The Northern California Pipe User's Group
22nd Annual Sharing Technologies Seminar

www.norcalpug.com

Berkeley, CA
February 20, 2014

HANDS ON EXPERIENCE WITH THE BROADBAND ELECTROMAGNETIC TOOL IN THE TRENCH

Noy Phannavong[1]

[1] V&A Consulting Engineers, Inc. 155 Grand Avenue, Suite 700, Oakland, CA 94612, PH (510) 903-6600; FAX (510) 903-6601, email: noyp@vaengineering.com

ABSTRACT: Broadband Electromagnetic (BEM) testing is being used as part of corrosion control/condition assessment practices on pipelines and force mains. The tool provides a means of measuring wall thickness of piping. Determining the level of internal and external corrosion are critical to evaluating assets remaining useful life. The pros and cons of using BEM in the field will be discussed. The pipe materials include welded steel, ductile iron and cast iron pipe. Case studies and lessons learned will be explained. In the trench testing techniques and limitations will be highlighted. The practice of using BEM testing in conjunction with or in lieu of ultrasonic testing will be evaluated.

INTRODUCTION

Asset management programs help utility owners decide where budgets should be spent to extend the useful life of their assets. Condition assessment of assets provides valuable information that is used to prioritize repairs and rehabilitation. One measure of a pipeline's condition is its remaining wall thickness. There are many technologies available to perform condition assessment of pipelines. Two of the main technologies used are acoustics such as ultrasonic testing (UT) and electromagnetics.

Ultrasonic testing provides a measured wall thickness where the transducer is placed. A-scan UT is a point-specific test in which the thickness is determined directly where the transducer is placed. B-scan UT with multiple transducers allows scanning over an area as the transducers are slid across the pipe surface. The data output provides the measured wall thickness with data based on the separation of the transducers. The pipe surface must be smooth enough for UT to allow the transducers to send the signal and receive the response without distortion.

BEM testing is a non-destructive frequency-independent application of electromagnetic or eddy current systems that produces an apparent wall thickness profile of a pipe. The BEM scan is not affected by background electromagnetic interference, and the test frequencies can be adjusted to the specific pipe material and site conditions. This technology allows for the assessment of ferrous metal and asbestos cement pipe thickness. For ferrous pipe, metallurgic changes in the pipe composition, as formed by corrosion processes such as graphitization, can be identified. The BEM assessment can be done externally or internally to the pipe and does not require intimate contact with the metal surfaces. Rock Solid Group (RSG) of Victoria Australia developed the technology and software, and manufactures the equipment.

The advantages of BEM include:

1. Does not require physical contact with the surface to be tested.
    a. Removal of coatings, mortar, or insulation from pipe surfaces up to 2 inches is not required.
    b. This is very advantageous for heavily corroded cast iron pipe (CIP) and ductile iron pipe (DIP) as surface conditions can hinder or prevent UT.
2. A contour plot 360 degrees around the pipe of the apparent wall thickness is provided.
3. Provides coverage over the entire area scanned, rather than at discrete points or along narrow bands.
4. Can be used on materials such as cast iron that may make UT difficult, with the same ease as on other materials.

BEM EQUIPMENT

The BEM scanning system consists of 1) Antennae to transmit the electromagnetic signal, 2) Electronic console for data conversion, 3) Power supply, 4) Laptop computer with MetCon (by RSG) software and 5) data cables to interconnect the components. The system can be powered by batteries, a cigarette lighter adapter or AC. Six antennae of different lengths in 1-inch and 2-inch grid patterns are available for testing. The 1-inch antenna is used on 12-inch diameter and smaller pipe.

The data cable comes in up to 1,000 feet on a reel. The reel can be cumbersome and difficult to transport on an airplane. A cable approximately 30 feet long has been found to be effective. The cable is long enough to extend from the trench to the laptop topside.

The BEM scan is performed using a handheld antenna tool held to the surface of the pipe. The antenna is connected to an electronic console (See Photo 1). The antenna is moved 360 degrees around the circumference of the pipe to create a scanning ring. Three consecutive scanning rings are required. The handheld antenna is moved around the pipe taking successive readings, which are stored on a computer (See Photo 2). The data is post-processed by Rock Solid Group to provide a contour map of apparent wall thicknesses from the surveyed sections. These contour plots provide an indication of internal and external corrosion. With the BEM information correlated to the nominal pipe wall thickness, a rate of corrosion can be established.

