NEWS ALERT

ISO 9001 • ISO 14001
ISO/IEC 17025

Cortec® Releases New Guide to Corrosion in the Pulp & Paper Industry

Pulp and paper mills can be very corrosive environments, especially due to the chemicals often used for pulping. This takes a toll both on structures and equipment. Furthermore, when a plant shuts down, high dollar assets face another dimension of corrosion risk while idle. To address these concerns, Cortec's Technical Director – Energy & Engineered Solutions, Jim Holden, P.E., who has worked directly with paper mill asset preservation, has created a guide to corrosion in the pulp and paper industry.

Pulp and Paper Overview

The guide starts with an overview of pulp and paper mill processes, equipment, and general corrosion threats. It then identifies specific areas where protection may be needed. These include concrete, structural steel, paper machine bearings, oil and cooling water systems, electrical systems, rotating equipment, valves, and external machined surfaces.

Strategies for Corrosion Protection

Some strategies can be applied to operational equipment while the majority are designed for successful preservation during shutdown. Structural remediation is valid for either time and includes concrete repair with MCI® repair mortars and surface applied corrosion inhibitors (SACIs), as well as rust removal on metal surfaces. Operational corrosion protection strategies include the use of VpCI® Emitters for electrical systems, corrosion inhibitors for cooling water and condensate systems, and VpCI® aerosols for maintenance of valve fasteners and bushings. The shutdown and warehousing phases receive the most attention in this guide as Cortec's prime area of expertise. VpCI® fogging fluids for turbine flow paths, oil additives for gearboxes, and CorrLube™ VpCI® Lithium EP Grease for purging bearings are some of the key technologies and techniques outlined.

Equipping Plant Owners

At any stage of a plant's life cycle, it is important for owners and managers in the pulp and paper industry to be equipped with a variety of ways to mitigate corrosion and maintain asset value. Cortec's new guide offers valuable answers, especially in the critical period of layup, that help decision-makers do so. Scroll down to read about "Corrosion in the Pulp & Paper Industry." Contact Cortec® for specific assistance.

Keywords: corrosion in the paper industry, Cortec layup guides, corrosion in pulp and paper plants, bearing layup, concrete repair, paper mill shutdown, VpCI, asset preservation, mitigate corrosion, corrosion risks on idle equipment

Corrosion in the Pulp & Paper Industry

Pulp and paper mill sites consist of four major facilities:

- Mill
- Power plant and substation
- Warehouse
- Wastewater treatment plant

Each facility experiences corrosion due to the corrosive gases generated in the mill and the wastewater treatment plant. This document will concentrate on corrosion protection in the mill, warehouse, and wastewater treatment plant.[1]

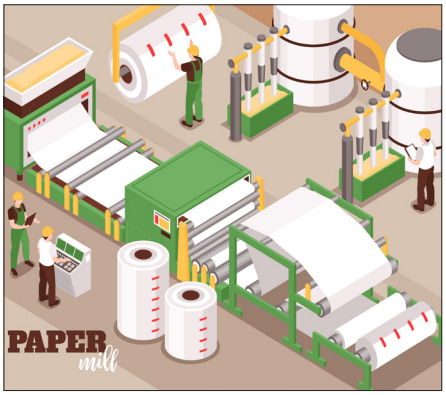
Studies performed by CC Technologies and published in March 2002 estimated the annual direct cost of corrosion in the pulp and paper industry to be $6.0 billion.[2] This cost did not include the costs related to revenue loss. Cost of corrosion is expected to increase as plants age and the experienced workforce decreases due to retirement and downsizing.

There are two primary pulping methods used in the industry: mechanical and chemical. Chemical pulping is used approximately 90% of the time. The sulfate or kraft process is the primary chemical process comprising approximately 80% of the chemical pulping capacity.[3] One of the major drawbacks of chemical pulping is the corrosive gases and greenhouse gases generated in the process.

Typical Corrosive Gases and Liquids:[4]

- H_2SO_3 – Sulfurous acid
- H_2SO_4 – Sulfuric acid
- HNO_3 – Nitric acid
- Black liquor
- White liquor
- Green liquor
- Calcium bisulphite
- CaO – Calcium oxide
- NaOH – Sodium hydroxide
- Na_2CO_3 – Sodium carbonate
- CO_2 – Carbon dioxide
- H_2S – Hydrogen sulfide
- SO_2 – Sulfur dioxide

Most of the corrosive chemicals are found in areas of the plant where wood fibers are broken down or digested. The cooking liquors listed above (white, green, and black) all are very corrosive; contain potentially hazardous and/or toxic ingredients; and corrode the pipes, valves, pumps, etc. with which they come in contact. Each system and component involved in the paper-making process is negatively impacted by the plant atmosphere.



