International Journal of Oil, Gas and Coal Engineering
2024; 12(1): 31-35
http://www.sciencepublishinggroup.com/j/ogce
doi: 10.11648/j.ogce.20241201.14
ISSN: 2376-7669 (Print); ISSN: 2376-7677 (Online)

Rationalizing Application Concept Between Spot UT vs Scan UT for in-Service Inspection of Assets for Better Reliability and PoD - Resolving the Conflict of Interest

Debasis Mitra

Independent Freelancer Consultant (Ex. ADNOC), Delhi, India

Email address:
debumitra2004@rediffmail.com

To cite this article:
Debasis Mitra. (2024). Rationalizing Application Concept Between Spot UT vs Scan UT for in-Service Inspection of Assets for Better Reliability and PoD - Resolving the Conflict of Interest. *International Journal of Oil, Gas and Coal Engineering*, *12*(1), 31-35. https://doi.org/10.11648/j.ogce.20241201.14

Received: October 17, 2023; **Accepted**: November 2, 2023; **Published**: January 23, 2024

Abstract: The key purpose of asset integrity inspection is to protect human being, environment, animals and business by preventing costly asset failures and hazardous leaks by enhancing inspection reliability, effectiveness, spirit of asset condition monitoring and ultimately boosting up the probability of detection (PoD) of various types of defect. I believe that safety is a state of mind and management perception. NDE procedures and selected application techniques need to be always 100% focused on "what, why and how we want to inspect?" and over and above to be on the top of 100% HSE governance. This paper wants to discuss the ill effect on some old house heritage strategy and practice by many Oil & Gas operators / refiners / other Business Areas on execution and misuse of local spot UT during in-service inspection of process plant assets. This paper will try to highlight and resolve the conflict of interest of many operators on application intent between point spot UT and Scan UT during in-service inspection of operating plant asset. As asset integrity management is all about intelligent housekeeping of assets, we should not work on GIGO (Garbage IN-Garbage OUT) mode but should deploy sense full and meaningful NDE governance model. The issue may look simple but has dire consequences on plant operations, business integrity and continuity.

Keywords: Spot UT, Scan UT, PoD, Effectiveness, Corrosion Damage, Good Data, Uncertainty, Reliability

1. Introduction

There is a difference between efficiency and effectiveness. These two terms play pivotal role to benchmark asset integrity business and dictates plant reliability in terms of forecasting plant availability and downtimes. Efficiency means doing things right but Effectiveness is to do things right in one shot - first go. As we know any measurement is one of the critical and key technical aspect to understand and decide on plant integrity. If the NDE measurement techniques are not fit for purpose due to the reasons of management orthodox heritage perception or leadership wrong direction or NDE technician's casual approach, plant operation faces sudden and surprise failures and often disasters due to loss of primary containment (LOPC) and lives. This paper will try to discuss a simple issue of NDE UT application strategy of spot UT vs. scan UT during in-service inspection, misuse & misinterpretation of which bears dire consequence of surprise failures that compels plant management to take decision of plant bypass and/or costly shutdowns which not only impacts business KPIs but also degrades overall HSE scorecard targets.

2. Abbreviations Used

API: American Petroleum Institute
CML: Corrosion Monitoring Location
CL: Corrosion Loop
CR: Corrosion Rate
DUTT: Digital Ultrasonic Thickness Testing
FMC: Full Matrix Capture imaging
GIGO: Garbage IN - Garbage OUT
HMI: Human Machine Interface
HSE: Health, Safety & Environment
IOW: Integrity Operating Window
KPI: Key Performance Indicator
LTA: Local Thinning Area

MAWP: Maximum Allowable Working Pressure
NDE: Nondestructive Examination
PoD: Probability of Detection
PSM: Process Safety Management
PAUT: Phased Array Ultrasonic Testing
PCI: Phased Coherent Imaging
RL: Remaining Life
TFM: Total Focusing Method
TMI: Thickness Monitoring Inspection
TML: Thickness Monitoring Location
tmin: Minimum available wall thickness
UHC: Unit Hire Charge
WT: Wall Thickness
WSE: Written Scheme of Examination

3. Background of Conflict

I have seen in my 30+ years of technical integrity experience in diverse business areas, that still there exist conflict on concept and practices across various engineering industries on deployment of appropriate asset Thickness Monitoring Inspection (TMI) techniques during in-service inspection.

