

HVAC Heat Exchanger Tube Brushing and Eddy Current Test Preparation

1.0 Maintenance Objective & Frequency

The objective of this procedure is to mechanically remove fouling, scale, and debris from the internal surfaces of HVAC heat exchanger tubes and to prepare the tube bundle for eddy current testing (ECT). Proper brushing restores heat transfer efficiency and reduces energy consumption. ECT preparation ensures accurate detection of wall loss, pitting, and cracking, preventing catastrophic tube failure and unplanned downtime.

This PM is performed annually or per OEM recommendation, typically during the chiller or boiler off-season. Additional triggers include observed performance degradation (e.g., approach temperature increase $>2^{\circ}\text{C}$) or after a tube leak event.

2.0 Lockout/Tagout (LOTO) & Safety

- **Electrical Isolation:** Lock out and tag out the main disconnect for the chiller/boiler and all associated pumps (condenser water, chilled water, or hot water). Verify zero voltage with a calibrated voltmeter.
- **Pneumatic Isolation:** Close and lock out the compressed air supply to any pneumatic valves or actuators on the heat exchanger. Bleed residual air from the lines.
- **Hydraulic Isolation:** Close isolation valves on the water supply and return lines. Drain the heat exchanger shell and tubes completely. Verify zero pressure by opening the vent valve.
- **Mandatory PPE:** Safety glasses with side shields, cut-resistant gloves, steel-toed boots, hearing protection (if using pneumatic brushing tools), and a full-face shield when handling chemical descalers (if applicable).
- **Confined Space:** If entering the water box or shell, follow confined space entry procedures including atmospheric testing (O₂, LEL, CO, H₂S) and continuous ventilation.

3.0 Required Tools, Parts & Lubricants

- Tube brushing kit: Nylon or stainless steel brushes sized to tube internal diameter (e.g., 3/4", 1") with flexible shaft or pneumatic drill attachment
- Pneumatic or electric tube cleaner (e.g., Goodway RAM-4 or similar) with variable speed control
- High-pressure water hose (1000-3000 psi) with tube flushing nozzle
- Tube plugging kit: Rubber or brass plugs for isolating leaking tubes
- Eddy current probe (e.g., Zetec or Olympus) with appropriate frequency range (100 kHz to 1 MHz) and calibration standard tube
- Data acquisition system (laptop with ECT software, e.g., Eddyfi or Zetec)
- Dial indicator and magnetic base (for tube wall thickness verification if needed)
- Flashlight, inspection mirror, and borescope (for visual inspection of tube ends and baffles)
- Personal protective equipment (PPE) as listed in Section 2.0
- Lubricant: Water-soluble lubricant (e.g., K-Y Jelly or equivalent) for probe insertion
- Chemical descaler (if heavy scale is present): e.g., sulfamic acid or citric acid based, per OEM spec

4.0 Step-by-Step Maintenance Procedure

1. Perform LOTO as per Section 2.0. Verify zero energy state by attempting to start the pump and checking pressure gauges.
2. Remove the water box covers or channel heads. Use a crane or hoist if covers exceed 25 kg. Inspect gaskets for reuse; replace if cracked or compressed.
3. Visually inspect tube ends for gross debris, broken tubes, or severe fouling. Document any obvious damage with photos.
4. Select the correct brush size: the brush diameter should be 0.005" to 0.010" larger than the tube internal diameter. Attach brush to the flexible shaft or pneumatic drill.
5. Insert the brush into the first tube and run the cleaner at 500-1000 RPM while moving the brush back and forth the full length of the tube. Repeat 3-5 passes per tube. Use water flush simultaneously if using a wet system.
6. After brushing, flush each tube with high-pressure water (1000-3000 psi) from the opposite end to remove loosened debris. Confirm water flows freely and exits clear.
7. Perform a visual inspection of each tube using a flashlight and mirror. Look for remaining scale, pitting, or through-wall holes. Use a borescope for tubes with suspected internal damage.
8. Prepare the eddy current test equipment: calibrate the probe using a standard tube with known defects (e.g., 20%, 40%, 60% wall loss notches). Set frequency based on tube material and wall thickness (e.g., 200 kHz for copper, 100 kHz for stainless steel).
9. Apply a thin layer of water-soluble lubricant to the probe tip. Insert the probe into the first tube and advance at a steady rate of 0.5-1 m/s. Collect data for the full tube length. Mark any tubes with signal anomalies for re-testing or plugging.
10. Repeat ECT for all tubes in the bundle. For tubes with signals indicating >40% wall loss, perform a secondary test (e.g., using a different frequency or probe) to confirm. Plug any tubes with confirmed through-wall defects or wall loss exceeding the OEM rejection criteria (typically >50%).
11. Document all findings: tube numbers with defects, wall loss percentages, and plugging actions. Save ECT data files with a unique identifier (date, unit, bundle).
12. Replace water box gaskets with new ones. Reinstall covers and torque bolts to OEM specification (e.g., 80-100 ft-lbs for 3/4" bolts, in a cross pattern).

5.0 Verification & Return to Service

1. Remove all LOTO devices. Restore power and water supply. Open isolation valves slowly to avoid water hammer.
2. Pressurize the system to operating pressure (typically 100-150 psi for HVAC water side). Check all gasketed joints for leaks using a flashlight and mirror. Tighten any leaking bolts to spec.
3. Start the pump and circulate water for 15 minutes. Verify flow rate and pressure drop across the heat exchanger are within OEM limits (e.g., pressure drop <5 psi).
4. Monitor approach temperature (leaving water temperature minus refrigerant saturation temperature) for 30 minutes of steady operation. Approach should be within 1-2°C of baseline or OEM spec.
5. Complete the PM work order in ServiceGrid: log tube brushing details, ECT results, number of tubes plugged, and any anomalies. Attach ECT data files and photos.
6. If more than 10% of tubes were plugged, schedule a retube or replacement during the next planned outage.

Regulatory Disclaimer: This document is a generic maintenance template provided for educational and informational purposes only. It does not constitute professional engineering or reliability advice. The end-user assumes all liability for validating all step sequences, torque specs, and LOTO protocols against specific machinery OEM manuals before deployment to a live production floor.