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Failure analysis on domestic pipeline

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ABSTRACT – Today, structural health monitoring is a major concern in the engineering community. Multisite fatigue damage, hidden cracks and corrosion in hard-to-reach locations are among the major flaws encountered in today's extensive diagnosis. In this research, the understanding of non-destructive testing (NDT), thermographic analysis was applied to locate defect as complementary analysis towards the failure analysis of a defect pipe through SEM technique an analysis on specimen morphology and topography.

1. INTRODUCTION

Providing an adequate water supply is a major challenge facing many public water utilities in developing countries, such as Malaysia. A significant part of these challenges is non-revenue water (NRW), which is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. It is estimated that water utilities in developing countries can lose 40-50% of the water they put into their systems and they are unable to bill their customers for this loss. NRW can occur through physical losses from leaking and broken pipes, which failure analysis come in play, to minimize the leakage of domestic water pipeline, by investigating the failure causes through proper analysis and Non-Destructive Technique (NDT) technique [1].

The most powerful technique commonly used for fractographic investigation is the SEM technique. This technique utilizes electron as a source to create high resolution images [2]. Fracture morphology such as fracture sequence, which is at crack initiation, crack propagation, and fast fracture. Revealing marks enable differentiating the different areas and, therefore identify the condition leads to the fracture, such areas are, the fibrous zone, radial zone, and shear lip zone. The fracture also can be future characterize into ductile and brittle fracture [3].

Infrared thermography technique uses an infrared imaging and measurement camera to see and measure invisible infrared energy being emitted from an object. Unlike visible light, in the infrared spectrum, everything with a temperature above absolute zero emits infrared electromagnetic energy. Even cold objects such as ice cubes, emit infrared radiation. The higher the temperature of the object, the greater the infrared radiation emitted. In the industrial/commercial environment, almost everything gets hotter or cooler before it fails, making infrared cameras extremely valuable diagnostic tools with many diverse applications [4].

2. METHODOLOGY

Failure analysis on the domestic pipe line conducted in series of step, to verify the specific fault of the pipe. Two pipe was tested, a good, non defect pipe and bad pipe, the defect pipe. The purpose of conducting analysis on both good and pipe is to create a baseline for comparisons between two results. Both active and passive thermographic analysis approaches are conducted on both pipes, as complementary analysis. Both pipe will be analyzed and compare through string of analysis, visual examination as a preliminary examination and fractography analysis through Scanning Electron Microscope (SEM).

2.1 Scanning Electron Microscopy (SEM)

A scanning electron microscope (SEM) is an electron microscope that produces images samples by scanning it with a focused beam of electrons. The electron beam released from the electron gun travels pass through the electromagnetic field and electromagnetic lenses where it is focused prior to hitting on the specimen surface. Then the X-ray, back scattered electrons, secondary electron and auger electrons are produced. These signals are subsequently collected to produce images and information important for the interpretation of failure analysis. The electrons interact with atoms in the sample, producing various signals that can be detected that contain information about sample's topography and morphology in high resolution ranging from 1000x, 3000x, 6000x, and 12000x pixel resolutions.. The intrados and extrados of the specimen, the pipe, will be scanned.

2.2 Thermographic analysis

All objects, cold or hot, radiate heat in the form of infrared energy. As an object increases in temperature, it radiates more energy, and the wavelength gets shorter. Human eye can only see a narrow range of wavelength in the electromagnetic spectrum. Most of what the eye sees is reflections from objects that high energy from the sun or an incandescent light bulb is striking. However, the infrared camera can detect infrared energy well before we can see it with our eyes. The camera converts this invisible infrared energy into a two-dimensional visual image. The amount of energy radiated from an object is dependent on its temperature and its emissivity. The emissivity of an object is the ratio of the energy radiated to that which the object would emit if it were a Black Body. Specimens are conducted through active and passive thermographic analysis, to observe the spot of defect and comparing the result.

3. RESULTS AND DISCUSSION

Thermographic analysis of the pipes shows the location of defect on bad pipe more clearly. The high temperatures reading on the pipe indicate the crack location.

