

1.0 PURPOSE:

- 1.1. To inspect tube bundles for the purpose of improved reliability, reduce operating costs, prevent costly repairs, and unscheduled downtime due to heat exchanger tube bundle failures.

2.0 SCOPE

2.1 To perform eddy current inspections of installed heat exchanger tubing for the purpose of detecting tube degradation and/or abnormalities. TAI Services will supply all materials, labor and test equipment needed for the inspection. 100% of the tubes in the heat exchanger or chiller will be inspected unless otherwise specified in the purchase order. A formal written report will be prepared documenting the results of the inspection within two days following the completion of the inspection. This practice conforms to ASTM Standards E243, E426, and E571.

3.0 PREPARATION

- 3.1 **Accessibility:** The tube bundle to be inspected must be accessible from at least one end, with a minimum clearance of twenty four inches (24"). This is required for probe insertion.
- 3.2 **Heads:** Heads must be removed prior to the arrival of the inspecting technician. Removed heads must be placed where they will not interfere with access to the tube sheet or present a falling hazard.
- 3.3 **Cleanliness:** The tubes must be free of foreign material such as scale and debris. It is not necessary for the tubes to be dry.

4.0 SUPPORTING DOCUMENTS

4.1 Supporting documents such as Test Frequency List, ASTM Standards and Calibration Procedures, shall be used based on the type of test instrument used and the type of equipment being inspected shall be made available upon request.

5.0 RESULTS

5.1 All relevant indications of tube damage, abnormalities, degradation and those tubes which are inaccessible or impassible shall be reported. Where possible, tube abnormalities shall be reported in Percent of Wall Loss. Freeze bulges which cannot be measured in percent wall loss shall be reported in diameter increase. Tube conditions which cannot be reported in percent wall loss or diameter change shall be indicated as Nominal or Excessive.

6.0 TEST EQUIPMENT

- 6.1. Computer based eddy current test instrument manufactured by Highline Automation. The Highline Automation EC14 has a frequency range of 40Hz to 2 MHz The instrument will meet or exceed the requirements of Appendix "A".
- 6.2. The instrument is a dual channel dual frequency instrument.
- 6.3. The EC14 instrument is capable of recording the inspection data for playback and analysis at a later time.
- 6.4. Strip charts are such that the vertical and horizontal deflections produced by the inspection probe of both channels are recorded. In addition, the XY screens of both channels are captured as well.

- 6.5. The test instrument used shall generate a tube sheet map and tube list for the purpose of tracking the tubes being tested, and reduce the possibility of human error.
- 6.6. The test instrument shall automatically mark defective tubes on the tube sheet map, generate data sheets with defect description and location, and summarize the inspection results.
- 6.7. The test probes used shall be capable of operating at the various frequencies necessary to perform the specific test. Special wound probes are permitted if requirements of Appendix "A" are met. The probes used shall have a minimum fill factor of not less than .80, as calculated using the formula $\eta = (D/d)^2$. Probes shall be constructed to perform without failure or frequency drift for the entire inspection period.
- 6.8. The test instrument used shall be capable of recording both the Vertical and Horizontal outputs of the detection circuits to enhance signal interpretation and review. A sampling of these recorded images shall be printed as strip charts and included in the final written report.

7.0 CALIBRATION STANDARDS

7.1 The tube used when adjusting the instrument sensitivity shall be of the same alloy, diameter, nominal wall thickness(s) and configuration as the tubes being inspected. The tube shall be selected from a typical production run and exhibit low background noise.

7.2 The reference standards used shall be milled as specified in the purchaser's work order or in accordance with accepted industry standards. Where specified, or as deemed necessary, additional notches, grooves artificial and/or natural discontinuities may be included in the calibration reference standard. Artificial discontinuities shall be spaced to provide adequate signal resolution for interpretation.

8.0 PERSONNEL QUALIFICATIONS

8.1 Personnel shall be certified and qualified in accordance with the requirements of ASNT document SNT-TC-1A, December 1992 Edition, and shall meet the following requirements:

- LEVEL I: Helper status; minimum of thirty (30) days experience in testing of heat exchanger tubing under the direct supervision of at least a Level II certified technician.
- LEVEL II: Demonstrated proof of proficiency through written and practical exams.
- LEVEL III: Minimum of four (4) years field experience in testing heat exchanger tubing and have demonstrated proof of proficiency through written and practical tests.

9.0 TEST PROCEDURES

9.1 Unless otherwise specified in the purchase order, 100% of the tubes contained in each vessel shall be inspected their full length.

9.2 Probe speed shall not exceed 60 feet per minute.

9.3 Test instrument calibration shall be checked at the beginning, at the end, every two hours of continuous operation, or when improper operation is suspected. When the test instrument is found to be improperly calibrated or malfunctioning, all tubes shall be re-inspected since last known good calibration.

9.4 Access to documented failure trends, and Level III consultation for correlation of damage signatures and severity shall be made available to the field technician as needed.

10.0 RECOMMENDATIONS FOR CORRECTIVE ACTION

10.1 Recommendations for corrective action shall be included in the inspection report. Reject criteria shall be established, based on the progressive nature of the damage found, history of the equipment tested, and the limitations of the inspection method used.

11.0 FIELD REPORT

11.1 An on-site informal verbal report, tube map and tabulated data sheets indicating inspection results shall be given upon test completion to a representative of the contracting firm.

12.0 FINAL REPORT REQUIREMENTS

12.1 A final written report will be submitted within two (2) working days. As a minimum, this report will include the following information:

12.2 Vessel Information sheet containing the unit model and serial number, tube specifications, test end, row and tube numbering information.

12.3 Summary of findings that include percent of tube bundle affected by the different type and degree of defects detected.

12.4 Tabulated defect data sheets detailing the type, degree and location by row and tube number to permit selective plugging/replacement.

12.5 Tube bundle layout (Tube Map) with defective tubes marked by defect description and severity with a legend on the tube sheet map.

12.6 Strip charts showing the vertical, horizontal and XY detector outputs of selected sample good and/or defective tubes. Defects will be labeled on the strip charts to identify type and location.

12.7 A calibration strip chart of the machined calibration referenced standard will be included for correlation of tube damage severity. Instrument settings shall be automatically included on the calibration strip chart page for accurate reproduction of the inspection results.

12.8 Calibration procedures and explanation of damage correlation.

12.9 Recommendations for corrective action based on industry accepted reject criteria.

12.10 The inspection report shall be reviewed by a Certified Level III.

APPENDIX - A -

As a minimum, the eddy current test instrument and probes used must be able to detect the following Defects, Discontinuities, and/or Abnormalities.

1. ID Pitting
2. OD Pitting
3. ID Corrosion
4. Longitudinal crack
5. Longitudinal flaw
6. Radial crack
7. Radial flaw
8. OD metal loss (corrosion)
9. OD corrosion at the supports
10. OD wears at the supports
11. OD deposits
12. OD defects, damage
13. ID erosion/metal loss, ID defects
14. Freeze bulge (land area) .015 or greater
15. Freeze bulge in the finned area
16. Mechanical expansion (land area/finned area)
17. Tube plugged/removed
18. Tube dented
19. Tube constricted
20. Tube restricted
21. Misformed land area
22. Missed expansion
23. Not expanded
24. Abnormal indications