronic memory within the gage.
MEASURING SURFACE PROFILE USING REPLICA TAPE

- ASTM D4417 Method C is used to measure the surface profile of an abrasively-cleaned steel surface.
- The method uses a compressible tape to make a mirror image or replica of the surface profile.
- The replica of the surface profile produced in the tape is then measured in a micrometer.
USING REPLICA TAPE

HOW REPLICA TAPE WORKS:

1. Mylar compressible foam
   Before burnishing

2. Mylar compressed foam
   During burnishing

3. Mylar impression-bearing compressed foam
   After burnishing

4. Top anvil Mylar impression-bearing compressed foam
   During measurement

Bottom anvil
HOW MANY PROFILE MEASUREMENTS ARE RECOMMENDED ON A GIRTH WELD?

- The ASTM D4417 standard allows for the field determination of the number and frequency of measurements to determine surface profile.
- Additionally, Appendix 7 of SSPC PA-2 for measuring coating thickness on piping lends some guidance for developing a measurement protocol on piping. The following protocol has been adapted for girth welds:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Number of Measurements on One Side of the Girth Weld</th>
<th>Total Number of Measurements*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 12”</td>
<td>4 evenly spaced</td>
<td>8, or 4 on each side of the girth weld</td>
</tr>
<tr>
<td>14”-24”</td>
<td>6 evenly spaced</td>
<td>12, or 6 on each side of girth weld</td>
</tr>
<tr>
<td>Greater than 24”</td>
<td>8 evenly spaced</td>
<td>16, or 8 on each side of girth weld</td>
</tr>
</tbody>
</table>

Note (*) – Report the average and range of the profile measurements.
USING A TYPE 1 COATING THICKNESS GAGE

- The Type 1 instrument is a manual, magnetic pull-off gage that uses a counterweighted, spring-loaded lever with a magnet attached to one end.

- The gage is operated by allowing the magnet to be attracted to the coated surface.

- The thumb wheel is then turned to apply a lifting force to the magnet and remove it from the surface.

- When the magnet is released, the thumb wheel dial will indicate the coating DFT.
**USING A TYPE 2 COATING THICKNESS GAGE**

- A Type 2 gage is referred to as constant pressure probe or electronic gage.
- It has a battery-operated electronic circuit that produces an electromagnetic current to measure coating thickness on a magnetic (steel) substrate.
- When the gage is placed on a coated surface, a circuit detects the effect of the coating on the magnetic field and converts it to a thickness measurement.
- The coating DFT is sent to a digital display and also retained in memory.
The following standards are useful in using Type 1 and Type 2 gages:

- SSPC PA2 - Procedure for Determining Conformance to Dry Coating Thickness
The non-mandatory Appendix 7 of SSPC PA-2 suggests a protocol for measuring the coating thickness on pipe surfaces. This standard has been adapted for determining the location and frequency of thickness measurements at girth weld areas:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Circumferential Spot Measurements</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 12”</td>
<td>4 evenly spaced</td>
<td>8, or 4 on each side of the girth weld</td>
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Note (*) – Report the average and range of the thickness measurements
Environmental conditions measured by the inspector prior to coating application should include:

- Dew point
- Relative humidity
- Surface temperature

Ambient conditions should be measured and recorded prior to final surface preparation and at 4-hour intervals during coating operations. If conditions are changing, more frequent checks may be required.
WHAT IS DEW POINT?

- The dew point is the temperature at which water vapor will condense out of the air and deposit on a surface that is cooler than the surrounding air.

- A cold bottle of beer sitting outside on a humid day will “sweat” or develop drops of water that illustrates this effect.
WHAT IS RELATIVE HUMIDITY?

- Relative humidity is a ratio of the actual amount of water vapor in the air compared to the amount of water vapor it could contain at 100% saturation. The actual relative humidity is calculated using the following equation:

\[
\text{% Relative Humidity (RH)} = \frac{\text{Actual water in air}}{\text{Water at 100% saturation}} \times 100
\]

The calculation of relative humidity is made by using published psychometric tables or within the microprocessor of an electronic psychrometer.
HOW IS DEW POINT AND HUMIDITY MEASURED?