Photo 1. BEM Antennae and Electronic Console

Photo 2. Laptop Connected to BEM Antennae

SITE PREPARATION AND BEM SCANNING PROCESS

The standard procedure is to perform three 360 degree scans on the piping. The recommended length of exposed piping for testing varies from 18 inches to three feet depending on the antennae used. This provides a reasonable surface area to be analyzed. BEM testing configurations need to be adjusted when piping has appurtenances that interfere with placement of the antennae. Test areas should be placed at least 6 inches from joints or appurtenances to prevent signal attenuation to thicker pipe cross sections or metallic material near these locations. Testing has been performed on just the crown of the pipe when excavation around the pipe is not possible.

For testing around the circumference of a pipeline in a trench, sufficient clearance should be provided around the sides and bottom of the pipeline for a person to position the antenna for BEM scanning. Typically, 2 feet around the sides and 1 foot at the bottom of the pipe is sufficient room for a person to position the antenna around the full circumference of the pipe.

Cleaning off the pipe surface prior to testing is beneficial in reducing any antennae offset. Cleaning also can provide a better surface for placement of the UT transducer.

Impressed current cathodic protection (CP) systems can affect BEM results because CP induces a current into the pipe wall. BEM can detect the CP current. The CP system should be deenergized several hours prior to BEM testing.

An onsite scanning grid is created on the pipe so the antennae can be systematically moved around the circumference of the pipe. This can be accomplished by wrapping grid paper around the pipe or marking a grid with tape or chalk. As the antenna is moved around the pipe, each location must be recorded by the BEM software on a laptop. Two people should be used for the testing. One person moves the antennae around the pipe and the other records the data on the laptop.

It is important to keep the antennae the same distance off the pipe surface while scanning. The data will be skewed if one end of the antenna is offset more than ½ inch from the other. The offset distance should be recorded on the NDT Field Notes form. If surface irregularities such as welds, joints or appurtenances are found, they must be accounted for. In addition, areas of extensive scaling or pitting should be noted within the test grid for comparison to the BEM results.

An NDT Field Notes form is completed to describe the pipe conditions and provide background. This information is used for post processing. Some of the required information is:

- Sketches of the overall site and BEM survey area
- Photos
- Record information on pipe material, installation date and dimensions
- Ultrasonic thickness measurements, if available
- Condition of pipe surface to include number and depths of pits

The MetCon software is configured on the laptop prior to testing. A critical step in the setup is the selection of a database based on the material. The database supplies the correlation between the electromagnetic signal strength and wall thickness. This is especially true for cast and ductile iron pipe. The material matrix can vary and will affect the signal intensity. Ultrasonic testing (UT) is performed in conjunction with BEM testing whenever possible to provide a reference point. Without UT data, the apparent wall thickness is based solely on selection of the correct database. The system is calibrated with a calibration plate that is attached to the equipment case.

BEM SCAN RESULTS

BEM data analysis provides an average apparent wall thickness over a 1-inch or 2-inch grid (depending on the antennae used). A grouping of pits will appear as general wall thinning over the grid area.

A BEM survey was performed on a 42-inch DIP that had been excavated in three locations. The post processing plot from one excavation was provided by Rock Solid Group and is shown in Figure 2. It can be seen that there are areas (cyan color) that have lower wall thickness than the surrounding areas. This was confirmed with visual observation and UT data. The area with indefinable data is where the trench jacks were too close to the pipe, which caused loss of electromagnetic signal to the metallic object.

