

NON-DESTRUCTIVE INSPECTION OF ABOVEGROUND PRODUCT PIPELINES OF SOME MANUFACTURING INDUSTRIES IN PNG

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ABSTRACT

Service induced Non-Destructive Inspections are frequently requested from many clients in the ever-increasing industries of Papua New Guinea (PNG). In the immediate past, all of these inspections were conducted by NDT companies from overseas until recently, the PNG University of Technology set up Papua New Guinea's own Non-destructive Evaluation Centre to cater for the growing needs of NDT services in our country. This paper examines and discusses the various issues associated and arising from the NDT techniques that have been employed for the inspection of stainless steel, mild steel and titanium pipelines with varying lengths from 0.05 – 1.474 km in industries such as gold mines, fuel supply companies, breweries and etc. Inspection conducted on various pipelines with different industries utilizing the skills and knowledge of non-destructive testing techniques revealed that sudden and major failures would be detected prior to catastrophic failure occurring, if a Systematic Maintenance NDT Inspection Program is maintained consistently established.

Keywords: Non-Destructive Inspections Programs, NDT Data Baseline, Systematic Maintenance

1. INTRODUCTION

Non-destructive testing (NDT) has come into stable practice in assessing product quality and predicting of the cause and time of failures associated with the components of producing equipment [1]. Safe operations of product pipelines are essential for the profitable state of the firm and hence, forth adding value to shareholder's assets. Otherwise, it would adversely affect lives, the environment and therefore, would diminish the reputation of the company or an organization.

This paper discusses the NDT methods that were being employed during the course of NDT inspections conducted in PNG. It also elaborates further the significance with constrains that lay ahead for each NDT technique to a testing condition. It appears that none of them seem superior to another due to all having limitations. However, client requirement and the test piece acceptance practicing standards determines the techniques suitable for only that particular application and testing conditions.

Out of all the NDT techniques, Visual Test (VT) dominates the practice and thus, many acknowledge as being the first method available to NDT inspectors. It's affordable and limited only to test piece surface with sufficient lighting presence. VT has been used only to detect surface discontinuities (defects) on the pipelines and mechanical components tested. Visual testing capacity is further enhanced by utilizing, Liquid Dye

Penetrant (PT) for the determination of surface defects. With experience, PT provides more data on the approximate width and depth of the defect by examining the amount and the intensity of dye around and on the defect [2]. With this method, we were able to detect surface associated defects on the welds and along the numerous pipelines inspected.

On many testing instances, the pipelines were subjected to paint coatings and therefore, limiting the capabilities of VT & PT. When such situation arose, Magnetic Particle Inspection (MPI) or Ultrasonic Testing technique (UT) was utilized depending very much on the requirement of the clients. MPI was purposely used during inspections to further verify VT & PT results and also to examine any subsurface defects.

Again on many occasions, the clients specifically requested for thickness survey of the pipelines utilizing UT. This was to determine the pipe wall thinning marginally due to both internal and external corrosion and erosion. The data obtained from the test was vital for establishing the safe operations of the pipelines and the other test components. However, in other times they also request for both thickness survey and weld examination with ultrasonic testing technique.

2. INSPECTION TECHNIQUES

2.1 Visual Inspection

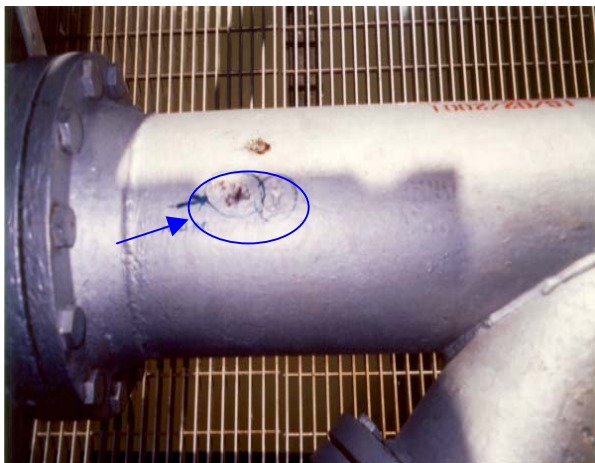


Figure1 - Arrow pointing to dent at wharf manifold.

Visual inspections are the first and for most form of all the NDT techniques. Just as with the other methods, it is limited only to the inspector's visibility range. Beyond this, the other NDT techniques would be employed to determine the integrity of the test piece.



Figure 2 - Pitting on the surface of the 10 inches diameter pipeline.

It has been found from the inspections that, paint coatings, insufficient lighting and inaccessible to the outside surface of the pipeline limited the inspectors capability of this technique.