- The sling psychrometer is a hand-held instrument.
- The spinning (top) part of the sling psychrometer has a pair of thermometers to measure the wet bulb and dry bulb temperatures.
- Once the temperatures are obtained, dew point and relative humidity can be determined from a set of psychometric tables.
- The procedure is described in ASTM E337, Measuring Humidity with a Psychrometer.
ARE THERE OTHER WAYS TO MEASURE DEW POINT AND HUMIDITY?

- Electronic psychrometers are available that will measure and display wet and dry bulb temperatures, dew point, relative humidity and surface temperatures.

- They require no manual calculations.

- The results can be stored on a continuous basis within the instrument.
There is no written industry standard for dew point limits.

However, an implied industry requirement is that the metal surface temperature should be at least 5°F above the dew point before surface cleaning or coating work is performed.

The 5°F is an artificial “buffer” value to compensate for small errors in the measurement process.

AN EXCEPTION TO THE DEW POINT LIMIT exists when performing maintenance work on an operating pipeline. With gas temperatures typically around 55°F, the pipe may carry a layer of condensation during the work.
WHY IS SURFACE TEMPERATURE IMPORTANT AND HOW IS IT MEASURED?

Pipe surface temperature must be measured to determine if it is above or below the dew point. Temperature measurement can be made with the following three instruments:

- **DIAL-TYPE SURFACE**
- **ELECTRONIC**
- **NON-CONTACT I R**
GIRTH WELD COATINGS AVAILABLE FOR FIELD USE

- HOT APPLIED COATINGS
  - MICRO WAX
  - HEAT SHRINK
    - SLEEVES
    - TAPE

- COLD APPLIED TAPE
  - WAX TAPE
    - PVC/HDPE ADHESIVE
    - PP/PP MPA BLEND

- LIQUID APPLIED
  - EPOXY
  - URETHANE

- FUSION BOND EPOXY
Coatings selected for a girth weld applications must be chemically compatible with the coating applied to the main pipeline and develop good adhesion.

In addition to chemical compatibility, the girth weld coating must form a tight seal to prevent water infiltration.

If a generically similar coating is not available, other joint materials can be chosen to meet sealing requirements.
WHAT IS MICROCRYSTALLINE WAX?

- Microcrystalline wax is a solid by-product of petroleum that melts at 160-175°F.
- When coating girth welds, the wax is heated in a pot to 270-350°F and applied by the “granny rag” method to reach 40-60 mils. It can also be applied by brush to small areas.
- The wax develops excellent adhesion to cleaned steel and exhibits good long term flexibility in a soil environment.

APPLYING MICROCRYSTALLINE WAX TO A GIRTH WELD USING A GRANNY RAG
WHAT IS PETROLEUM WAX TAPE?

- Petroleum wax is a by-product of crude oil that is mixed with mineral fillers, plasticizers, and corrosion inhibitors.

- The wax is applied to a polyester mesh and used as a tape product over pipeline and girth weld surfaces.

- An additional wax-based filler with glass micro beads is used to smooth out irregular shapes prior to coating.

- The tape can be applied over tight rust. It contains no toxic materials and can be placed in service immediately after application.
WHAT ARE COLD-APPLIED TAPES?

- Cold–applied tapes are prefabricated materials made from a polymer backing attached to an adhesive film. Some may also use a liquid primer.
  - Petroleum wax
  - Polyethylene (PE)
  - PE/PP blends
WHAT IS POLYETHYLENE (PE) TAPE?

- Polyethylene (PE) tape is a cold-applied joint covering that has an elastomeric or butyl rubber-based adhesive.

- Prefabricated tapes use a high-density version (HDPE) for better resistance to mechanical damage.

- HDPE tapes are compatible with most pipeline coatings in current use.
WHAT IS AN ALLOYED TAPE?