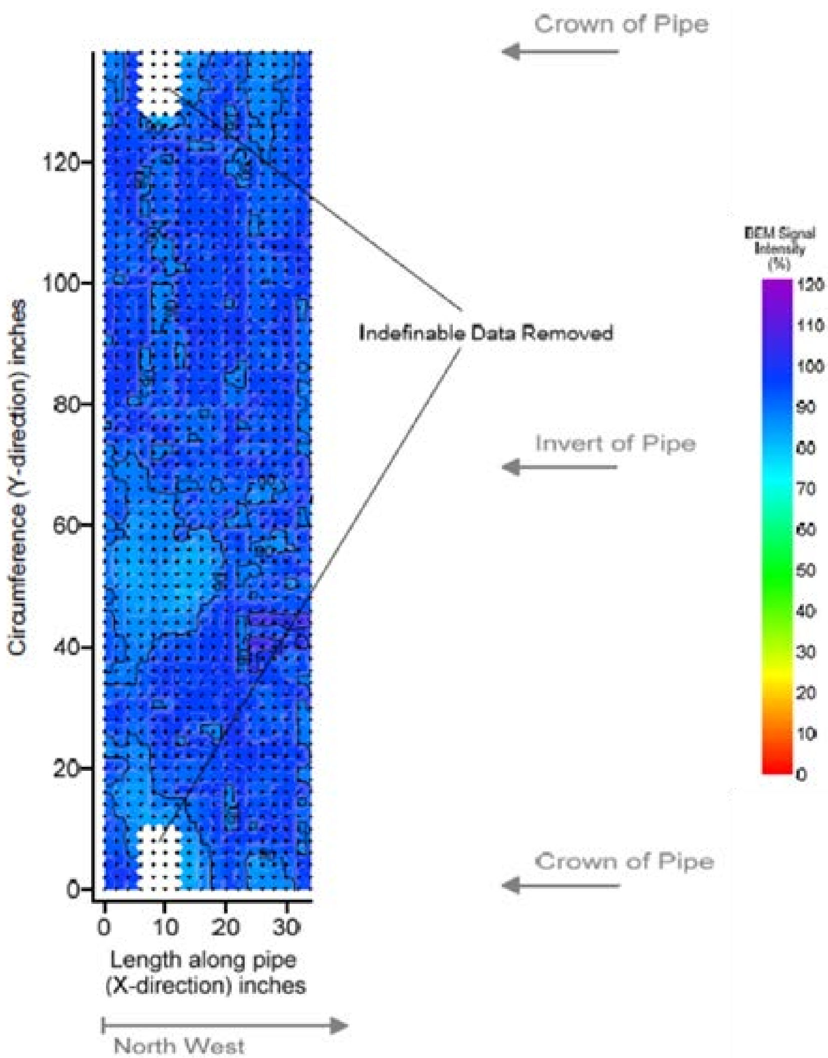

Figure 2. BEM Contour Plot of Apparent Wall Thickness

Photos 3 and 4 show the locations with reduced wall thickness on the exterior of the pipeline.

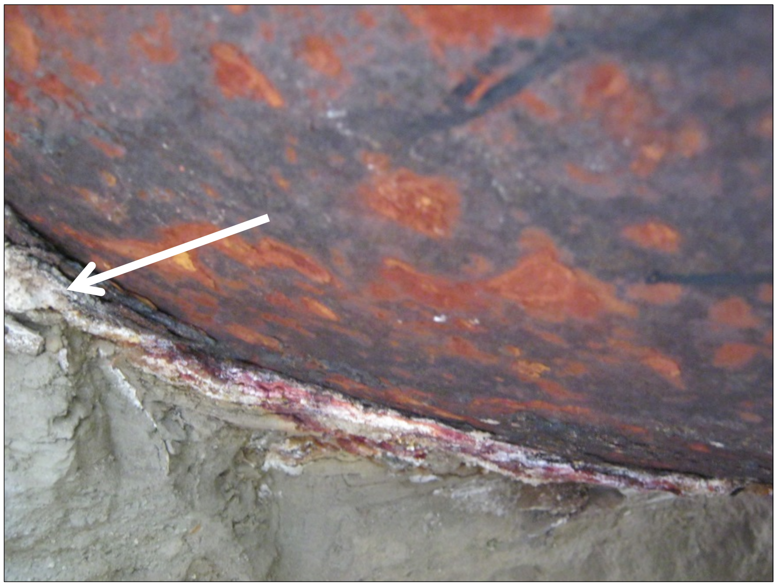

Photo 3. Corrosion Scaling Near Invert of Pipe

Photo 4. Corrosion Pitting

BEM testing has been found to be an effective tool for obtaining wall loss corrosion rates. This is very apparent for CIP and DIP that have surface profile corrosion that prevents using UT. The contour plots clearly show corrosion areas relative to the entire surface of the pipe. When possible, using UT in conjunction with BEM provides a useful reference and verification of BEM data.