EDDY CURRENT INSPECTION PROCEDURES QCP201-072007

1.0 SCOPE

1. Perform eddy current inspections on installed heat exchanger tubing. Eddy Current is a cost effective method of detecting tube degradation, discontinuities and/or conditions which could affect the longevity or serviceability of a tube.

2. Eddy Current is a method of nondestructive testing whereby electromagnetic induction is used to interrogate a test part. Tubing is inspected by moving an internal inspection coil arrangement, energized by alternating currents at one or more frequencies the full length of the tube. Typically, tubing is inspected at two or more frequencies. The electrical impedance of the inspection coils is modified by dimensional and metallurgical discontinuities in the tube wall. Each discontinuity produces an electromagnetic response unique to the anomaly detected. These responses are processed electronically and displayed on the test instrument screen for interpretation. The types of damage which can be detected are listed in Appendix A.

3. Prime Surface tubes shall be inspected with Absolute - Differential, or Cross Axial - Differential coil arrangements. Finned tubes shall be inspected with a Cross Axial - Differential coil arrangement.

4. This practice conforms to ASTM Standards E243, E426, and E571.

2.0 WRITTEN PRACTICE

2.1 Written Practice, TAI Services, Inc. QCP200 Eddy Current Inspection procedures shall be followed. This written practice conforms to the American Society of Nondestructive Testing (ASNT), and is available for review upon request.

3.0 SUPPORTING DOCUMENTS

1. TAI Services, Inc. QCP200, Appendix C, Test Frequency List, QCP211, Definitions and Terms relating to eddy current inspections. ASTM Standards and Calibration Procedures.

4.0. RESULTS

1. Detect and report all discontinuities, conditions and/or defects listed in Appendix "A". Damage will be reported in percent of wall loss. Discontinuities which can not be measured will be reported as nominal or excessive,

5.0 TEST EQUIPMENT

1. The test equipment used shall be a computer based Multi Channel, Multi Frequency system with Mixing capability. This system shall be capable of operating in one of the following modes; (1XY),(2XY, 2StripChart), or 4XY. The System output is 55 Hz - 4 MHz, with a drift rate of less than .002% in 24 hours. Repeatability shall be better than .002%.

2. The system shall be capable of displaying the outputs of all channels used simultaneously.

3. The test equipment shall be capable of recording the inspection data to Optical Drive or VHS tape as needed to satisfy inspection requirements.

4. The inspection probes used shall be designed for Absolute - Differential inspections, or Cross Axial - Differential inspections.

5. Finned Tubes shall be inspected using a Cross Axial - Differential coil arrangement. This coil configuration produces eddy current flow both parallel to, and perpendicular to the tubes axis, making it sensitive to all defects including radial cracks and flaws in transition zones which might otherwise be undetectable using other coil configurations.

6. Prime Surface Tubes shall inspected using Absolute - Differential. Where inspection frequencies do not exceed 200 KHz, a Cross Axial - Differential coil configuration may be used.

7. Inspection Frequency shall be determined through experimentation based on tube alloy, wall thickness, and tube configuration. As a starting point frequency may be determined using formula $F = 3.9262 \times 10^{8} \, r/\mu t i^2$.

8. The probes used shall have a minimum fill factor of .80, as calculated using the formula $\eta = D^2/d^2$. Probes shall be constructed, and sealed to perform without failure or frequency drift for the entire inspection period.

9. The test instrument used shall be capable of recording both the Vertical and Horizontal outputs of the detection circuits simultaneously to enhance signal interpretation and review. These recorded images shall be printed as strip charts and included in the final written report.

10. The system shall be capable of recording the inspection to VHS tape or Optical drive if test specifications require.

6.0 CALIBRATION STANDARDS

1. Calibration Standards used for system set-up 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.

2. Calibration Standards used shall contain natural and/or artificial discontinuities. These discontinuities shall be spaced to provide adequate signal resolution for interpretation.

7.0 PERSONNEL QUALIFICATIONS

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: Experienced in testing heat exchanger tubing and has demonstrated proof of proficiency through written and practical test given both in-house and through an outside agency.

LEVEL III: Minimum of four (4) years field experience in testing heat exchanger tubing, or having completed with passing grades two (2) years of engineering or science studies at a college or technical school and have demonstrated proof of proficiency through written and practical tests.