- Alloyed tapes are proprietary blends of polymers like polyethylene (PE) and polypropylene (PP).
- They are applied cold with an integral pressure-sensitive adhesive.
- Alloyed tapes have temperature resistance to 250°F.
WHAT ARE HEAT-SHRINK PRODUCTS?

- Heat-shrink products are made from specially-processed PE or PP that will shrink when heated.
- The reverse side of the sleeve is coated with an adhesive.
- The adhesive layer becomes molten when heated and upon cooling completes the seal to the pipe surface.

APPLYING A HEAT-SHRINK SLEEVE
WHAT KINDS OF HEAT-SHRINK PRODUCTS ARE AVAILABLE?

- Heat–shrink products include tube sleeves, wrap-around sleeves and tape.
- Shrink ratios are in the 2:1 and 3:1 with minimal change in the linear direction along the pipe.
- Heat shrink products can be used over a wide variety of pipeline coatings.

COMPLETED HEAT-SHRINK SLEEVE OVER A GIRTH WELD
PRECAUTIONS WHEN USING HEAT-SHRINK PRODUCTS

- The applications of heat shrink sleeves and tapes must be closely monitored to ensure that both the preheating of the steel surface and heat applied to achieve the shrinking of the material is adequate to maximize the adhesive bond.

- If the temperatures are below levels specified by the manufacturer, an insufficient bond will form and lead to failure by water penetration.

- Pull-off peel tests provide a means to evaluate the adhesive bond of heat-shrink products in the field.
WHAT IS LIQUID EPOXY?

- Epoxy is a two-part liquid coating made by mixing a resin with a hardener.
- After mixing, a chemical cure involving polymerization of the individual molecules takes place.
- The process creates a hard, tough, chemically-resistant coating.
- Epoxy has excellent resistance to water penetration and cathodic disbondment damage.

APPLYING LIQUID EPOXY TO A GIRTH WELD
HOW IS LIQUID EPOXY USED FOR GIRTH WELDS?

- Epoxy is an excellent choice for coating welds in many field conditions. Epoxy is typically applied at 10-20 mils DFT using brush, roller, or spray.

- Surface preparation requires a surface cleaned to an SSPC-SP10, Near-White Metal Blast Cleaning condition.

- Air and surface temperature should be at least is 50°F.
COATING IN COLD WEATHER

- Conventional epoxy formulations will not cure in cold weather unless the ambient conditions are modified.
- If conventional epoxies are to be used, supplemental heat must be used to heat the pipe and cure the resin.
- However, low temperature epoxies are available that can be applied and cured from 32°F down to 4°F.
HOW IS FUSION-BONDED EPOXY (FBE) USED AS A GIRTH WELD COATING?

- FBE is used the same way in the field as it is applied in the mill.
- The weld area is cleaned to SSPC-SP10, Near-White Metal Blast Cleaning condition, and then heated by induction.
- The FBE is applied by electrostatic spray.
- The liquid coating is then heated to complete the cure.
HOW ARE FBE JOINTS APPLIED UNDER FIELD CONDITIONS?

- Girth weld completion must go on regardless of weather conditions.

- When FBE is applied to welds it may be necessary to erect environmentally controlled structures along the right-of-way.

- Welding and coating takes place within the structures.
The hardness of a polymer coating can be used to verify the degree of cure.

The Shore Durometer provides a means of measuring coating hardness.

It is a hand-held instrument with a spring-loaded steel indenter tip.

When the durometer is held against the coating, the indenter presses into the coating to a depth that is indicated on a scale of 0-100 on an analog dial.

The test is described in ASTM D2240.
MEASURING COATING CURE: THE SOLVENT RUB TEST

- The solvent rub test is used to determine the cure of a coating by its solvent resistance.
- A cloth is saturated with a solvent like methyl ethyl ketone (MEK) and making a series of up to 50 “double rubs” against the coating surface.
- The test is continued until up to 50 rubs are completed without removal or softening of the coating, or until the coating is dissolved by the solvent.
- The test is described in ASTM 5402
WHAT IS THE PEEL ADHESION TEST?