The key conflict is between deployment of spot UT (point reading) vs. scan UT (area reading) during in-service inspection within the marked-up Thickness Monitoring Locations (TML) at designated Corrosion Loop (CL) / Corrosion Monitoring Locations (CML). Many Refiners (Indian and overseas) and Oil & Gas Producers practices spot UT within TML examination zone for in-service inspection of assets.

4. Understanding and Misunderstanding

Let me discuss here for better understanding on the issue of deployment of spot UT vs scan UT during in-service inspection and I believe this will eradicate some common misunderstanding in this regard.

4.1. Understanding the API Code Languages

The term general uniform corrosion is somehow misnomer. For process industries, in-service asset degradation is in principle non-uniform in axial and/or circumferential directions. Even for austenitic stainless steels uniform corrosion to some extent ca get inhibited by local pitting and local thinned area (LTA) [4].

If we read carefully the lines of relevant API codes, this will clarify and give us direction whether to deploy spot UT or scan UT during in-service inspection of assets.

API 574 [2] (Inspection Practices for Piping System Components) clause 10.2.1.2.1 speaks that - There are three types of digital ultrasonic thickness instruments: numeric thickness readout, A-scan with numeric thickness readout, and flaw detectors.

API 574 [2] clause 10.2.1.2.2 speaks about - Numeric Thickness Readout - a small handheld, dual-element pitch-catch transducers. Use of "numeric thickness readout only" DUTT instrument have been misused /misapplied within the industry and seen to lead to erroneous/ inaccurate results.

API 574 [2] clause 10.2.1.2.3 speaks about - A-scan with Numeric Thickness Readout which accounts 2 groups of Instrument. "thickness measurement" & "flaw detectors". Code speaks that advantages of A-scan display over a pure numeric display are:

1. It allows examiner to view the ultrasonic echo to verify proper signal, handle issues of thickness doubling (for WT<0.1") and ability to differentiate between laminar indication vs. corrosion damage.
2. While scanning a corroded area, the signal from corrosion will break the baseline at the back wall signal and the corrosion signal will move (signal walking) left toward the IP signal due to the sound reflecting from the edges of the corrosion until the thinnest area is being reflected. until the minimum thickness is reached. This is a good way.
3. Ability to operate in either of two timing modes viz. "the IP timing mode" or "the multiple echo modes". The IP timing mode measures the transit time from the IP to the first echo. The multiple echo mode allows the examiner to set the instrument to measure between a set of multiple successive echoes instead of the IP to first in order to establish the thickness.
4. Corrosion evaluation should be conducted using the IP timing mode. In cases where a component is painted at the measurement location and is corroded on the reflection side (which can cause lack of sufficient echo-to-echo signal and therefore measurement error), the paint should be removed for accurate thickness measurements. However as paint removal is not allowed dual gate multi-echo mode to be used.

API 574 [2] clause 5.7.1 speaks about - Corrosion Evaluations - The best search units for conducting corrosion evaluation are dual-element transducers which should have a good wear surface on the face of the search unit to allow the examiner to scan corroded areas for the minimum reading and minimize the wear on the search unit.

When conducting corrosion detection or evaluation during in-service inspection, the examiner should scan the area of interest with the search unit in lieu of conducting individual point spot measurements. Scanning provides a greater PoD of small diameter (less than one-half of the search unit diameter) indications than taking point measurements. Examiner should scan max 6 in./s (152 mm/s). Additionally, overlap each scan path by a minimum of 10 % of the transducer diameter.

Thus API 574 [2] clearly directs user/operator to use scan UT for better corrosion evaluation PoD and Reliability rather than spot UT either by dual probe or delay lined normal probe.

API 570 [1] (Piping Inspection Code) clause 5.7.1 speaks about – Condition Monitoring Methods (UT and RT) which clearly recommends that when corrosion is non-uniform RT or UT scanning are the preferred techniques.

API 510 [3] (Pressure Vessel Inspection Code) clause 5.6.2.3 speak about - Where thickness measurements are

obtained at CMLs, the minimum thickness at a CML can be located by ultrasonic measurements or radiography. For localized corrosion, it is important that examinations are conducted using scanning methods such as profile radiography, scanning ultrasonic techniques, and/or other suitable NDE techniques that will reveal the scope and extent of localized corrosion. When scanning with ultrasonic, scanning consists of taking several thickness measurements at the CML searching for localized thinning. [13]

4.2. Misunderstanding on the Use of Spot UT During in-Service Inspection

There are companies who still deploys spot UT by DUTT or UFD to cover up CML inspection in-service. Other than lack of technical understanding and Code awareness, there exists multiple reasons behind selection of spot UT by plant management for in-service inspections which are intended to save NDT contract cost, to get quick spot results and faster work coverage progress, to have low UHC (Unit Hire Charges), due to orthodox mindset and old man's guidance. This spot UT approach will be a GIGO and dangerous approach as it misleads reality WT and often overestimates with higher WT values which often computes for a false impression of higher RL and eventually leads to surprise failures.

