RTD-Incotest for Evaluation of Corrosion under Insulation.

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Abstract

RTD-Incotest or insulated component testing, a method of pulsed eddy current, is designed and developed by Applus-RTD for the detection and sizing of corrosion under insulation.
RTD-Incotest measures average wall loss over an area beneath the probe. This is accomplished by measuring the decay curve of the eddy current and then utilizes a software algorithm to determine percent wall loss. If there is a verification point this can also give average remaining wall thickness.

The benefits for the nuclear industry are:
1) No need to remove insulation. Only requires one verification point.
2) Reduces potential exposure/ maintains ALARA
3) Quick and accurate screening method.
For exposed piping there is no need for contact with the piping. So it can be applied for high temperature or for increasing standoff to reduce exposure.

1. Introduction

The propagation of Corrosion under insulation (CUI) has been in the forefront of nuclear industry outage inspections (flow accelerated corrosion, erosion, impingement, etc.) for the last 30 years. It causes vast amounts of money to be spent on water analysis, mitigation, inspection, reporting and tracking. CUI has caused tremendous amounts of plant damage, injuries and has even resulted in fatalities.
Typically, the only way of detecting CUI has been to strip the insulation, prepare the surface utilizing mechanical means, performing ultrasonic thickness examinations and re-insulating the equipment until the next in service inspection. This is done repeatedly to build a model for forecasting the remaining life of the subject.
The process to inspect one heat exchanger, or one elbow utilizing the above process is both time consuming and costly. The time and cost involved in this process increases dramatically when you consider all the susceptible areas in the feed water lines, drainage pipes, heaters etc. This results in difficult decisions being made in regards to which areas to prioritize for inspection during the limited time allotted for each outage.
RTD Incotest allows for screening large areas of equipment/piping in a short time frame during operation of the plant. The ability to screen CUI susceptible areas without removing insulation has been available for over 15 years, although it is still relatively unknown technology. The RTD Incotest, pulsed eddy current system is capable of screening ferrous materials through insulation and fireproofing materials. This provides the capability to screen large areas for CUI and target problem areas for more rigorous testing. This allows the owner to bring down the overall cost of examination and more efficiently utilize resources in examining the trouble areas.

2. Background

The RTD Incotest system was originally developed by Arco Chemical under the name of Transient Electro Magnetic Pulse or TEMP. Although the theory for measuring eddy current strength in materials had been discussed for some time, Arco was the first to develop an application that they were introducing into their Alaskan fields. After taking the development to a state considered sufficient for their purposes, Arco decided to sell their product to a company who could take it into commercial use. A number of companies were given the opportunity to work with the system and after three years, RTD was awarded the license to market their improved product. The name was changed to Incotest, an acronym for Insulated Component Test and was put on the market in June, 1998.
The test itself is simple and straightforward. Once the shroud has a grid in place, the Incotest probe, or coil, is placed on the surface. The probe is energized with a DC current for a brief period and the shell is saturated with a magnetic field through the shroud, insulation or fireproofing. When the DC current is switched off, eddy currents develop in the shell at a constant rate for that materials' permeability and conductive properties. The receiving coils detect the resulting eddy current field and measures the time it takes for it to develop and decay.

