# Ultrasonic Measurement of Weld Root Erosion

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**Abstract.** Selective corrosion and erosion of the weld root on pipe-work and vessels is a serious threat to integrity, and raises significant safety issues, especially in the oil and gas industry. The quantification of root erosion is made difficult by the presence of the weld cap, especially on thinner material. This paper describes an ultrasonic method of measuring the extent of root erosion in the field on pipe-work which does not require any weld preparation for the majority of automated welds on pipe which have a relatively flat profile.

## Ultrasonic Examination

Ultrasonic inspection is a long established method for identifying sub-surface discontinuities in materials. A piezoelectric transducer is used to generate a pulse of sound that propagates through the material and reflects from discontinuities, the return echo time gives the range to the reflector. In most field applications the probe runs on the surface of the material and the ultrasound is coupled by the use of a gel or a thin water layer. Weld inspection is usually carried out using probes adjacent to the weld, since the weld surface is unsuitable for the probe to run against, shear wave angle beam probes, and time of flight diffraction probes are typically used for weld inspection.

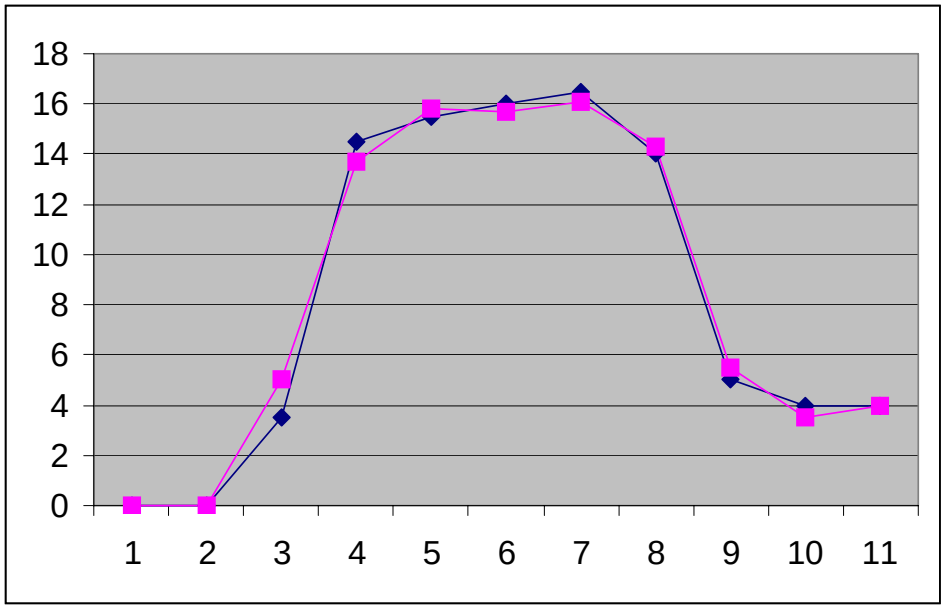
## Background and Inspection

Routine inspection identified general internal corrosion of this piping system, ultrasonic weld inspection identified discontinuities that proved difficult to quantify reliably using shear-wave and TOFD methods. The use of a water column “squirter” probe allows ultrasound to be coupled through uneven surfaces, and allows “water immersion” type probes to be used, these may be focussed at the point of interest, improving sensitivity and resolution. Using this approach and a Physical Acoustics “LSI” automated scanner it proved possible to scan the welds and measure the extent of weld root erosion using a normal incidence “thickness mode” ultrasonic approach, which is fairly robust as far as measuring remaining thickness is concerned.
The scanner was modified by adding a “dog-leg” to enable it to scan the welds at the elbows since the magnetic tractors normally operate with the scanning bridge between them.

A section of corroded pipe was cut from the piping system, and the ultrasonic measurements compared with measurements of weld loss using a physical depth gauge, the results are presented in the following figures. Scanning the 1200mm circumference takes approximately five minutes.

**Table 1** Physical Internal Measurement versus UT Results

| Position | Actual Loss measured | Loss From UT | Notes | Associated Figures |
|---|---|---|---|---|
| A/1 | 0 | 0 | Weld flush with inner surface of pipe | Fig 4 |
| B/2 | 0 | 0 | Weld flush with inner surface of pipe | Fig 4 |
| C/3 | 3.5mm | 5.0mm | | |
| D/4 | 14.5mm | 13.7mm | | Fig 3 |
| E/5 | 15.5mm | 15.8mm | | Fig 3 |
| F/6 | 16.0mm | 15.7mm | | |
| G/7 | 16.5mm | 16.1mm | Pipe very corroded, edge eroded away | |
| H/8 | 14.0mm | 14.3mm | Weld partial loss | |
| I/9 | 5.0mm | 5.5mm | Weld partial loss | |
| J/10 | 4.0mm | 3.5mm | Weld partial loss | Fig 5 |
| K/11 | 4.0mm | 4.0mm | Weld partial loss | Fig 5 |




**Graph 1** Comparison of UT measurement from outside (with internal physical measurement. X-axis is position around pipe, Y-axis is loss in mm.