5. Intent of NDE UT for in-Service Inspection

If the purpose of TMI is clear, then the selection of NDE UT technique need to be accordingly. During in-service inspection (online or offline/shutdown) the sole purpose of NDE UT is not to measure "just thickness" but to address, assess and evaluate thickness loss profile gradient and/or local thinning area (LTA) assessment to understand prevailing damage mechanism [4, 13, 18]. The intent is to identify minimum available thickness (tmin) to calculate remaining life (RL) and safe integrity operating window (IOW) and to redefine maximum allowable working pressure (MAWP) based on lowest available thickness. Thus spot UT cannot provide a guarantee for minimum available thickness due to measurement location based huge uncertainty.

1. If the intent of measuring WT is for baseline data collection at new project pre-commissioning dry stage - can do spot UT by DUTT to understand nominal available product thickness.
2. If the intent of measuring WT is for corrosion assessment during in-service inspection at various operating stages [10] – recommend always to do scan UT covering complete TML Circles by placing probe index till circle periphery or circumferential band scan by single or dual element A Scan UT-L probe for better PoD for tmin determination.
3. There are many other advanced UT scanning technique starting from PAUT to FMC, TFM and PCI for high temperature and other business sensitive defect identification but this paper is focused on the basic application conflicts and issues of spot vs scan UT.

6. Spot UT Sensitivity Analysis [5]

Statistical analysis with three sets of spot UT by DUTT wall thickness measurement found with uncertainty (errors) of the order +/- 20 mils (0.020 inch), +/- 30 mils (0.030 inch), +/- 0.40 mils (0.040 inch). Error contributing factors are calibration, coupling, temp, probe rocking, technician mind & skill, training, surface etc. collectively termed as HMI (Human Machine Interfaces).

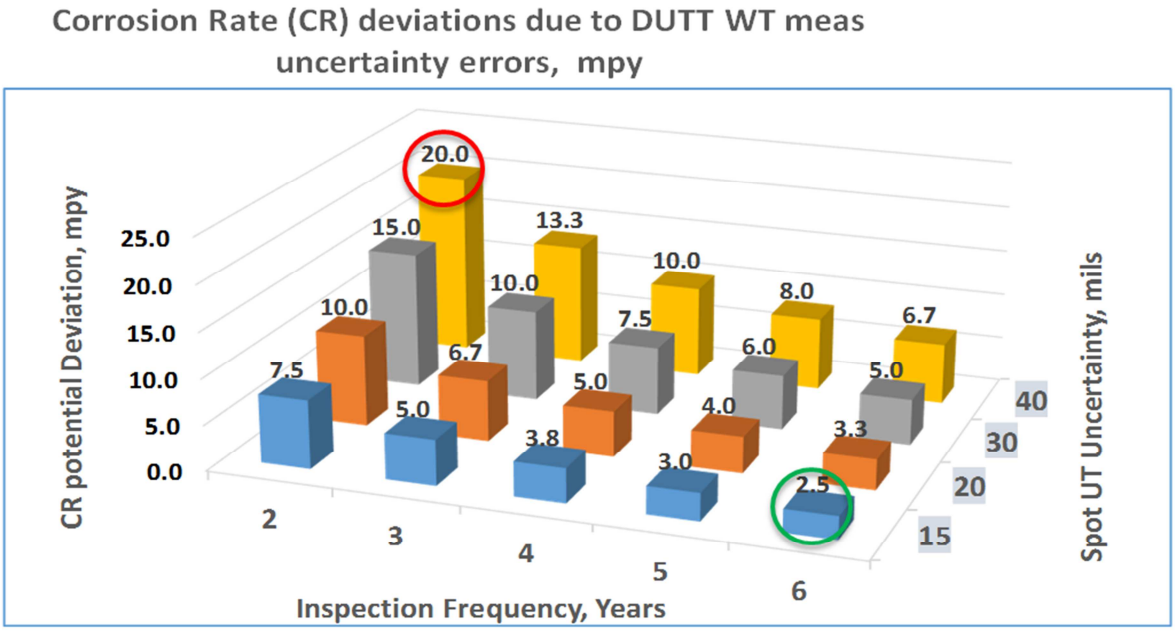

Figure 1. *Graphics of Potential Corrosion Rate Deviation due to DUTT Wall Thickness Measurement Uncertainty Errors.*