However, on the contrary some of the anomalies that were detected in the course of visual inspection along the petroleum base product pipelines are listed below and are shown on Figures 1 and 2:

- Blister
- Dent
- Pitting
- Pinholes
- Scratch

2.2 Ultrasonic Thickness Survey

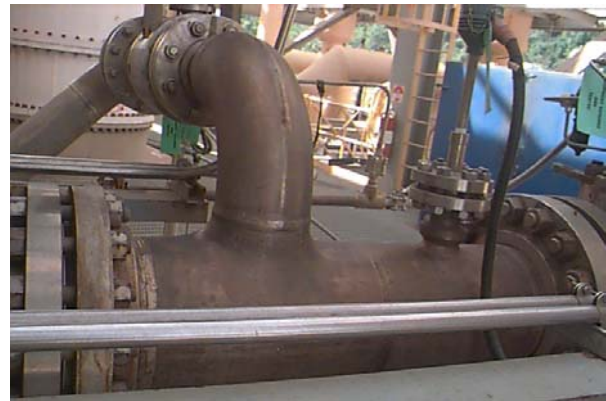


Figure 3 – Photograph illustration Auto-Clave slurry discharge T-joint titanium pipeline.

Ultrasonic testing has been widely utilized to monitor thin wall lining of pipelines and other plant components. Ultrasonic Thickness Gage (Dakota Ultrasonic MX – 3) single spot multiple measurement method was employed to determine the thickness measurements of the pipeline [3]. The gage had an accuracy of 0.01mm, less tedious and portable. These are the attributes that a NDT technician would greatly embrace since it makes the inspection more comfortable and therefore less fatigue [4]. Thickness survey was employed at a processing plant of a gold mine as shown in Figures 3 and 4 to determine the thickness at the slurry discharge pipe T-joint and elbow.

Of the many UT thickness survey conducted for the industries in PNG, these observations were made after analyzing series of thickness measurement results. Obviously, this has been greatly attributed to erosion rather than corrosion from both externally and / or internally. The results revealed the following trends:

- For all the liquid base fluids, the pipes were much thinner at the bottom than the top.

All liquid base fluids were pumped at high pressure from one point to another over several hundreds and even thousand meters. As the fluids make their journey along the lengthy pipelines, gravity acts on the fluid and particularly it's effect at every contact point of the fluid and the inside pipe wall. The effect of gravity is higher at the bottom of the pipeline and is least on the top of pipeline since is directly proportional to the mass of the fluid. And as such, the effect of erosion was much higher at the bottom inside wall of the pipeline than the top, resulting to the above observation.

- At the pipeline elbows, the pipes were much thicker at the inside than outside diameter.

All fluids were pumped at high pressure along lengthy pipelines. When it turned at pipeline elbows, much of the fluid momentum is

greatest at the outside radius of the elbow than the inside radius of the pipeline due to the fluid velocity always been directed out [5]. As such, the fluid began to wear away the outside pipe wall surface resulting the trend observed above.

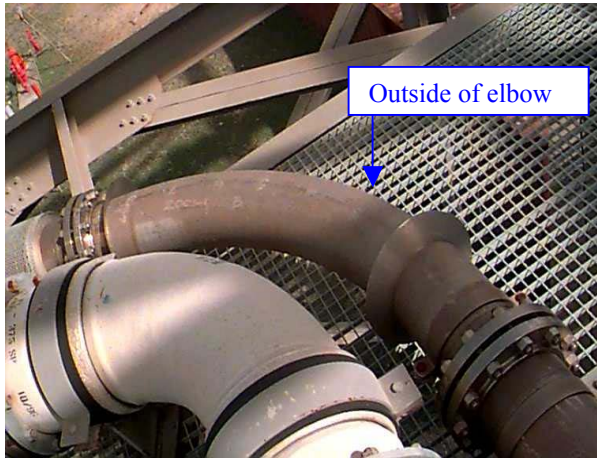


Figure 4 – Photograph of Auto-Clave slurry discharge titanium pipeline elbow.

2.3 Magnetic Particle Testing

Magnetic Particle Inspection (MPI) was applied on mild steel hot water supply/return lines to determine any form of subsurface and surface defects at the single butt welds along the pipeline and also on a highway truck trailer turntable circumferential fillet weld. MPI is a fast and relatively easy to apply and part surface preparation is not as critical as it is for some other NDT methods [6]. The mild steel pipeline was painted prior to the inspection. Thus made MPI ideal NDT technique over PT and UT for this test component.