The following figures show the scanner set-up, pipe, weld and UT results.

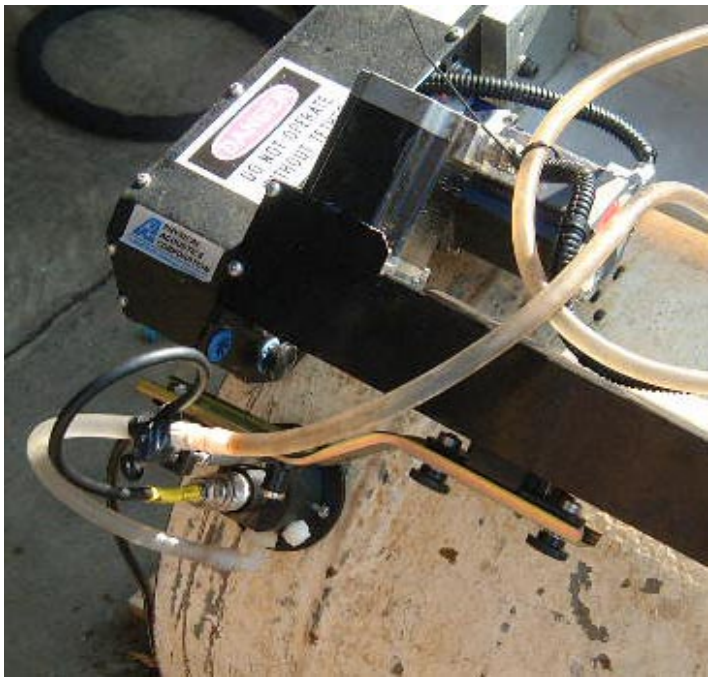


**Figure 1** Section of pipe showing weld and LSI scanner with “squirter” probe.

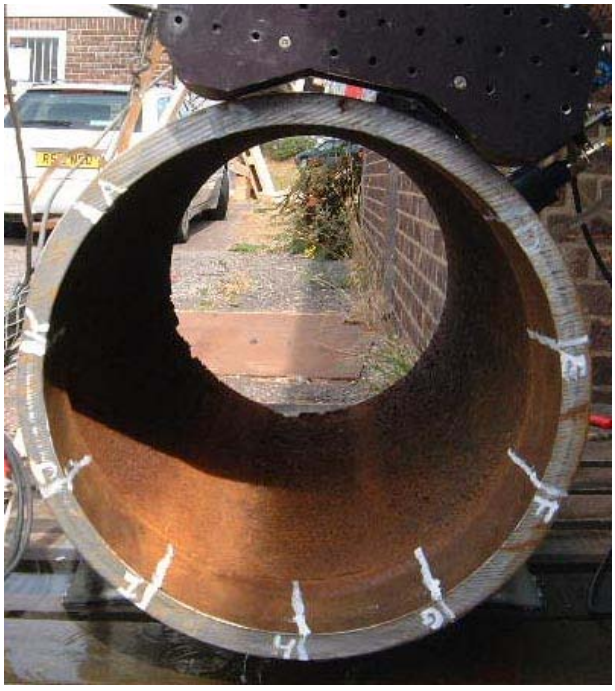


**Figure 2** End view of pipe showing weld and points at which depth measurements were made.


**Figure 3** Close-up of pipe weld at points D and E, physical depth of corrosion 14.5mm.

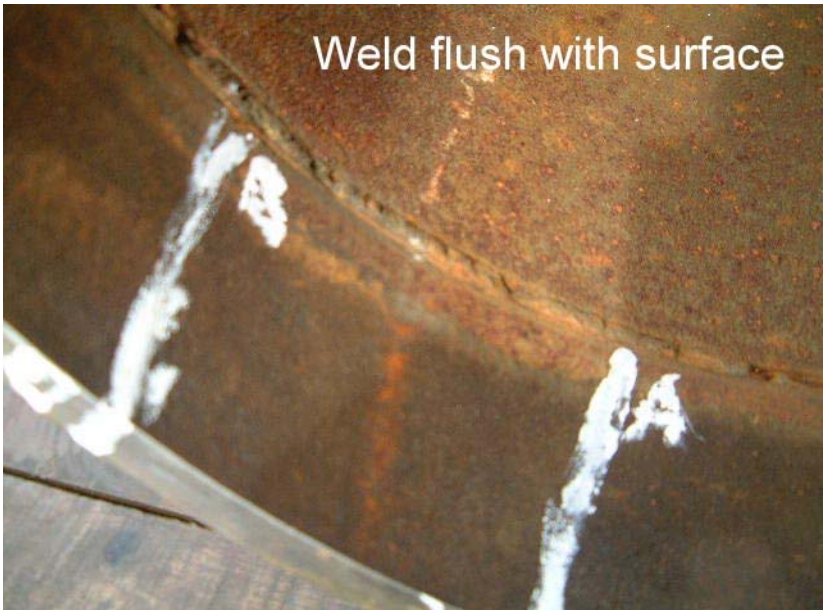