Table 1. *Raw Data of 4 sets DUTT Spot UT WT Measurement Uncertainty Computed to Corresponding CR Uncertainty w.r.t. Inspection Frequency [5].*

Inspection Frequency, Months (years)	Corrosion Rate (CR) potential deviation due to DUTT WT meas errors, mpy (mm/year)			
	Spot UT WT Measurement Uncertainty (errors), mils i.e. in. (mm)			
	15 mils i.e. 0.015 in. (0.381 mm)	**20 mils i.e. 0.020 in. (0.508 mm)**	**30 mils i.e. 0.030 in. (0.762 mm)**	**40 mils i.e. 0.040 in. (1.016 mm)**
24 (2)	7.5 mpy (0.191 mm/yr)	10 mpy (0.254 mm/yr)	15 mpy (0.381 mm/yr)	20 mpy (0.508 mm/yr)
36 (3)	5 mpy (0.127 mm/yr)	6.7 mpy (0.169 mm/yr)	10 mpy (0.254 mm/yr)	13.3 mpy (0.339 mm/yr)
48 (4)	3.75 mpy (0.095 mm/yr)	5.0 mpy (0.127 mm/yr)	7.5 mpy (0.191 mm/yr)	10.0 mpy (0.250 mm/yr)
60 (5)	3.0 mpy (0.076 mm/yr)	4.0 mpy (0.101 mm/yr)	6.0 mpy (1.524 mm/yr)	8.0 mpy (0.203 mm/yr)
72 (6)	2.5 mpy (0.063 mm/yr)	3.3 mpy (0.084 mm/yr)	5.0 mpy (0.127 mm/yr)	6.7 mpy (0.169 mm/yr)

1. The above sensitivity analysis is an eye opener and vividly depicts the potential uncertainty error by DUTT spot UT that can generate CR error of the order of 2.5 mpy to as high as 20 mpy due to various HMI errors.
2. Above sensitivity analysis is not intended to STOP use of spot UT (DUTT) but directs Operator to use DUTT during any new project WT measurements before operation start-up and encourages scan UT (Dual or single element) at TML Circles and/or Band Scan as per WSE during in-service inspection.

7. An Advice to Field NDT Technicians for TMI for CML TML – A Sample

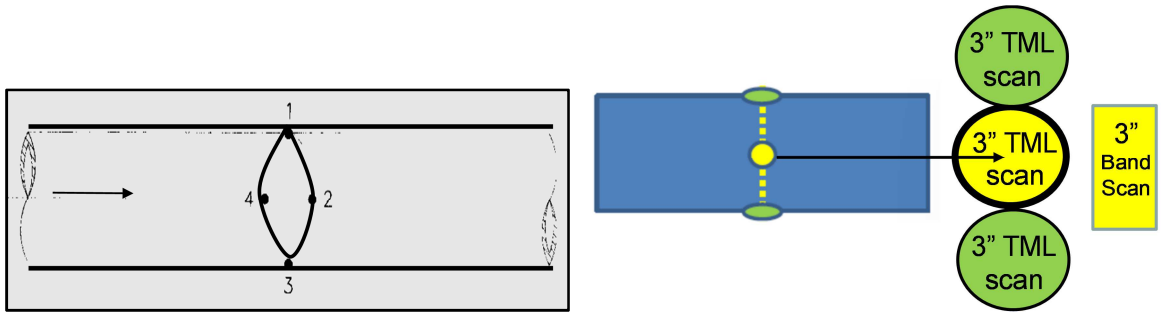

Figure 2. *TML 3"Circle Mark-Up on Straight Piping for Circle Scan and for Class 1 & 2 Service Recommend 3"Band Scan. [16]*

The permanently marked up TML Circles (2"circle for piping up to 10"dia and 3"circle above 10"piping dia) to be 100% scanned including Circle border by placing probe index at circle border. This should the default minimum practice.

For service critical piping viz. Class 1 and 2 advised to do 2 "or 3" circumferential band scan 360 degree covering the TML Circles and the tmin point/zone need to be clearly marked up within TML Circle/ band.

For all other Category pipeline advised to do at least TML Circle full scan and identify and mark tmin circle unless band scan is prescribed in procedure.

The intent should be to do corrosion mapping/ profiling to understand tmin and not just to take few thickness data.