Papermaking Process

There are three major types of paper machines used in today's industry—the Fourdrinier, twin-wire formers, and multi-ply formers—of which the Fourdrinier is most prevalent.[5]

Corrosive gases not only attack the equipment, but also the concrete and structural steel components of the plant infrastructure. Therefore, any corrosion prevention program should address the structures, equipment, and systems to minimize the total cost of corrosion to the plant.

Cortec® Vapor phase Corrosion Inhibitors and Migrating Corrosion Inhibitors (MCI®) provide corrosion protection by displacing moisture (hydrophobic action) from the metal surface and neutralizing the surface electrical charge (ionic bonding). This eliminates free electrons/protons that interact with corrosive elements, thus preventing initiation of corrosion cells. Cortec® products have been developed to optimize corrosion prevention in corrosive atmospheres such as those experienced in pulp and paper mills.

BUILDINGS

Existing concrete should be inspected using GalvaPulse or iCorr corrosion measuring equipment to identify potential damage. Meaningful readings can be effectively accomplished using a grid network and statistical analysis. Once damage is identified, it can be repaired using Cortec® MCI® enhanced repair mortars and following the recommended repair procedure.

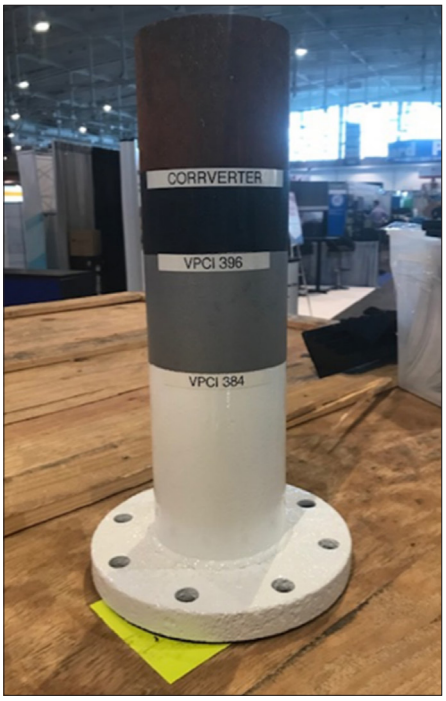
Cortec® repair mortars / repair mortar additives include the following:

- MCI®-2006 NS
- MCI®-2023
- MCI® Mini Grenades
- MCI®-2039 High Performance Horizontal Repair Mortar
- MCI®-2040 High Performance Vertical/Overhead Repair Mortar
-

Existing concrete that is in sound condition can be protected using surface treatments such as the MCI®-2020 Series and water-repellent/weather-proofing sealers such as MCI®-2018, MCI®-2019, MCI®-2021, and the MCI®-2022 Series. The inhibitors in these products migrate into the concrete over time to protect embedded rebar and wire mesh.

STRUCTURAL STEEL

Situations like the one pictured occur when conventional coatings are scratched and/or chipped, allowing moisture and corrosive gases to access the bare metal. Corrosion is a voluminous product and, as it grows, it puts pressure on the coating, eventually exceeding the coating bond strength, causing the coating to lift off the metal, and exposing additional surfaces to the corrosive atmosphere. As this reaction progresses, blisters appear, followed by bubbles and eventually sheets of coating peeling from the surface. Over time, this ultimately leads to failure of the structure unless proper action is taken. Conventional repair methods include mechanical cleaning, sand blasting, grinding, or wire brushing, followed by repainting with the same coating.



Cortec® rust removers, cleaners, and coatings with corrosion inhibitors provide a more user-friendly, cost-effective process. The first step is to address existing corrosion. If sufficient metal cross-section remains to meet minimum design requirements, Cortec® rust removers VpCI®-422, VpCI®-423, or VpCI®-426 can be used to dissolve away the rust without mechanical cleaning. The metal should then be rinsed with an alkaline cleaner/neutralizer such as VpCI®-414, VpCI®-416, or the VpCI®-418 Series. This process is good for small areas.