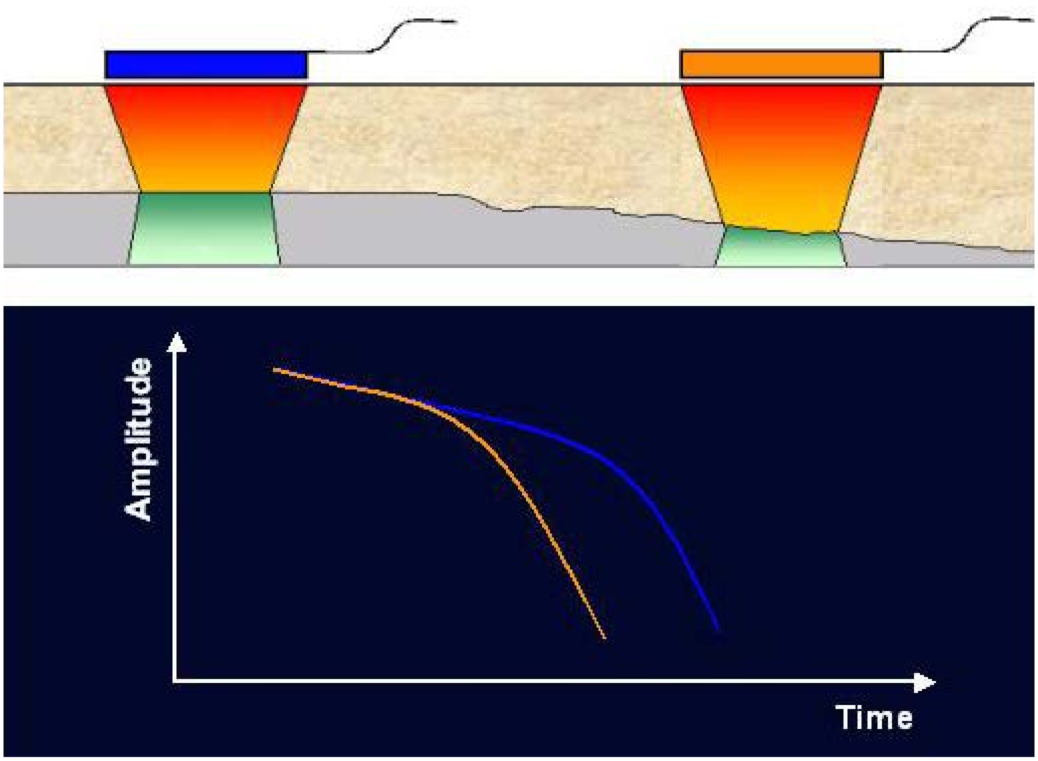

Figure 1 - the upper image shows the crossection of the probe and "footprint" area or coverage area. The bottom image shows the decay curve of the eddy currents induced in the field.

The measured signal is presented in a double logarithmic graph: the horizontal axis represents the time in milliseconds (ms) and the vertical one the measured signal amplitude (μV). Characteristic of this signal is the presence of a bending point that indicates the induced eddy current decay time, see figure 1.

At this time the eddy current reached the opposite object side and rapidly disappears (signal drop after bending point). This time is called TAU and it is a function of the material magnetic permeability (μ), of the material electrical conductivity (σ) and of the square of the object average thickness (d) in the footprint area, and it is given as τ = μσd2 (figure 2).

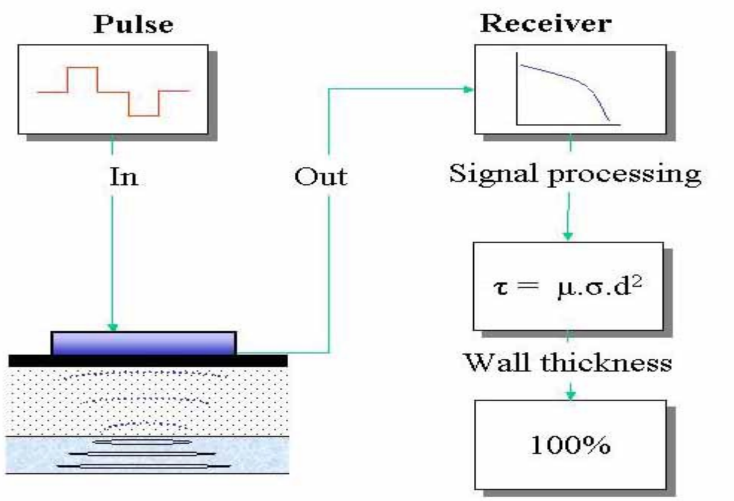

Figure 2 - shows the base process of Incotest, from pulse generation to wall thickness determination.