8. Good Data Driven Operation Is the Key to Successful Integrity Assurance

Most management and technical staffs are confused with the term good data and bad data. Inspection data which are good to someone may be bad to many and vice -versa.

The definition of Good Thickness Data is trustworthy and reliable data close to real time thickness scenario with least uncertainty and to achieve good data proper NDE tools and techniques are the key. Lower the Uncertainty, Higher the Reliability and confidence on integrity assurance. Management intent should be to reduce measurement uncertainty below an agreed KPI level.

Reliable Asset health assessment by intelligent thickness measurement [11] is one key to asset performance and in-turn to safeguard business continuity without surprise failures. For that CML/TML need intelligent selection based on zones of potential damage and process safety sensitivity rather than chronological progression fashion of marking [9]. Damage sensitivity need to be defined in terms of CML risk prioritization from historical data trend based on an agreed threshold risk target i.e. (failure risk in USD$ say $100K on or before next inspection date) and only CML that exceeds the risk target to be targeted and inspected with some revised frequency. Rest can be inspected later. [6-8]

Many Operators still believes and practices "Numeric Thickness Readout DUTT" gage for in-service inspection and examines the TML Circles by few random spot UT readings. This is not only an wrong approach but also dangerous as the hidden threat of tmin not get well discovered due to all the measurement uncertainty, low PoD and un-reliability by spot

UT DUTT which leading to surprise failures due to wrong evaluation of CR and vis-à-vis incorrect estimation RL and corresponding remedial actions.

9. Conclusion

Concluding Words of API 574/570 Recommendations on in-service UT Thickness Measurement for Corrosion Evaluation.

1. For the purpose of in-service inspection of piping assets [14, 15, 17] the key intent is corrosion degradation assessment and not simply thickness measurement.
2. As mostly corrosion degradation is non-uniform, code encourages to deploy scan UT and not spot UT.
3. Scan UT can be done at least within the TML marked-up circle area or in band scrub form which will yield better PoD for reliable identification of tmin.
4. For reliable asset management and intelligent PSM it is requested and recommended to avoid the business of spot UT for in-service inspection and use scan UT program for in-service inspection for better PoD and Data Reliability.

Acknowledgments

I acknowledge as the sole author that this is entirely my own thought and narration based on my experiences.

References

[1] API 570 - In-Service Inspection, Rating, Repair and Alteration of Piping System.

[2] API 574- Inspection Practices for Piping System Components.

[3] API 510 - In-Service Inspection, Rating, Repair and Alteration of Pressure Vessels.

[4] API 571 - Damage Mechanism affecting Fixed Equipment in the Refining Industry.

[5] Challenging Baseline Inspection Paradigms for Oil & Gas Upstream Equipment, By George C. Williamson, VP of Integrity, Risk Management & Litigation Support at Integrity & Emission Reduction Partners, LLC, and Dr. Bill Hedges, Independent Consultant.

[6] CML OPTIMIZATION: EFFECTIVE AND EFFICIENT COVERAGE AND PLACEMENT, By RYAN MYERS, Operational Excellence Manager at PinnacleART and RIAN MARINO, Engineering Specialist at PinnacleART.

[7] Increasing the effectiveness of CML optimization through condition monitoring optimization- A Pinnacle eBook.

[8] Special Emphasis Programs and TML Placement as Entry Points for RBI Implementation, By Stephen P. Webb, P. E., Asset Integrity Engineer at Metegrity.

[9] Quantifying the Value of Your Inspections, By Lynne Kaley, Director of Reliability Strategy at Pinnacle, Siddharth Sanghavi, Product Manager at Pinnacle.

[10] API 581 - Risk Based Inspection Methodology.

[11] Managing Corrosion of Pipelines that Transport Crude Oils, Material Performance Roundtable Q & A, By Kathy Riggs LaRsen, associate editor.

[12] API 653 - In-Service Inspection, Rating, Repair and Alteration of Storage Tanks.

[13] THE 101 ESSENTIAL ELEMENTS IN A PRESSURE EQUIPMENT INTEGRITY MANAGEMENT PROGRAM. By John T. Reynolds is a Principal Consultant with Intertek AIM.

[14] ASME B 31.3 - Process Piping.

[15] ASME B31.8S - Managing System Integrity of Gas Pipelines.

[16] A Work Process for Petroleum Refining Piping CML Placement and Testing Determinations, By Jim McVay, Sr Manager, Metallurgy and Inspection, Andeavor.

[17] ASME PCC-2 - Repair of Pressure Equipment and Piping.

[18] Practical hands on Experiences and Technicians Feedback.