Tangential Radiographic Testing

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ABSTRACT

Ultrasonic inspection is a common method for measurement of wall thickness on pipes and vessels. In its normal application, only a small portion of the surface is inspected, which may miss major defects. Also the technique is normally not sensitive to defects such as pitting.

As an alternative, tangential radiography provides a more complete and accurate picture of the metal thickness and defects. This paper describes the basic methodology of the technique and then focuses on a number of examples that show the value of tangential radiography.

INTRODUCTION

In response to OSHA 1910.119 requirements for Mechanical Integrity, a large number of process plants are measuring the wall thickness of pipes, vessels and tanks on their hazardous chemical process systems. Often the measurements are made by removing insulation plugs and recording the thickness ultrasonically at very limited locations. The measurements may not be taken at the location(s) of minimum wall thickness, and thus the expected life of the pipe or vessel may be less than expected.

A second problem exists on material which is subject to pitting corrosion. A typical ultrasonic measurement measures an average wall thickness. The depth of small diameter pits is not measured. This paper is written in direct response to clients who provided material samples to our laboratory for failure analysis. A common statement has been made "We just measured the wall thickness on this pipe a few weeks ago. Everything was fine, and now we have a through-wall leak."

The failure analysis usually found a form of pitting corrosion that could not be measured by ultrasonic methods without performing a full volumetric inspection with multiple transducers. Perpendicular transducers designed to measure wall thickness do not measure the depth of small diameter pits.

One final limitation of ultrasonic thickness measurements is that transition geometry cannot be accurately measured. Even gradual changes such as in a pipe reducer are difficult to measure because of the problems in repeating the measurement at the exact same location. On sharp transitions, no reliable measurement can be made.

As an alternative method, tangential radiography has been used with great success. If the pipe is 24" diameter or less, the radiograph may be taken through insulation. With a 10" or smaller diameter pipe, one radiograph may be used to measure wall thickness on two sides of the pipe. Shading of the radiograph between the two sides allows observation of local corrosion, erosion and pitting, even if the thickness is not directly measurable.

Radiography provides a permanent record that can be used to directly compare from one point in time to another.

The final advantage is that often suspected or unsuspected problems are revealed without having to cut into the pipe.

There are limitations to the use of radiography because of the size of the pipe and vessels, access limitations because of radiation, and size and weight of the source. However, at most plants there are a large number of locations in which tangential radiography should be the inspection method of choice.

Following are radiographs that Brown & Root has obtained from Pacific Gas & Electric, Rhodia and Gulf Coast Inspections which show the types of results that can be expected from tangential radiographic inspection.

wpe1.jpg (4284 bytes)

Figure 1:

This is a typical tangential radiography shot through insulation. Full contour of joints is visible. If this radiograph had a gage, the actual wall thickness could be measured.

wpe2.jpg (4603 bytes)

Figure 2:

Tangential radiograph of a pipe elbow with gamma gage. Increments are 0.2" on major marks and 0.04" on the minor marks. This is a very accurate method to measure the actual pipe wall thickness. In this radiograph the viewer can see thinning on the bottom of the pipe, process material in the bottom 10% of the pipe, heat tracing wire, and the socket weld fit-up. This amount of detail allows for inspection for evidence of crevice corrosion, which does not exist in this example. If this same piece were inspected by traditional UT, there would be a concern of cutting the heat trace wire.

wpe3.jpg (3759 bytes)

Figure 3

This is a standard TEE fitting with pitting corrosion. The small diameter pits would probably not be observed if straight beam UT were used to measure wall thickness.

wpe4.jpg (3715 bytes)

Figure 4

This radiograph shows an alternate means of calibrating for the observed wall thickness. A 1" diameter ball is visible at the top (encased in a sleeve to hold it on the insulation), and can be used as a scale when evaluating the film.

Heavy external corrosion is visible on this pipe.

wpe5.jpg (4695 bytes)

Figure 5

This radiograph shows thinning in the pipe wall. The welds at the reducer and flange are almost corroded through wall. Due to the problems with geometry, UT probably wouldn't find this thinning.

wpe6.jpg (3311 bytes)

Figure 6

In this pipe, there is a large amount of debris on the inside, and there is external corrosion on the bottom of the pipe.

wpe7.jpg (4071 bytes)

Figure 7

This pipe is filled approximately 60% with product. This tends to mask the bottom wall thickness from view. There is a slight indentation that makes it appear there is a circumferential dent in the pipe, as if it were dented by a band.

wpe8.jpg (4174 bytes)

Figure 8

There is significant thinning in the elbow extrados. There also appears to be thinning along elbow about 30degrees up and at weld

wpe9.jpg (4376 bytes)

Figure 9

This represents one of several slides in which the radiograph was used for observation of internal problems, not necessarily for wall thickness measurement. In this case, the valve wouldn’t operate, and it is apparent that the ears are broken on the disk.

wpeA.jpg (5455 bytes)

Figure 10

This is a double reducer to a control valve, with heavy erosion on downstream side, and not quite through wall. On the upstream side, the erosion is cutting through the weld metal.

wpe29.jpg (4873 bytes)

Figure 11

This is the first of two slides from a re-boiler. There is debris in the tubes, which is exfoliation.

wpe2A.jpg (4632 bytes)

Figure 12

In this second of two slides from a re-boiler, the left tube is totally blocked. The right tube debris is at the bottom with heavy internal scale above.

wpe2B.jpg (3876 bytes)

Figure 13

This radiograph was originally taken to check for thinning which is apparent at the downstream end of the valve. The cause of the erosion is apparent from the broken disks in the control valve.

wpe2C.jpg (4962 bytes)

Figure 14

This is a small branch line in a high temperature operating environment. Creep swelling with a crack visible in the center is apparent.

wpe2D.jpg (4647 bytes)

Figure 15

This radiograph shows significant thinning at a flange outlet

wpe2E.jpg (3970 bytes)

Figure 16

This elbow has several areas of severe thinning. It is paper thin downstream of the top weld. There is also a cut-out area at the weld. There may be a backing ring that is blocking flow or a very heavy bead on the inside of the pipe.

wpe2F.jpg (4746 bytes)

Figure 17

The thinning on the extrados of this elbow is not particularly surprising, but the cause was startling to the inspectors. That’s a size 10 tennis shoe stuck in the elbow.

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