RTD INCOTEST is a screening tool and a qualitative inspection technique: it gives information about the status of the object in order to isolate the areas of interest on which to perform a deeper survey. RTD INCOTEST needs no reference blocks for the examination set up and calibration. The reference block is the object under examination. Before starting the object examination, a reference measurement is needed. The reference measurement will give per definition an average wall thickness (AWT) of 100% and its signal will be compared with all other measurements. The reference measurement shall be taken on a good object part and/or on the thicker location in an area free of appendances and uniform in thickness. When possible, the reference measurement shall not be adjoining cell measurements with a variance larger than 2% of the reference thickness, the edge of a grid, intrados of an elbow or blank cells where obstructions are present. The reference measurement shall not be taken on sheeting overlap or near obstacles. At the end of the survey, during its evaluation, the reference shall be verified and if a thicker and more uniform area with good signals will be identified, then the reference location will be replaced with the best signal within this area. Measurements evaluation is in real time. Typically, a measurement of a single grid point is done in five seconds and up to 1000 measurements per day can be taken under favorable (field) conditions. Neither direct contact nor special surface cleaning is required to operate RTD INCOTEST. This non-contact characteristic makes it possible to detect corrosion on high temperature surfaces without many probe adaptations. A simple thermal shield protects the probe from extreme temperatures allowing measurements up to +500 ºC. Above this temperature the reduction of the magnetic permeability in the object prohibits the use of RTD INCOTEST. Two characteristics make the RTD INCOTEST suitable to monitor inaccessible piping. There is no need to remove insulation or coating, which reduces cost and increases the inspection speed. The other characteristic is that coupling the signal to the object is not critical. This allows the technique to be used under uncommon circumstances.

Incotest results are given in relative terms until a value can be assigned to the Reference Point. Once the thickness of the Reference point is established, that value can be entered into the program and each reading is then automatically recalculated and absolute values are presented. The thickness readings are an average, volumetric representation of the remaining wall thickness. If a UT thickness reading cannot be obtained, the nominal wall thickness can be used for the Reference. However it should be noted that the actual thickness at that location may be less than the nominal thickness and this can give the plant a false sense of security. The Incotest Operator does have the ability to move the Reference to a point which appears to consistent wall thickness which appears to be free of corrosion or outside influences after the data has been taken. This includes areas near an open edge of the protective shroud thus allowing a UT reading to be taken without cutting a hole in the stainless steel sheeting. This is done with its own caveat that the operator may not know what, if any influences may be adjacent to that particular location.

RTD INCOTEST is designed for generalized corrosion detection and it will not reliably perform with localized corrosion type such as small pits.

RTD INCOTEST results should always be presented in percentages (%) to avoid any association to a local minimum wall thickness value. The local minimum WT value can deviate from the AWT measured value, which represents the material volume in the location under examination.

