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Over the past 10 or more years, the principal of CorrView International has provided ultrasonic testing services to many of New York City's largest office building properties. These include the General Motors Building, The World Trade Center, Met Life, The Pan Am Building, The Daily News Building, Federal Reserve Bank of New York, The New York Stock Exchange, and Carnegie Hall, among others.

We have provided testing services to most of the major real estate management firms, and have worked through some of the largest consulting engineers in support of projects locally, as well as throughout the United States.

As a result of this work, we have developed and refined a testing and reporting procedure that we believe provides to our clients the most comprehensive and useful piping evaluation report available. We offer this specification below for those individuals interested in better understanding the scope of work provided by CVI, or for those looking to specify such a level of investigation under open bidding conditions.

This pipe testing specification is also available in Adobe PDF format, HTML, Microsoft Word, and basic ASCII text.

Preliminary Investigation

Prior to the actual testing, CorrView International, LLC shall, where possible, conduct a full walk through inspection of the subject location, and review the operation of the piping system(s) in question. Specifics such as material type, pipe size, pipe construction, operating pressure, and general physical condition shall be determined.

Operating parameters such as previous mechanical maintenance history, hours of operation, internal fouling, accumulated deposits, quality of water treatment, etc., shall be noted. A review of each system layout shall be made based upon existing piping specifications and blueprints, as well as any supplemental information available through the engineering department, or professional engineer.

An historical review of any prior leaks, obstructions, or failures at the subject piping system(s) shall be made with the engineering department. Areas where a specific concern for the integrity of the piping exists by building operators and representatives shall be noted as probable test locations. Visually observed examples of outer pipe corrosion or leakage shall be highlighted as probable test locations.

Where an on-site walk through cannot be performed, or judged as not necessary, information shall be gained as best possible through blueprints, floor plans, or other documents, and from interviews or information supplied by building property operators to best illustrate the layout and operation of the subject property.

Based upon the number of piping locations to be tested, a general plan of action shall be proposed, and testing fees quoted. Depending upon specific job requirements and conditions, every effort shall be made to produce an evaluation comprised of:

- **Largest and smallest piping sizes**
- **Top and bottom extremes of the system**
- **Horizontal extremes of the piping layout**
- **Main lines and distribution piping**
- **Risers and horizontal runs**
- **Welded, threaded, or clamped pipe**
- **Areas of no flow**
- **By-pass lines**
- **Pipe serving alternating equipment**
- **Roof level piping**

Every effort shall be made to reach representative types of piping in order to produce the most informative report. The client shall provide the personnel necessary to direct CVI to such areas in a timely manner.

Test Equipment

Field testing shall be performed using a Panametrics 36DL Plus, 26DL Plus, or equivalent ultrasonic thickness gauging device. The instrument shall have an on-board waveform display allowing its operator to instantly evaluate the validity of each and every wall thickness measurement taken, and have data logging capability.

All wall thickness measurements which do not show an acceptable waveform pattern shall be discounted, and further investigation made to identify the cause for the problem. Measurements showing an acceptable waveform display and indicating an accurate wall thickness value shall be saved for later download and analysis. Both the wall thickness value and the accompanying waveform display shall be saved in the memory of the 36DL Plus or equivalent device for future reference and re-evaluation, if necessary. Equipment requiring the written recording of thickness values shall not be acceptable.

The measurement instrument shall feature "echo to echo" technology allowing the measurement of coated or painted pipes without scraping, sanding, grinding, or otherwise potentially removing outer metal from the test surface, or defacing client equipment. A Panametrics D794 dual crystal element straight probe transducer, or equivalent, shall be used in order to provide the highest wall thickness accuracy possible, and to locate interior pitting.

This probe shall have a frequency of 5.0 MHz and a tip diameter of 7.2 mm. A coupling agent of glycerine or its acoustic equal shall be used to facilitate the transmission of the ultrasound signal into the test surface. The appropriate high temperature couplant based upon operating temperature shall be used for steam, steam condensate, and hot water piping.