Magnetic particle yoke (AC/DC) was applied on the welds at the flanges and joints to determine any abnormalities such as toe crack, undercut, surface porosity and cold lap. White contrast paint and prepared iron oxide bath were used to improve the defect detecting efficiency.



Figure 5 – Photograph white contrast paint being applied on fillet weld of the truck turntable.

In the course of inspection, the yoke revealed magnetic particle indication along some of the welded joints of the pipelines and other mechanical components like the truck turntable in Figure 5. It showed surface porosity and cold laps. Immediate actions were taken by the fabrication company upon notification to correct them.

2.4 Liquid Dye Penetrant



Figure 6- Photograph of Developer being applied on 2” stainless steel single butt weld

Since cracks expose to the surface are detrimental to the health of the component, dye penetrant techniques was employed to detect it. The test object or material is coated with a visible or fluorescent dye solution. The excess dye is removed from the surface, and then a developer is applied. The developer acts like a blotter and draws penetrant out of imperfections that open to the surface. With visible dyes, the vivid color contrast between the penetrant and the developer makes the "bleedout" easy to see. With fluorescent dyes, an ultraviolet lamp is used to make the "bleedout" fluoresce brightly, thus allowing the imperfections to be seen readily [2]. Toe cracks, surface porosity, cold lap and incomplete weld fill can be detected by this method.

During inspections, cold laps and surface porosities were encountered on numerous occasions on welds as shown in Figure 6.

3. DATA BASE LINE

Systematic approach to non-destructive inspections is vital in the detection of minor abnormal changes on the grain structure of the test component. Documented inspection programs are required to monitor the changes and therefore, remedial actions would immediately be ordered for prevention or minimizing the magnitude of catastrophic failures in the event a discontinuity (defect) had been identified on the test component [7]. Data collected from the various NDT techniques are recorded and thus becomes as the benchmark for successive inspections.

Experiences with industries show that many of the component failures were attributed to lack of monitoring by the respective personnel of the firms. This would lead one to believe that the person

deliberately acted out of ignorance or was it a lack of insight of the maintenance management team into the cause issue. However, further investigations revealed that it was directly due to the companies not having a documented NDT Data Base Line, and thus was evident even with well establish international companies.

The establishment of the NDT Data Base Line by the companies who require this service continuously will reap a lot of benefits either directly or indirectly in a long way. This would greatly enhance the capability of the personnel in monitoring the integrity and present conditions of the test components. The information gathered from the Data Base will be required and utilized by the management to assist in their planning and making decisions for the wholesale good of the firm [8].

4. DISCUSSION

The NDT techniques employed varied marginally due to the method capabilities and the test piece condition. Such as the environment, whether directly exposed to sunlight, rain and in many occasions, the test surfaces were coated with epoxy paint. In many instances, the paint coatings were removed from the test component and the test surface scan with the UT. And in other times, paint strippers were used to remove the coatings.

In all pipeline thickness surveys conducted so far, corrosion and erosion happens to be the main cause of it. Moreover, the cost of it is rising rapidly in two forms; the need to protect the pipelines and the replacement of severely corroded and eroded pipelines.

Rusting requires the presence of both oxygen and water [8]. Fuel pipelines running from the wharf manifold to vertical storage tanks are usually cleaned/flushed with salt water from the sea upon completion of pumping petroleum base fuel from the fuel tanker berth at the wharf. Since oxygen is present in the pipeline, then the water pumped through the pipe acts as catalyst for internal corrosion. Continuous pumping of the fuel wears away the internal pipe surface due to erosion.

There are other means of reducing the corrosion rate on the outside surface of the pipelines. It was observed that protective layer of epoxy painting on the surface of pipeline was obvious on numerous lines. Not the least, one other option that the firms are yet to employ is the application of sacrificial metal such as zinc or manganese alloy along the pipelines whether underground or aboveground [9].

Of the many NDT inspections conducted by Unitech NDE Centre in Papua New Guinea since it's inception. It has been observed that industries in PNG tend to utilize NDT services only for the following purposes:

- Inspection on installation (before commissioning)
- Service inspection (after a period of time)
- Inspection on repair of component
- Inspection when component failed (determine extent of failure, eg: crack depth etc.)

5. CONCLUSION

In the course of the inspections, it appears that the major cause of pipe wall thinning is due to both erosion and corrosion in many of the industries product pipelines in PNG. The outside pipe wall is subjected to corrosion obviously due to high salt and sulfur content in the atmosphere on some location. Whilst the inside pipe wall suffers marginally to both erosion and corrosion simultaneously.

The failures associated with these causes can be detected at an earlier stage and preventive measures would be taken with the data provided from NDT Data Base Line

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