For larger areas, it may be necessary to air blow or pressure wash the surface to remove loose particles and contaminants. Once clean, the surface can be coated with CorrVerter® Rust Converter Primer, which converts hematite into magnetite. The CorrVerter® is white when applied and turns black when fully cured. Multiple corrosion inhibitor coating systems are available as topcoats over CorrVerter®.

The pipe section in the photo shows one coating system where a rusty surface was conditioned for painting using the above-mentioned CorrVerter® process, then primed with VpCI®-396 (solvent-based moisture cure urethane) and topcoated with VpCI®-384 (solvent-based 2K urethane). This particular combination has excellent chemical resistance, very good UV/color resistance, and meets the ISO 12944 C5/CX criteria for corrosion protection.[6]

PLANT SYSTEMS AND EQUIPMENT

The heart and soul of the paper mill is the paper machine. The primary components of the paper machine are the frame, rolls, and bearings (see image of paper machine bearing with corrosion[7] at left). Each is subjected to corrosion due to the water present in the paper-making process and the corrosive gases in the surrounding air. The frame is subjected to coating failures similar to those described for structural steel and can be handled accordingly. Bearings are subject to water etching during both operating and static conditions. Within 48 hours of shutting the paper machine down, it is recommended to purge all grease-lubed bearings with Cortec® CorrLube™ VpCI® Lithium EP Grease. The bearings should remained filled with this grease until being put back into service, at which time it can be left in and used for operation or purged and replaced with a non-VpCI® grease. For oil-lubricated systems it is recommended that Cortec® M-535 be added to the operating oil at between 2% and 3% by volume and circulated for one hour. Compatibility testing of the M-535 and the operating oil should be done prior to using M-535 during operation. Contact Cortec® for testing. If it is not possible to add M-535 to the operating oil, the roll bearings should be misted with M-535 or M-531.

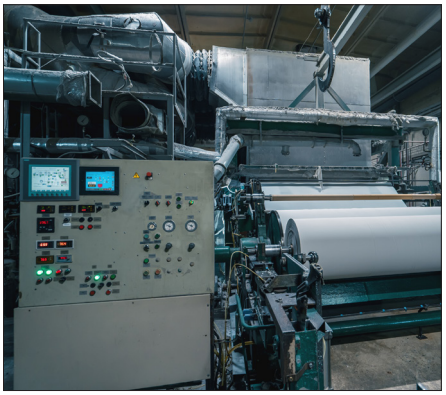
Paper machines have multiple rolls that perform various functions as the fiber comes in the wet end of the machine and finished paper exits at the other end. These rolls experience corrosion during operation, shutdown, repair, and warehouse storage.[8] Corrosion can be addressed during these times by the use of Cortec® products. Exterior rust can be removed by using one of Cortec's rust removers such as VpCI®-422, VpCI®-423, or VpCI®-426 followed by a rinse with a 10% solution of a Cortec® cleaner such as VpCI®-414, VpCI®-415, VpCI®-416, or a similar product. Internal corrosion can be removed by filling the roll internals with VpCI®-422 or VpCI®-426, waiting one hour, then draining and flushing with a Cortec® cleaner. Once all internal and external surfaces are clean and rust-free, the internals can be fogged with VpCI®-337 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3), then shrink-wrapped with either VpCI®-126 HP UV Shrink Film or MilCorr® VpCI® Shrink Film. Once wrapped, the roll can be stored outside if needed with no corrosion concerns.

CORTEC CORPORATION
Environmentally Safe VpCI®/MCI® Technologies

OPERATING SYSTEMS

Fluid Systems

- Lube Oil Systems – Add M-535 at 2.0-3.0% by volume to operating oil. **NOTE:** Contact Cortec® for compatibility testing prior to using for operation.
- Cooling Water Systems – Add VpCI®-649 at 1500-3000 ppm to treat closed loop cooling systems and VpCI®-647 at 50-100 ppm for continuous treatment of open loop systems. System should be monitored with corrosion coupons or other means to ensure proper dosage. Contact Cortec® for application guidance.
- Feedwater/Condensate Systems – Add S-15 at 2-5 ppm by continuous treament.
- Wastewater Treatment or Process Pre-Treatment – Use Bionetix® BCP57™.[9] Contact Bionetix® International for guidance.