Instrument calibration shall be performed at the beginning of the test session and at regular time intervals throughout the investigation. A calibrated test block of the material to be evaluated and having reference thickness steps above and below the minimum and maximum anticipated pipe wall thickness to be tested shall be used. The test block and instrument probe shall be allowed to equalize to the temperature of the test medium before calibration.

Re-calibration shall be performed whenever a change in temperature of the medium occurs. Re-calibration of the instrument and probe shall also be performed after each hour of use, whenever the instrument is turned off and on, or when pipe of a different diameter and wall thickness is measured.

Testing Procedure

A preliminary review of each test location shall be performed to generalize the condition of that particular area. A minimum of 12 wall thickness readings shall be taken and saved to memory for use in the final analysis of the test location. When possible, those 12 measurements shall be taken at 3, 6, 9, and 12 o'clock positions around the circumference of the pipe, and at three cross sections along the length, each separated by approximately 3-4 inches.

Under conditions where the entire pipe circumference is not available, or where conditions do not allow, measurements shall be taken at random, but with evenly spaced intervals as best possible. Measurements shall be identified as being taken at random or based upon the above referenced standard grid in the final report.

A photograph of each test location shall be taken in order to illustrate the general test area location and supplement the written description. All relevant information regarding the location, operating conditions, observed problems, etc. shall be noted for incorporation into the final report. All observed piping related problems such as thread leakage, outer surface corrosion, weld failure, and insulation failure, etc. shall be noted for incorporation into the final report. A photograph shall be taken to document the specific test location, or to document a failure event or condition.

Small 8 in. to 12 in. sections of insulated or covered pipe surfaces shall be removed in order to provide access, if necessary. The removal, replacement, and re-painting of any insulation or pipe covering shall be the responsibility of the engineering or property management. Asbestos covered pipe will not be tested until properly abated.

A final written report shall be produced following the completion of the field testing, and incorporate all compiled data. No measured data derived from the field testing shall be discounted, amended, or falsified. Excepting clear examples where error on the part of the ultrasound technician or test equipment has produced a false wall thickness measurement, as verified by a review of the saved waveform, all test data shall be incorporated into the final report.

An attempt shall be made to explain all data anomalies. The report shall be available within 21 days following completion of the actual field testing. The report shall be separated into sections of summary and detailed information in order to suit the information needs of various potential readers. The final report shall be written in a clear and easily understandable format, shall be arranged in a logical progression, and provide a full explanation of all accumulated data and derived statistics.

Specifically requested information from the client falling outside the general scope of the report shall be incorporated into the final report to the best degree possible. An executive summary shall be produced condensing the most important findings of the report, as well as any specific highlights of the investigation.

An introductory report section shall be provided detailing the testing procedure and instrumentation used. It shall also include a listing and explanation of any assumptions made during the testing and reporting procedure, as well as any investigative limitations created by either the testing procedure, pipe medium, physical access, availability of physical data relative to the pipe, or actions of the client. Definitions of any specific technical terms and labels used in the report shall be provided.

A preliminary statistical summary section shall be provided showing overall measured corrosion rates, pipe loss, remaining pipe life and retirement dates of all test locations. A breakdown of the number of locations tested and corrosion statistics per each piping system tested shall be provided.

Detail for each individual test location shall be compiled providing all measured and calculated data. Full physical identification of the pipe and piping service shall be provided. A photograph of the location shall be included with highlighted indication of the general test area. All 12 measured ultrasonic test values shall be graphed to provide a visual representation of the variation at the interior pipe surface.

Test locations shall be organized and presented in the final report in order to produce the best understanding of piping conditions. Where an investigation involves multiple piping systems, the data shall be organized and presented in the report according to each separate piping system; with all relevant corrosion rate and retirement date statistics generated for each individually. The report shall be printed in color.

The original wall thickness of the pipe shall be determined, and estimated to be at industry specification, or above or below industry specification. It shall be noted as such in the report. The minimum allowable wall thickness for each individual location shall be calculated based upon the particular pipe diameter, operating pressure, construction (E value), material (S value), schedule, and pipe service provided.

