Condition assessment of Ammonia pipe lines – Case study

D.UMAPATHI
DY. MANAGER (MECH), INSPECTION SECTION
Indian Farmers Fertiliser Cooperative Limited (IFFCO),
Paradeep Unit. – 754142.
Odisha, India.
Mob: +91 9937999969
dumapathi@iffco.in

ABSTRACT

Condition assessment of Ammonia pipe lines in process plants is very essential to avoid unexpected breakdowns, interruption of production as well as avoid the severe effects on human and environment. In our plant ammonia pipe lines are existed in different sizes and different lengths in entire complex and port jetty. Thickness measurement, Corrosion under insulation (CUI), weld joints condition are carried out by different non-destructive methods.

The most effective and direct method is to remove the insulation and check the surface condition of the pipe But this is associated with huge cost and time to perform the inspection. Due to this, we choose advanced technology like Pulsed Eddy Current Testing (PECT) for checking the pipe lines. In this method there is no requirement of removing the insulation material for thickness measurement and corrosion mapping. For checking the weld joint, we choose the profile radiography.

Keywords: Corrosion under insulation (CUI), Pulsed eddy current testing (PECT), profile radiography.

INTRODUCTION

The facilities in IFFCO Paradeep plant include 20” Ammonia Import Line and 4” Ammonia Pre-cooling line, both being 7 kms in length along with cross country conveyor lying above 15 meters from ground level which runs above river-canal and port jetty area to Ammonia storage tanks with the following characteristics:

- 20” SCH 20 Ammonia Imported line from port jetty to storage tank and thickness is 9.53mm and Insulation thickness for 20 inch Ammonia Imported line was 140mm.

- 4” SCH 40 Ammonia pre cooling line from port jetty to storage tank and thickness is 6.02 mm and Insulation thickness for 4” Ammonia pre-cooling line is 80mm.
There are number of conventional techniques available for condition monitoring, most common being visual inspection, thickness survey, Dye Penetrant testing of weld joints, ultrasonic flaw detection for weld joint and radiography of joints etc. after removing the insulation but these techniques are associated with huge cost, a lot of time to perform the testing and engagement of more manpower as well as establish the scaffolding arrangement. Therefore we searched for advanced techniques like Pulsed Eddy Current Technique, Profile radiography etc. in which the tests are performed without the removal of insulation and also choose articulated boom lifter for approaching the pipe lines.

**INSPECTION TECHNIQUES:**

There are number of techniques available for the inspection and assessment of condition of pipelines the most basic being visual testing after removal of insulation, ultrasonic thickness measurement, guided waves testing, pulsed eddy current testing, thermography, radiography, profile radiography etc. which are discussed in detail below:

- **Insulation Removal:** The most effective and direct method is to remove the insulation and check the surface condition of the pipe. But this is associated with huge cost and time to perform the inspection. Moreover periodic inspection is impossible with this technique.

- **Visual Testing:** Visual inspection is the most basic inspection method used before performing any test. The basic principle used in visual testing is to illuminate the test specimen with light usually in the visible region. The specimen is then examined with the naked eyes or by magnifying glass, bore scope etc.
**Pulsed eddy current principle:**

Pulsed eddy current (PEC) is an inspection technique for inspecting carbon steel objects, such as pipes and vessels, without the need for contact with steel surface. PEC can measure percentage variations in steel thickness through any non-conductive and non-magnetic material between sensor and steel surface such as air, insulation material, concrete, plastics, coatings, paint, sea water, marine growth deposits, oil etc. A PEC measurement has two phases as illustrated in Figures 1 and 2. In the first phase electrical current flows through the transmitter coils of PEC probe. This current generates a magnetic field around the probe, known as ‘primary field’. The primary field is unaffected by the presence of any non-conducting and non-magnetic material and penetrates undisturbed through to the steel below. In this way, the carbon steel directly beneath the transmitter coils is magnetized. Since the carbon steel is ferromagnetic (i.e. it has a high relative magnetic permeability), only the top layer of the steel is magnetized, as shown schematically in Figure 1.

In the second phase of measurement the current in the transmitter coil is switched off, collapsing the primary magnetic field. The changing magnetic field induces electrical ‘eddy’ currents in the surface of the steel. These eddy currents generate a secondary magnetic field, Figure 2, which reaches the receiver coils of the PEC probe. The secondary magnetic field induces an electrical voltage in the receiver coils. The magnitude of this voltage as a function of the time is referred to as the ‘PEC signal’.