Electrical Systems

Various types of electrical/electronic controls and motors are located throughout the plant in every process. The components in these controls and motors are made of various metals such as steel, silver, copper, and dielectric materials which are susceptible to corrosion.[10] Place the appropriate size of Emitter into control panels and junction boxes.

- VpCI®-101 Device – 1 ft^3 (0.03 m^3)
- VpCI®-105 – 5 ft^3 (0.15 m^3)
- VpCI®-111 – 11 ft^3 (0.31 m^3)
- VpCI®-308 Pouch – 35 ft^3 (1.0 m^3)

External Surfaces

- Threaded Fasteners and Bushings – Spray fasteners, especially packing body bolts and nuts, with VpCI® Super Penetrant or EcoLine® Long Term Rust Preventative.
- Valve Stem Bushing – Spray with CorShield® VpCI®-369 (aerosol).

SHUTDOWN AND WAREHOUSING

NOTE: Fogging should be done in short bursts of 15-20 seconds with hold time of 15-20 seconds between bursts. This process should be continued until the required amount of product is applied.

When possible, fog from high elevation to low elevation. This process can be facilitated by placing an air mover or vacuum pump at the opening farthest from the point of application.

Recommended application equipment is an airless paint sprayer with a 0.015” (0.38 mm) diameter nozzle (tip).

Contact Cortec® for product selection and application assistance.

Rotating Equipment (Pumps, Turbines, Compressors)

- Flow Path – Fog with one of the following: VpCI®-337 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3), CorroLogic® Fogging Fluid VpCI®-339 at 0.15-0.20 oz/ft^3 (0.16-0.21 L/m^3), or Boiler Dragon™ at 0.7-1.0 oz/ft^3 (0.7-1.0 L/m^3).

Lubrication Systems

During shutdown, equipment can be laid up either wet or dry.

- Wet Layup – Add M-535 at 2-3% by volume to operating oil and circulate for one hour. System may be left at operating level or drained. If system is left full and the existing oil is to be used during operation with the M-535 additive, contact Cortec® for compatibility testing data prior to operation.
- Dry Layup – Dry layup is accomplished after the system has been drained by fogging M-535 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3) into all bearing housings, piping, and sumps. It normally does not require removal prior to startup.

Gearbox

During shutdown, equipment can be laid up either wet or dry.

- Wet Layup – Add M-535 at 2-3% by volume to operating oil and circulate for one hour. System may be left at operating level or drained. If system is left full and the existing oil is to be used during operation with the M-535 additive, contact Cortec® for compatibility testing data prior to operation.
- Dry Layup – Dry layup is accomplished after the system has been drained by fogging M-535 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3) into all bearing housings, piping, and sumps. It normally does not require removal prior to startup. Dry layup is recommended for warehouse storage.

Motors

Place a VpCI®-101 Device in the junction box. Shrink wrap the unit with VpCI®-126 HP UV Shrink Film or MilCorr® VpCI® Shrink Film for outdoor storage.

Cooling Water Systems

- Wet or Wet-Dry Layup – Add VpCI®-649 at 1500-3000 ppm to treat closed loop cooling systems. Circulate one hour prior to shutting down the system. System can be left filled (wet layup) or drained (wet-dry layup).
- Dry Layup – Dry layup is accomplished after the system has been drained by fogging VpCI®-337 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3) into all coolers, piping, and valves. VpCI®-337 normally does not require removal prior to startup.

External Machined Surfaces (Shafts, Mounting Surfaces, etc.)

Remove existing corrosion with VpCI®-423 (applied by brush); let sit for one hour; then remove with a 10% solution of VpCI®-414. After cleaning, coat with one of the following: VpCI®-391 (water-based acrylic, dries clear ≈ 1 mil DFT) provides ≈ 24 months protection and can be welded. EcoShield® VpCI®-386 (water-based acrylic, dries clear ≈ 1 mil DFT) provides > 24 months protection and can be welded and painted.

Static Equipment (Boilers, Tanks, Condensers, etc.)

Fog with VpCI®-337 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3).

Piping Systems (Contact Cortec® for Guidance)

- Oil and Hydraulic Piping Systems – Fog with M-531 or M-535 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3).
- Non-Lubrication or Hydraulic Piping (Steam, Water, etc.) – Fog with VpCI®-337 at 0.3-0.5 oz/ft^3 (0.31-0.52 L/m^3).