- Peel adhesion tests are used to evaluate the adhesion of a heat-shrink product or a FBE to a metal substrate.
- It consists of cutting a three-sided test strip into the sleeve with intersecting 6” legs across at the top.
- The free end of the strip is grasped with a clamp with a digital tension gage.
- The tape is pulled off the pipe surface at an angle of approximately 45° to the surface and the peak tension recorded.
WHAT ARE COATING HOLIDAYS?

- Holidays (pinholes) are small defects in a coating that may penetrate through to the steel substrate.
- They are caused by out-gassing, air entrapment, or solvent evaporation.
- They may be visible or detected through high voltage testing.
- They can be repaired by the application of a compatible coating.

HOLIDAYS IN A SPRAY APPLIED EPOXY COATING
**WHY MUST COATING HOLIDAYS BE FOUND?**

- Specifications for coating pipelines require a holiday-free coating.
- Holidays penetrating through a pipeline coating create passages for water infiltration leading to corrosion.
- Holidays not extending to the substrate can significantly reduce the effective coating thickness.
- All holidays must be located and repaired before the pipeline is buried. However, most holidays are too small to be found by visual inspection.
WHEN IS HOLIDAY DETECTION PERFORMED?

- Holiday detection is usually performed after the final coat girth weld coating has been applied and fully cured.

- If the coating requires multiple coats, testing should take place when the coating is fully cured, but within the recoat window.

- Once a girth weld coating has been tested with high voltage, only the repaired holidays should be retested, and not the entire girth weld area.

USING A HOLIDAY DETECTOR TO LOCATE HOLIDAYS IN A PIPELINE COATING
What is a high voltage holiday detector?

- A high voltage detector consists of a power module producing a range of high frequency or pulsed DC outputs.

- The unit has a ground cable and a wand made from carbon-filled-neoprene, brass or steel. The electrode is used dry.

- The high voltage units are available up to 30,000 volts and have a significant potential shock hazard if used improperly.

- The high voltage will “jump” a column of air in a pinhole, and even burn through a series of coating voids, even though the surface appears to be free of defects.
RECOMMENDED JEEPING VOLTAGES

The following table presents a list of jeeping voltages calculated for coating thicknesses in the range of 20 to 95 mils using equations in NACE SP0188-2006 standard on holiday testing:

<table>
<thead>
<tr>
<th>Thickness, Mils</th>
<th>Jeeping Voltage</th>
<th>Thickness, Mils</th>
<th>Jeeping Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2,348</td>
<td>45</td>
<td>8,385</td>
</tr>
<tr>
<td>22</td>
<td>2,462</td>
<td>50</td>
<td>8,839</td>
</tr>
<tr>
<td>24</td>
<td>2,572</td>
<td>55</td>
<td>9,270</td>
</tr>
<tr>
<td>26</td>
<td>2,678</td>
<td>60</td>
<td>9,682</td>
</tr>
<tr>
<td>28</td>
<td>2,778</td>
<td>65</td>
<td>10,078</td>
</tr>
<tr>
<td>30</td>
<td>2,875</td>
<td>70</td>
<td>10,458</td>
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<tr>
<td>32</td>
<td>2,970</td>
<td>75</td>
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<tr>
<td>34</td>
<td>3,061</td>
<td>80</td>
<td>11,180</td>
</tr>
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<td>36</td>
<td>3,150</td>
<td>85</td>
<td>11,524</td>
</tr>
<tr>
<td>38</td>
<td>3,236</td>
<td>90</td>
<td>11,858</td>
</tr>
<tr>
<td>40</td>
<td>3,320</td>
<td>95</td>
<td>12,183</td>
</tr>
</tbody>
</table>
TOPICS COVERED IN THIS WEBINAR

- Purpose of girth weld coatings
- Performance expectations of girth weld coatings
- Types of girth weld coatings in current use
- Field installation of girth weld coatings
- Field inspection techniques for girth weld coatings
QUESTIONS?