CARBON STEEL INSPECTION, INC
VERSA INTEGRITY GROUP

CSI Tech Brief

U-Bend Inspection No.013 Rev.01 05/26/15

What's it all About?

We at Carbon Steel Inspection are often asked to provide a general description and background information of the capabilities and limitations when performing inspections on U-Tubes. There are different inspection techniques that we have developed in order to perform an inspection of the U-Bend region. This Tech Brief only addresses our implementation of the ET and RFT technology from our perspective and does not imply the capabilities or limitations of any manufacturer or vendors' performance.

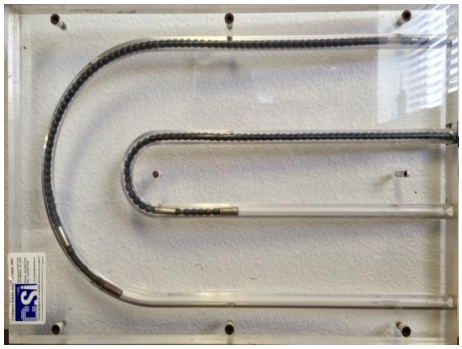
Challenges

- Bend radius varies by row. Outer vs. Inner
- Outer radius of the bend has a thinner tube wall thickness.
- Inner radius of the bend has a thicker tube wall thickness
- Probe Fill Factor ratio is determined by bend radius.
- ASME Code for ET requires a minimum of 80% fill factor and 70% for RFT in straight tubes.
- U-Bend Tube Cleanliness

Typical RFT U-Bend Probe Design

RFT Technique

When performing a RFT U-Bend inspection, technicians must select a probe with the highest fill factor possible to physically traverse the U-Bend radius. Typically a special single exciter probe design is used because it produces a unique bend signature that enables external signatures and manufacturing anomalies to be distinguished from relevant indications. A scope that includes U-Bends is separate from the straight length inspection which uses a dual exciter probe designed optimized for detection around baffle plates.



RFT U-Bend Probes in Clear Display

ET Technique

When performing an ET U-Bend inspection, technicians must assess the scope for the number of U-Bend regions to be tested. The U-Bend is a specialty probe designed to flex. Cost versus production or whether to test the entire tube leg from inlet to outlet end in a single pass is weighed against probe longevity, fill factor, anticipated damage mechanism and defect location. Usually the straight lengths are tested with rigid probes having higher than code fill factors while the U-Bends are tested with lower fill factor flexible probes.

Sensitivity

Probe sensitivity varies based on the radius of the tube being inspected, the fill factor of probe selection, as well as the inspection techniques that are being used. Tubes with a larger bend radius have a higher level of sensitivity than a tube with a tighter radius.

In general, if the fill factor remains the same as in the straight section then there is no change in sensitivity as compared to the U-bend region.

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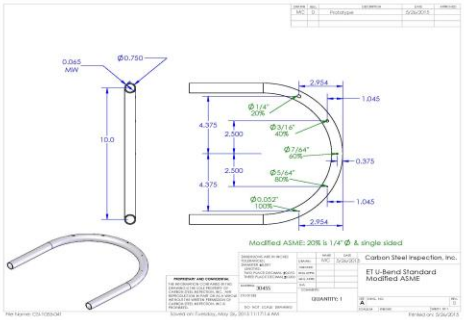
Accuracy

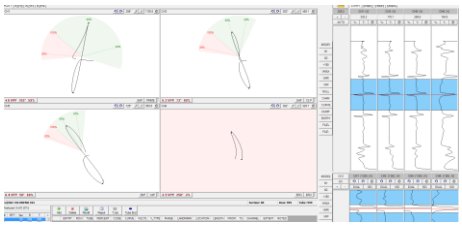
Typical accuracy using the ASME minimum fill factor guidelines is ± 10% for ET and ± 20% for RFT inspections. The accuracy tolerance widens as fill factor and centering decreases.

Calibration

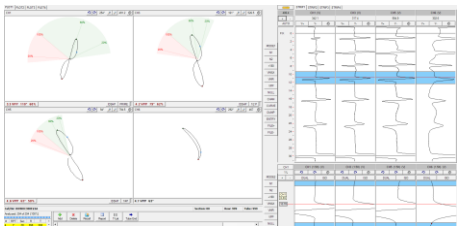
General practice when setting up a calibration or reference standard is to determine sensitivity limits or depth estimation curves by using a piece of material of the same tube specifications as the component being tested when possible. This ensures the highest quality of data and analysis. However, sample bent U-tubes aren't normally readily available to machine defects for a reference tube. If a specific degradation type or mechanism is anticipated a straight length sample will be comparable for determining sensitivity and accuracy limits.



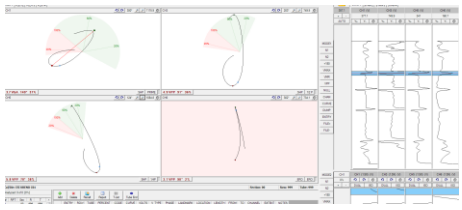
Below are some screen shots of the identical flaws in a U-bend region in row 6 with a bend radius of 4" versus a straight length.



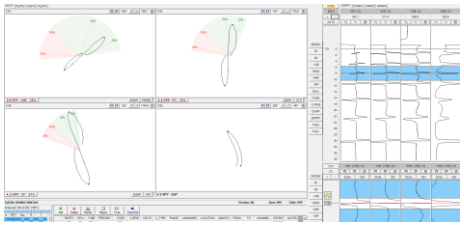
60% OD Indication U-Bend Region



60% OD Indication Straight Length Region



40% OD Indication U-Bend Region



40% OD Indication Straight Length Region

Tube Cleanliness

U-Bends need to meet the same cleanliness levels as the straight sections otherwise data quality will be decreased and probe longevity will be shortened.

Results-Presentation

The results of the U-Bend inspection are plotted from the first landmark or external structure on the opposite leg or test side. It is always preferred to have a bundle detail or component drawing showing the baffle arrangements for proper distance calculation and measurements.

Conclusion

Most often it makes economical and technical sense to perform a separate U-Bend inspection versus integrating the straight and U-bend inspection scopes. The very most inner row U-Bends are the highest at risk for getting the probe stuck and decrease the life of the probe due to wear and probe stretch.

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