Valves

Fog the valve internals with either VpCI®-337 or ElectriCorr™ VpCI®-239. Coat flange faces with either VpCI®-369 D or VpCI®-391. Spray fasteners, especially packing body bolts and nuts, with VpCI® Super Penetrant or EcoLine® VpCI® Long Term Rust Preventative. Spray the valve stem bushing with CorShield® VpCI®-369 (aerosol).

Shrink wrap with either VpCI®-126 HP UV Shrink Film or MilCorr® VpCI® Shrink Film.

Roll Bearings

Flush to remove old grease. Pack with CorrLube™ VpCI® Lithium EP Grease. Wrap with CorShield® VpCI®-146 Paper or VpCI®-126 Film, or place in a VpCI®-126 Bag.

Ball Bearings and Other Small Rolling Element Bearings

Spray with EcoSpray™ 325 Industrial Lubricant and either wrap with CorShield® VpCI®-146 Paper or place in a VpCI®-126 Bag.

Shafting

Inspect for rust and remove rust as necessary using VpCI®-423 and VpCI®-414. Once shafting is clean and dry, coat with ElectriCorr™ VpCI®-239 and either wrap with VpCI®-126 Film or coat with VpCI®-391 and do not wrap.

Small Items

- Electricals/Electronics – Spray with ElectriCorr™ VpCI®-239 and place in EcoSonic® VpCI®-125 (static-dissipative corrosion inhibiting bag) or VpCI®-126 Bag.
- Metal Components – Spray with ElectriCorr™ VpCI®-239, VpCI®-369 D, or EcoSpray™ 325 Industrial Lubricant. Wrap with CorShield® VpCI®-146 Paper or VpCI®-126 Film, or place in VpCI®-126 Bags.
- Parts Cleaning – VpCI®-418 LM has proved to be an effective product that is safer for operators to manage and apply than products such as potassium hydroxide, which has harsh fumes, creates havoc in waste-water applications, and provides no protection against flash rusting after the item has been cleaned.

References:

1. Information on power plant layup can be found at <https://www.cortecvci.com/layup-of-various-types-of-power-plants/>. Information on substation layup information can be found at <https://www.cortecvci.com/substation-preservation-corrosion-prevention/>.
2. Virmani, Y. Paul. "Corrosion Costs and Preventive Strategies in the United States." Publication No. FHWA-RD-01-156. USDOT Federal Highway Administration, March 2002. Accessed 12 Oct 2022 <https://www.watermainbreakclock.com/wp-content/uploads/2020/08/techbrief.pdf>.
3. "Conductivity Measurements for Kraft Pulping." Yokogawa. Accessed 25 Oct 2022 <https://www.yokogawa.com/us/library/resources/application-notes/kraft-pulping/>.
4. "Pulp and Paper Mills." *Construction Health and Safety Manual*, Chapter 33. IHSA.ca. Accessed 12 Oct 2022 <https://www.ihsa.ca/rtf/health_safety_manual/pdfs/locations/Paper_Mills.pdf>.
5. "Papermaking: Overview and Introduction." The University of British Columbia, Jan 2013. Accessed 13 Oct 2022 <https://www.fibrelab.ubc.ca/files/2013/01/Topic-11-Papermaking-Introduction-text.pdf>.
6. "High Performance Coatings Product Line Guide." Cortec® Technical Services, 25 Jul 2022.
7. Kerley, Lucas (Mobil Oil) and Scott Bryan (US Water). "Considerations for Improved Bearing Life." 20 Aug 2015.
8. Cortec® Corporation. "Long-Term Preservation of Twin Roll Press Roll." Cortec® Case History 723, Jun 2021. Accessed 12 Oct 2022 <http://www.corteccasehistories.com/>.
9. BCP57™ product page. Bionetix® International. Accessed 13 Oct 2022 <https://www.bionetix-international.com/products/bcp57/>.
10. Yadav, Arjun, et al. "A Case Study Paper on Corrosion of Electrical Conductors in Pulp and Paper Industrial Applications." *International Journal of Electrical and Electronics Engineers*, Vol. No. 8, Issue 01, Jan-Jun 2016. Accessed 13 Oct 2022 <https://www.corrosion-protect.com/wp-content/uploads/2019/02/IJEEE-Case-Study-06-16.pdf>.