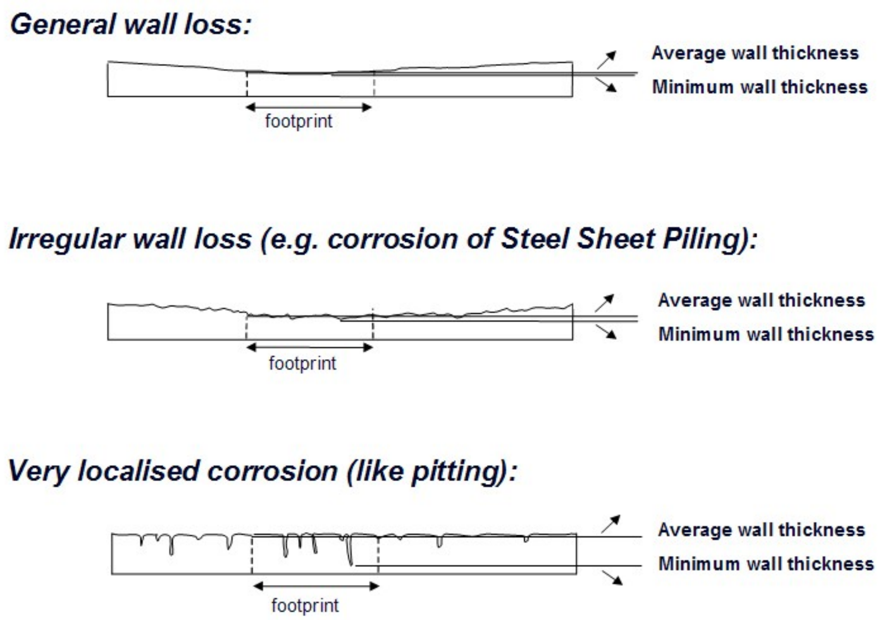

Figure 3 - Incotest Wall Thickness Determination

The area over which the measurement is taken is referred to as 'the footprint'. A defect to be detected must have at least an extension of 1/3 of the footprint area and a volume reduction exceeding 10%.

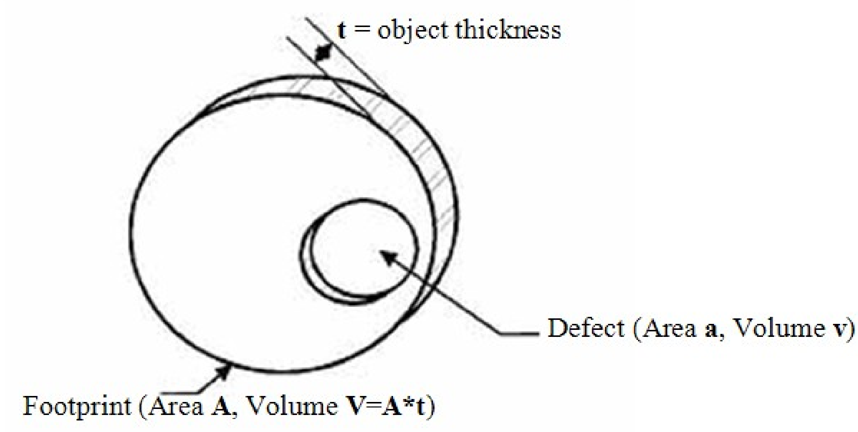

Figure 4 - Defect detection within the footprint

The practical dimension of the magnetic field at the material surface (footprint) is determined by the sensor construction. Combination of more coils within the construction enables magnetic field modelling also called focusing. The focusing effect is used to reduce the footprint size. To imagine what is happening with the magnetic field profile in an infinite flat plate during focusing, a sending coil through which a current is sent is positioned above a plate with much larger dimensions than the footprint of the probe to assure uniformity and to avoid any edge effect. Depending on the current and the coil winding direction, the field line in the center of the coil will be direct inwards (circle with cross) or opposite outwards (circle with dot), see figure 6. Part A shows the field pattern of the main probe sending coil, which has a lot of turns and a small diameter. Part B shows the field pattern of the probe “focusing” coil which has less turns and a large diameter connected in such a way that the generated magnetic field opposes to that one generated by the main coil (A). Part C shows the effect of connecting these coils (A&B) together. This connection (Focused Mode) modulates and focuses the magnetic field to achieve a smaller footprint than by using the main coil (A) only (Not Focused Mode).