The PEC signal contains information about the thickness of the steel, as described below: A specimen has a near and a far surface. Initially the eddy currents are confined to the near surface (closest to the PEC probe) but, as time elapses, they travel (or ‘diffuse’) outwards towards the far surface (Figure 3). As long as the eddy currents experience free expansion in the wall, their strength decreases relatively slowly. However, upon reaching the far surface, their strength decreases rapidly. The moment in time where the eddy currents first reach the far surface is indicated by a sharp decrease in PEC signal, known as ‘transition point’ (see Figure 3). The time of the transition point is therefore a measure of wall thickness. For example, the earlier the transition point, the sooner the eddy currents reach the far surface and the thinner the wall must be. Alternatively, if the transition point occurs later in time, the eddy currents take longer to reach the far surface, so the wall has a larger thickness.

In practice, each time a PEC measurement is requested, to voltage across the receiver coils of the PEC probe is amplified, sampled and digitized by the PEC instrument. This gives a digital record of the PEC signal over 3000 sample moments in time. The digitized signals are stored in a computer connected to the PEC instrument. Dedicated software is used to analyze the shape of all PEC signals and thereby determine wall thickness.
• **Thermography:** Using the basic thermography principles it is possible to detect the areas of scale build-up, decreasing pipe wall thickness and weld discrepancies. In the right conditions, infrared can be used to detect damp spots in the insulation, because there is usually a detectable temperature difference between the dry insulation and the wet insulation. Corrosion is a distinct possibility in the areas beneath the wet insulation.

• **Profile Radiography:** Profile radiography is a powerful, effective and simple technique for inspection of piping vulnerable to internal and external corrosion. Tangential radiography allows the pipe to be X-Rayed or radiographed without the removal of the lagging and also covers a larger area than the footprint area, of the ultrasonic transducer. The Radiographic source could be an X-Ray machine or a radioactive isotope. The greatest contrast and sensitivity will be obtained with X-Rays then Gamma-rays, such as produced by Selenium-75 and Iridium-192. The different types of radiation source result in decreasing definition due to the type of radiation although the penetration power increases with the above source. The whole concept of tangential radiography is to penetrate the sidewall of the pipe so that the thickness is projected on to the imaging material.

![Diagram of radiography](image)

**TECHNIQUES USED IN IFFCO PARADEEP PLANT:**

The thickness survey was carried out on 20” Ammonia Imported Line & 4” Ammonia Pre-Cooling line for information on remaining wall thickness of both the Pipelines.

Following techniques were carried out :-

- **Pulsed Eddy Current Testing :-** PEC can measure percentage variations in steel thickness through any non conductive, non magnetic material between sensor and steel surface such as air, insulation material, concrete, plastic, coatings, paint, marine growth deposit etc. PEC technique provides average remaining wall thickness within the footprint area & extent of the corrosion/erosion.

- **Thermography :** Thermography was carried out for any damp spots because there is usually a detectable temperature difference between dry insulation and wet insulation. Using this we may find out any discrepancy if exist.

- **Profile Radiography :**
RESULTS / DISCUSSION:

The results obtained after PEC were represented in a colored scale as shown on right side. A Total of 155 accessible locations were inspected for both the lines.

- Minimum reading observed for 4” Pre-cooling line was 5.1 mm against the design thickness of 6.02 mm.
- Minimum reading observed for 20” Ammonia Import line was 8.1 mm against the design thickness of 9.54 mm.

**General Inspection Pattern:**

![Diagram showing inspection patterns for 20” and 4” pipe lines.]

- Color scale representing the wall thickness in mm for both 20” and 4” pipe lines.

![Colour Scale for 4” Ammonia Pre-cooling Line and Colour Scale for 20” Ammonia Import Line]
Profile Radiography:

Profile radiography on 20” pipe line as well as 4” pre-cooling line was also carried out.

For this technique, we have to open the insulation at one place completely where weld joint was located. From this point every 6 mtrs, we can found weld joint exactly as per the fabricated drawing. For this technique exposure time calculated with consideration of insulation thickness and aluminium cladding thickness.

Findings: By using this technique we can find out the loss of material at welded joints as well as other defects which we can see through traditional method.
CONCLUSION:

As far as techniques are concerned there are number of techniques from very basic to advance for assessment of pipelines under insulation. We need to decide the appropriate technique to be used based on several factors like reliability of results, accessibility of pipelines, time consumption, economy involved, manpower needed etc. along with the advantages and shortcomings of the techniques. Advanced techniques like Guided Wave, PECT and profile radiography are boon for the industry as they offer reliable results in less time. Complete removal of insulation may also be required in certain areas but this should be done after all other methods have been exhausted.

REFERENCES:

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