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Guidelines for thermal spray coatings installed to prevent corrosion in pulp mill process equipment

1. Scope

These guidelines cover project and quality-related issues for metal thermal spray coatings installed to prevent aqueous corrosion in pulp mill process vessels, including digesters, flash tanks, evaporators and concentrators. Thermal spray coatings protecting recovery boiler tubes, restoring Yankee dryer surfaces, hard-surfacing calendar rolls, and ceramic (“granite”) coatings used on paper machine rolls are not covered by this document, although the basic, application guidelines and qualification procedures described here apply in general to those applications as well.

These guidelines describe properties thermal sprayed coatings must have to perform adequately, listing items to include in thermal spray job specifications. Coatings are generically described, mostly according to the spray process. No guidance is given either for choosing the coating process or the coating material for specific service applications. **Appendix A** describes the most common thermal spray processes.

2. Safety precautions

Thermal coating spray processes use different methods for melting and propelling ‘droplets’ made from the wire or powder material to the coated substrate, including electric arcs, combustible fuels and pressurized gas. Every spray process generates heat, excessive noise and potentially harmful hot gas fumes, dust and vapors that should not be inhaled. Personnel entering confined spaces for spray work or inspection must comply with the mill’s requirements for confined space entry.

Personnel protection procedures and equipment shall be appropriate for dealing with the arc or flame radiation and noise, and fumes and dust from surface preparation and coating installation. Forced ventilation addresses many health and safety concerns and supplied air hoods may be necessary for blasting and spraying operations, especially in small enclosed spaces. *Hazard and safety assessments should be done as standard practice for all thermal spray coating projects.*

3. Background information

Thermal spray coatings are obtained by spraying molten and semi-molten droplets of metal (or non-metal) powder or wire onto a properly prepared surface. Different spraying processes produce coatings with different physical properties, e.g., density, which controls permeability), oxide content, residual stress, etc. See **Appendix A**.

The coating material should resist corrosion by the process environment, cleaning solutions and shutdown conditions. The specified coating thickness depends mostly on the corrosion rate and planned service life and can be influenced by the coating’s density. Coatings applied by some thermal spray processes have *maximum* thickness limitations to avoid cracking and spalling.

Thermal spray coatings are applied manually or robotically: robotic application provides more uniform coating thickness and quality. A broad range of sprayable materials is available: stainless steel and nickel-alloy coatings are used in alkaline service (digesters, evaporators, other liquor-handling equipment (1-3)); Ti and high Mo stainless steels are suitable for acidic bleaching environments.

Thermal spray coatings *do not form a metallurgical bond* with the substrate surface: temperatures are too low to melt the substrate or allow solid-state diffusion. As with all coatings, adhesion/bond strength depends greatly on surface preparation, which entails thorough cleaning and producing the specified anchor profile. Achieving maximum bond strength on a properly prepared surface depends on the application technique, the applicator and on satisfactory quality control of the coating application process (4).

Because thermal spray coatings do not heat the substrate above 260°C (500°F), there is no heat-affect, warpage is minimal, and residual stress is insignificant other than in the coating itself. A completed thermal sprayed coating can have tensile or compressive residual stress, depending on the material, the spray process and the coating thickness. Application rates for thermal spray coatings depend mostly on the specified thickness and the spray process.

Thermal spray coatings are fairly simple to inspect. As with other coatings, performance depends on application quality. Some thermal spray coatings can be repaired more reliably than others. The densest coatings are readily repaired because the less a coating is permeated and contaminated by the process environment, the better is the bond between the new and old coatings. (Only tightly bonded coatings should be repaired.)

Permeable/porous thermal spray coatings may be painted with a liquid sealer to reduce permeation. Sealers used on thermal sprayed coatings in alkaline service include sodium silicate coating, penetrating epoxy sealer and epoxy paint. The recommended approach in acid conditions is to specify a non-permeable coating rather than relying on a sealer. (The inherent roughness of arc-sprayed coatings is a good painting substrate.)