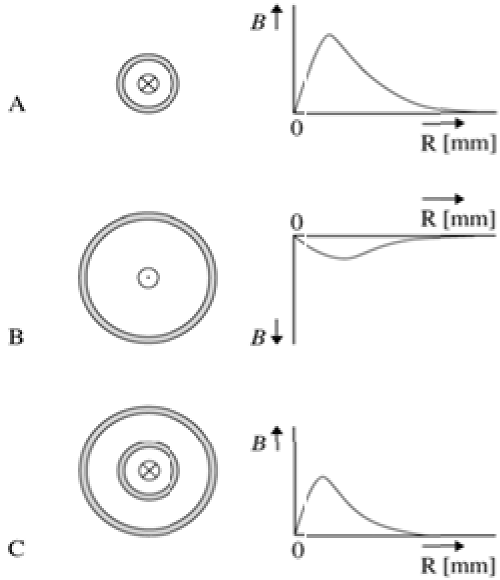

Figure 5 - shows the Focusing principle

The probe Focusing Mode will deliver a weaker signal, therefore in combination with examination on objects with large insulation (lift-off) and/or heavy wall thickness, the focusing sending coil may be disabled to achieve a stronger signal. All probe receiving coils are always focused. The footprint area is function of the selected sensor and of the measuring geometry situation: object wall thickness, insulation thickness and shape. The sensor footprint diameter increases linearly with the Lift-off distance (figure 7).

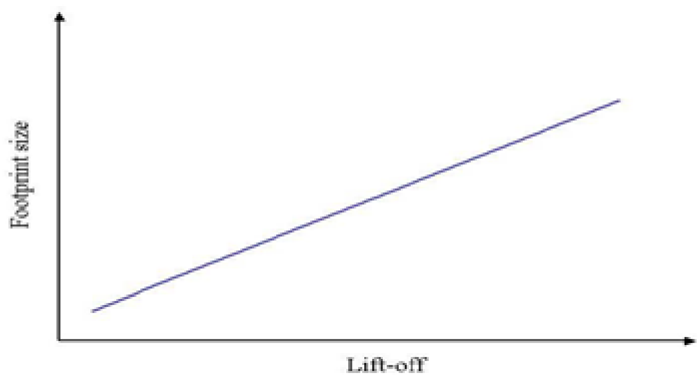

Figure 6 - graph displays the footprint size vs probe liftoff

For absolute thickness readings to be given, an ultrasonic reading must be taken at the reference location for any given component. This value is written into the test file and each reading is then given as an absolute wall thickness relative to the reference reading. Readings are displayed on the computer immediately, giving the Operator the opportunity to validate the reading or “re-shoot” it before moving on to the next point. This immediate validation saves valuable time by alleviating the need to perform downloads in order to view the test results. Other test systems may require numerous downloads at each component in order to validate readings. This can add as much as 40% to the time it takes to perform the same job required by Incotest. Over the course of a week, this can result in a substantial dollar amount.

3. Conclusion

The advantage of the Incotest system is the elimination of the necessity to strip a component, prepare the surface, take UT readings and re-insulate the component. In the instances where asbestos is present, the cost savings are significant. By pre-screening components with Incotest, a plant can make an informed decision on where to target their inspection dollars. Pre-outage screening also allows for planned repairs that are scheduled into the outage rather than having to react to discoveries made during the outage or turnaround.

Incotest has been used successfully to measure insulated piping systems, feed-water heaters, drums, tanks, concrete coated vessels and sphere legs, offshore platform legs, steel sheet piling, fractionating towers and skirts and high fin HRSG tubes. High energy piping systems can be tested on-line in a pre-outage inspection for planning purposes. Marine vessels can be inspected at depth with divers or ROV access. Fiberglass coated tanks and pipelines that are coated and wrapped can be tested without disturbing the integrity of the coating or wrap. Incotest can take from a few hundred readings a day to more than a thousand readings depending on the test subject and configuration.

Variables in pipe diameter, wall thickness, surrounding environment such as operating generators, pump motors, welding machines, proximity to electric appurtenances etc. can influence the outcome of the test. The ability to test each component would be assessed on a case by case basis.

4. References

[1] Riccardo Scottini, “RTD Incotest Application Guideline”, Applus RTD Technical Document, September 23 1995