**Figure 4** Points A and B where weld is nearly flush with inner surface.

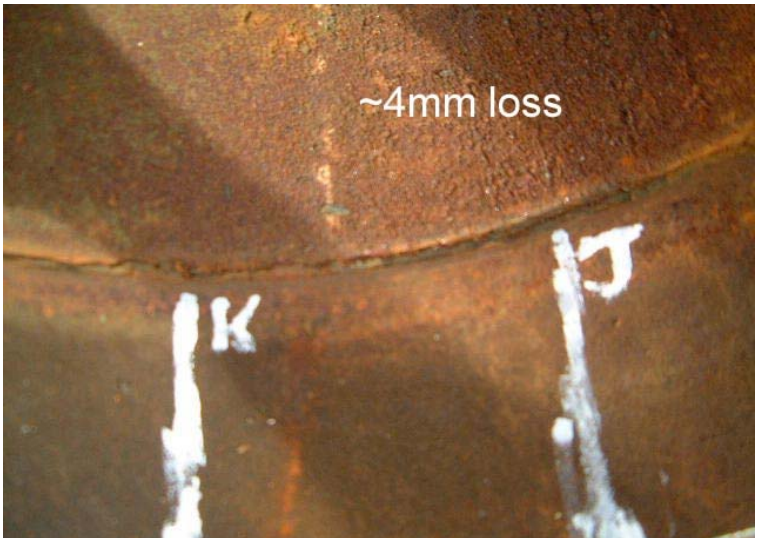



**Figure 5** Points J and K where weld has ~4mm maximum loss.

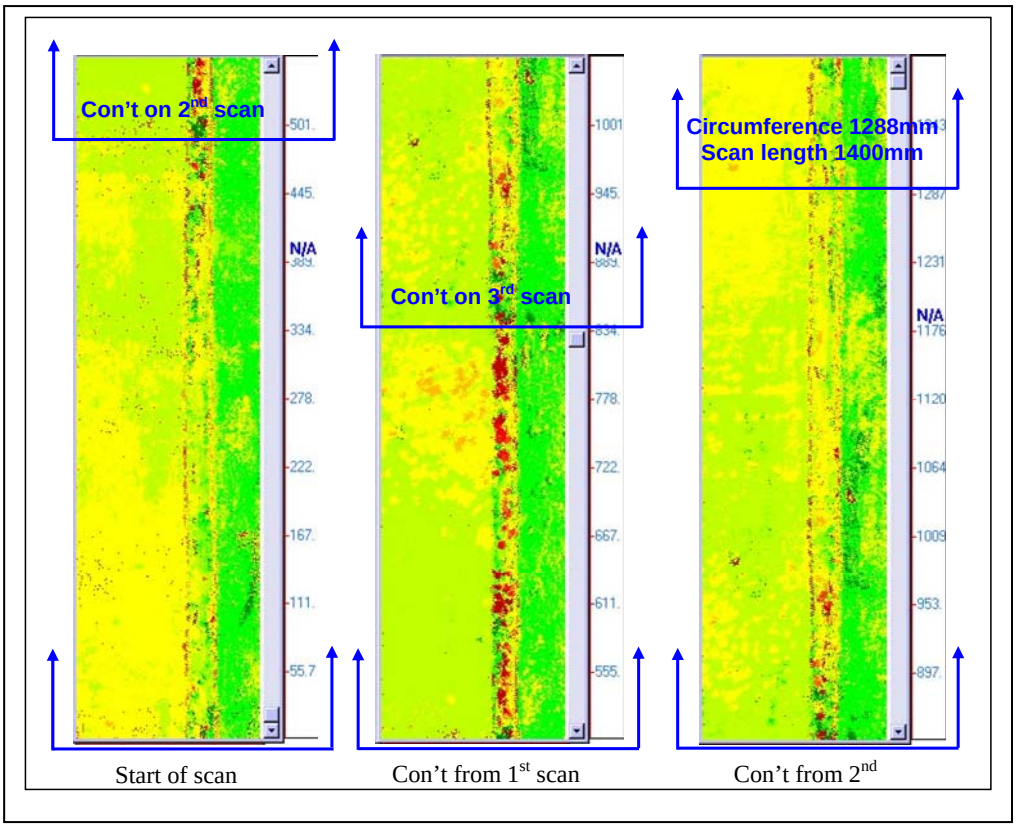



**Figure 6** C-scan of weld split into 3 images. Arrows indicate start of scan and overlaps. Note that circumference of pipe 1288mm, however, scan length 1400mm used to ensure full coverage of pipe. The thin red lines along the edge of the weld are knife-line attack of the HAZ. Red colour represents 5mm remaining wall (corroded from 18-24mm original).