4. Project specification items

Specifications for thermal spray coating projects normally should include the following items:

Substrate description:

1. Clearly define the areas to be coated.
2. List all substrate materials and their pre-preparation condition, including corrosion roughness.
3. Surface preparation requirements, including anchor pattern, edge rounding limits.

Application:

4. Workplace ambient conditions: humidity, dust control, temperature (mostly for worker exposure), etc.
5. Coating material(s) and spray process (more than one may be used).
6. Coating thickness – a minimum limit is essential.
7. Coating density (and how it is tested).
8. Robotic or manual application (if both are used, maximize robotic application).
9. Open edge, tie-in and repair procedure(s).
10. Sealer (if required).

Quality control:

11. Spray applicator qualification requirements.
12. Procedure documentation requirements.
13. Quality control specifications for equipment setup, environmental conditions, surface preparation, coating application,
14. Inspection plan for coating thickness, tie-ins/repairs, and the completed coating. (Cite this TIP document.)

5. Qualifying the thermal spray process and operators

5.1 Process and procedure qualification

Coating density and uniformity are crucial parameters in the coating specifications. Before a coating is installed inside the process equipment, the coating process parameters must be qualified by an experienced operator producing a test coupon with the specified density and uniformity on a blast-cleaned, test panel shown in **Figure 1**.

The 1/8" thick steel test panel has four sub-tiles tack-welded at the edges. Surface preparation shall be by sandblasting one surface to at least SSPC SP6 condition with a 2 mil anchor profile. Coating density is calculated as follows: because a 25 micron (1 mil) thick coating on a 400 cm² surface has a volume of 1 cm³, the coating's density is the weight of coating on the 20 x 20cm panel (grams), divided by its thickness (mils, measured per Section 7).

Coating quality on the test panel (e.g., uniform thickness, appearance, soundness, etc.) is evaluated by removing the tack welds, bending the coated test panel to break apart the seams and examining the exposed coating cross-sections, as described in Section 7. The coated side of a panel 'bows' concave if the coating is in tension, convex for compression. Panel testing can confirm the effectiveness of the written coating repair procedure.

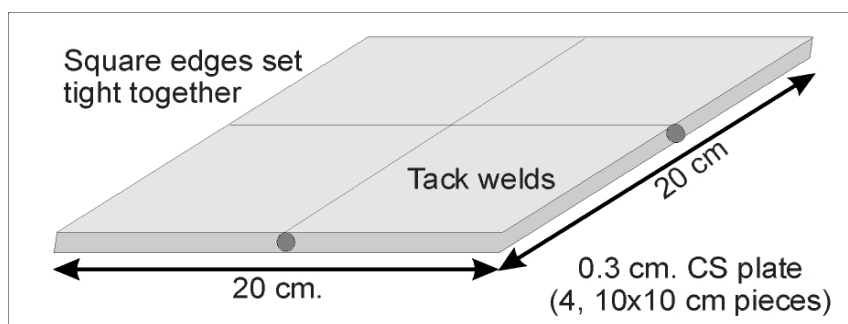


Figure 1. Test panel for qualifying thermal spray coating, application setup, and operators.

5.2 Operator qualification

Every operator who will apply coating shall demonstrate their individual proficiency with the equipment setup qualified in Section 5.1 above by producing a coated test panel that meets the specification requirements for soundness, thickness and density, as described in Section 7.1.

6. Surface preparation

6.1 Written procedures

The Contractor should furnish the mill (project engineer) with a *clearly stated written description* of the surface preparation procedure and specified requirements. The written procedure shall describe how to repair excessively rough surfaces, e.g., weld overlay, grinding, abrasive blasting, etc., to achieve the specified smoothness for coating.

Surface preparation criteria shall be clearly described using industry standards, visual aids, etc. to permit unambiguous verification of the results. The Contractor shall describe the inspection plan and testing procedures to be used to assure the specifications are met. The mill should approve the inspection plan and use the testing descriptions to independently verify that the inspection plan is fully executed and the specified quality is provided.

The mill should review the Contractor's written procedures before field mobilization so all agencies involved in the project can coordinate safety and resolve task conflict issues in advance.