8.0 INSPECTION INTERVALS

1. The application, load and operating cycle of a chiller or heat exchanger should be used to determine the frequency of inspections. Damage such as corrosion pitting on the water side of tubes typically is more prevalent when a unit is inactive. Corrosion damage caused by refrigerant contamination, and mechanical damage, such as support wear is more of a problem when a unit is operated under a heavy load.

2. A Base-Line inspection should be performed upon installation. Follow-up inspections should be performed after five years, unless questionable indications are detected. Intervals between subsequent inspection will be determine based on the findings of inspections.

9.0 TEST PROCEDURES

1. Prior to an inspection, the test instrument is set up and calibrated using a probe having the appropriate coil configuration for the type and alloy of the tubes being inspected.

2. The inspection probe shall have a fill factor of .80 or greater.

3. Test speed shall not exceed 60 feet per minute.

4. Each tube shall be inspected unless otherwise specified in the purchase order

5. Test instrument calibration shall be checked at the beginning, at the end, every two hours of continuous operation, or whenever improper operation in suspected. When the test instrument is found to be improperly calibrated or malfunctioning, all tubes shall be reinspected since last known good calibration.

6. Both the Cross Axial and Differential channels shall be observed as the probe is inserted and/or with drawn from each tube.

7. 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.

8. The contracting firm shall be briefed on the results recommended corrective action upon completion of the inspection.

9. A final written report shall be made available within two (2) working days or less of the completion of the inspection, next day turn around is typical.

10.0 RECOMMENDATIONS FOR CORRECTIVE ACTION

1. Recommendations for corrective action shall be based on the progressive nature of the damage detected, history of the equipment tested, and the limitations of the inspection method used.

2. Where damage and or discontinuities are measurable, tubes showing loss of 40% or more wall loss shall be condemned. Measurable bulges resulting from freeze damage shall be condemned at .100. All other damage shall be condemned if determined to be in excessive.

11.0 REPORT REQUIREMENTS

1. An on-site informal verbal report shall be given upon test completion. The final report will include the following information:

A. Vessel Information sheet which includes the unit make, style, model and serial number, tube specifications, test end, row and tube numbering information.

B. Defect Comparison charts comparing the number and severity of damaged tubes with previous inspections.

C. Summary of Inspection which details the different type and degree of tube damage or anomalies detected by percent of bundle.

D. Tabulated defect data sheets detailing the type, degree and location of damage by Row and Tube number to permit selective plugging or replacement.

E. Color Tube bundle layout with defective tubes marked by defect description and severity.

F. Strip charts showing the vertical and horizontal detector output of selected sample good and/or defective tubes. As a minimum, there shall be one strip for each type and degree of damage or discontinuity detected. Damage and/or discontinuities will be labeled on the strip charts to aid the reader in interpretation of the strip chart. Where applicable, the damage location will be given in inches to the nearest support or tube end.

G. A calibration strip chart of the machined calibration referenced standard will be included for correlation of tube damage severity. Instrument settings shall be included on the calibration strip chart page.

H. Recommendations for corrective action based on industry accepted accept/reject criteria.

I. The inspection report shall be reviewed by a certified Level III.

12.0 Report Delivery

1. The final report shall be E-Mailed to a representative of the contracting firm on or one day following the completion of the inspection. The file format will be PDF (Portable Document File).

2. A bound copy of the final report will mailed, via the US Mail service, on or one day following the completion of the inspection.

APPENDIX - A -

As a minimum, the eddy current inspection system used shall be capable of detecting and evaluating the following Defects, Discontinuities, and/or Abnormalities.

1. Abnormal Indications
2. Bulges, Freeze
3. Constricted Tubes
4. Corrosion; Internal, External and Under Supports
5. Cracks, longitudinal; in Transition Zones, Bay Areas or Under Supports
6. Cracks, Radial; in Transition Zones, Bay Areas or Under Supports
7. Dents in Transition Zones, Bay Areas or Under Supports
8. Deposits; Internal and External
9. Erosion; Internal and External
10. Gouges
11. Mechanical Expansions
12. Misformed Support Landings
13. Missed Expansions
14. Missing Expansions
15. Pitting, Internal and External
16. Restricted Tubes
17. Vibration Damage Under Supports