Two alternate corrosion rate and remaining life prediction scenarios shall be calculated for each test location. An "Average Case" scenario shall be presented based upon the average of all measured wall thickness values, and provide estimates for the following parameters:

- **Average wall thickness**

- **Average corrosion rate**
- **Percentage of allowable loss**
- **Remaining pipe life**
- **Retirement date**
- **Overall pipe condition**

An alternate "*Worst Case*" scenario shall also be presented based upon the single lowest measured wall thickness value found within the 12 measured values, and shall provide minimum estimates for the same parameters as highlighted above. A block graph showing the relationship between original pipe wall thickness, minimum allowable wall thickness, average measured wall thickness, and minimum measured wall thickness shall be provided for each test location. A comments section offering any additional information, details, or explanation about the test location or results shall also be provided.

All data points for each piping system shall be graphed together in order to show the relationship (or lack thereof) of the accumulated wall thickness measurements and calculated corrosion rate and remaining life estimates. Graphs shall utilize both average and minimum measured wall thickness values and be presented in color in order to clearly display the relationship between each series of values.

Summary graphs shall be produced showing the following trends and relationships:

- **Original pipe wall thickness vs. measured values**
- **Average, minimum, and maximum corrosion rates**
- **Remaining pipe life based upon average and minimum values**
- **Percentage of allowable pipe loss**
- **Actual wall thickness loss**
- **Breakdown of overall piping status**

Depending upon the scope of the testing program, various modeling scenarios shall also be investigated to show relevant trend comparisons. Modeling comparisons which add insight and understanding to this report shall be submitted. Possible modeling comparisons may include:

- **Corrosion rate vs. pipe size**
- **Corrosion rate vs. physical floor location**
- **Corrosion rate vs. pipe age**
- **Corrosion rate vs. horizontal or vertical orientation**
- **Corrosion rate vs. pipe material**
- **Corrosion rate vs. pipe use**

A calculation shall be made for each test location and set of 12 wall thickness measurements for the purpose of indicating the level of pitting activity which may exist. Since any spot check of

a piping system is not likely to locate the one lowest wall thickness value of that area, the standard deviation of all measurements shall be produced, from which a theoretical minimum wall thickness can be calculated.

A priority worksheet of all test locations shall be provided listing in order those locations having the highest amount of metal loss. This worksheet will offer writing space for engineering or building personnel to note any corrective actions or further testing performed at each location. For multiple piping systems, individual priority listings shall be provided.

A written summary section shall be provided to review the entire report and consolidate its contents into its major generalizations. The most significant findings and deficiencies identified through the investigation will be highlighted. Recommendations specific to the findings in the report shall be provided. General recommendations for good corrosion control in HVAC related piping systems shall also be provided, along with any other relevant and useful information.

An explanation of all mathematical calculations used in the preparation of the report shall be provided in order that interested individuals can verify and reproduce the calculations of corrosion rate and prediction of retirement date. An appendix section shall provide all supplemental information relative to the accumulation of data, and preparation of the report.

Observed problems or other information noted during the course of the ultrasonic testing investigation shall be documented. The report shall be clearly written and presented in a bound format with the primary objective of providing the greatest amount of useful information about the subject system to the client.

The report shall be made available on IBM compatible computer format in order to enable the client further manipulation or modeling of the data, or for other management purposes. At request, all statistical data of the report shall be supplied in either database format (dBase IV), spreadsheet format (Excel, Quattro Pro, or Lotus 123), or in universal language (ASCII), and provided on CD-Rom. Major sections of the report shall be made available in Adobe PDF.

The full report shall be archived by CorrView International, LLC in its original computer format for a minimum period of five years, or longer if requested. Additional copies of the report shall be available for as long as the data is on archive, at additional cost.

Follow-up investigations of the same piping locations shall include test data from the most previous report; with a series of calculations performed showing differences in wall thickness and corrosion rate.