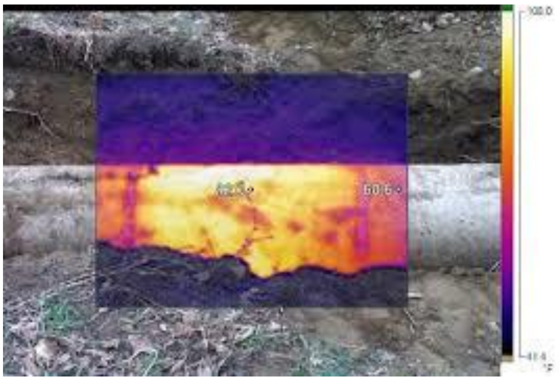

Figure 1 Defect location using thermographic analysis.

Initial observations of fracture failures in bad pipe suggest that in the majority of cases, voids or foreign inclusions in the pipe wall provide localized stress risers which lead to crack initiation under remote stress. However the initial assessment of the fracture surface, inspection, visible light microscopy unable to identify the stress riser at the source of the fracture. More detailed inspection was undertaken using Scanning Electron Microscope (SEM) to provide a higher magnification image and qualitative chemical analysis of any inclusions found. Figure 1 (a) and (b) shows higher magnification of the fracture initiation region.

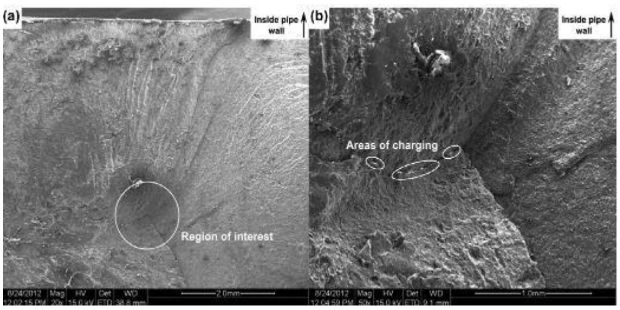

Figure 2 SEM image of cracks (high magnification).

Following exposure of the initiating defect behind the primary fracture surface SEM was again undertaken following the same procedure as used previously. As shown in Figure 2, the defect responsible for crack initiation in this case was a void in the pipe wall, approximately 0.45 mm wide. Three cracks can be seen to radiate out from the void. While this void has been identified as the stress riser that led to crack initiation and eventual failure of the pipe, it is unclear what caused the defect originally. For example, it is possible that the observed void was attributed to a particle or agglomeration of particles that were removed during fracture and subsequent failure. Alternatively, the void may also have been the result of air that was trapped within the pipe during extrusion or uneven shrinkage due to temperature gradients during cooling following pipe extrusion.

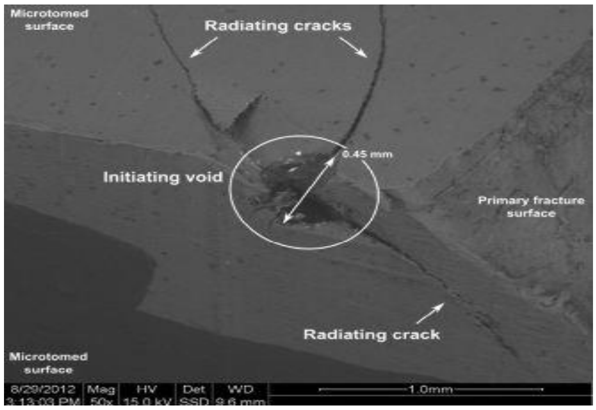

Figure 3 Primary fracture surface.

4. CONCLUSION

The thermographic analysis of pipe shows the presence of initial crack which then led to the failure analysis of the pipe. Based on the outcome of SEM, it was reasoned that no materials degradation has occurred in contact with domestic sewage. Rather, fracture failure has occurred from an inherent defect in the pipe wall. This study indicates that failure can occur by fracture from inclusions that were built-in during original manufacture.

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