ROTARY

Smart thinking. Safe hands.

NDE 4.0 for improving the Reliability of NDT for Storage tanks

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AGENDA

1. Storage Tank Inspection
2. Conventional Testing & Inspection
3. NDE 4.0 in Storage
4. Systematic Approach
5. Adopting Millennial methods
6. Critical Zone failure & life extension
7. System Reliability & Conclusion

Storage Tank Inspection

Large chemical and petroleum product storage tanks can be found at chemical processing plants, refineries, and industrial locations. They are huge metal structures 40-50m in diameter and 20m in height with some tanks for crude ranging to 100m in diameter, can easily hold more than 100,000cbm of petroleum products or gas or other hazardous liquids. Most tanks are made of steel plate that is welded together to form the structure. The material and the welds are inspected for manufacturing defects when constructed but must also be periodically inspected throughout their service life for signs of damage. The carbon steel is prone to attack by corrosion and in some circumstances, cracks can form over time.

NDT personnel use visual, X-ray, ultrasonic and other inspection methods to search for flaws and service-induced damage.

Tank Inspection

Tank inspection ensures the safety and integrity of aboveground storage tanks by preventing accidental leaks and avoiding costly decontamination, while providing critical data so lifetime and repair predictions can be made.

There are continued advances in new non-destructive testing (NDT) technologies that improve detection of defects and accuracy of sizing.

Storage Inspection

- AST are simple in Construction, the component includes the infrastructure of fixed or floating roofs including domes and seals, shell aperture, settlement analysis and strapping.
- Both internal and external usually take the form of isolated attacks governed by roof geometries, construction methods, plate flatness, and coating conditions.
- Critical areas involve bottom plates, shell plates, roof plates and all welding joints. While it’s assumed that leakage will occur before a failure, there may be catastrophic failure without any prior leakage.
- Monitoring the tank exterior for general metal loss in various areas provides a useful integrity assessment, but the extent of inspection necessary depends on the product stored, tank age, and historical inspection results. Most such inspection uses UTG.

Testing, Monitoring

- Visual Inspection
- Vacuum Box Testing
- Ultrasonic Testing
- Dye Penetrant Testing
- Magnetic Particle Testing
- Radiographic Testing

Testing, Monitoring

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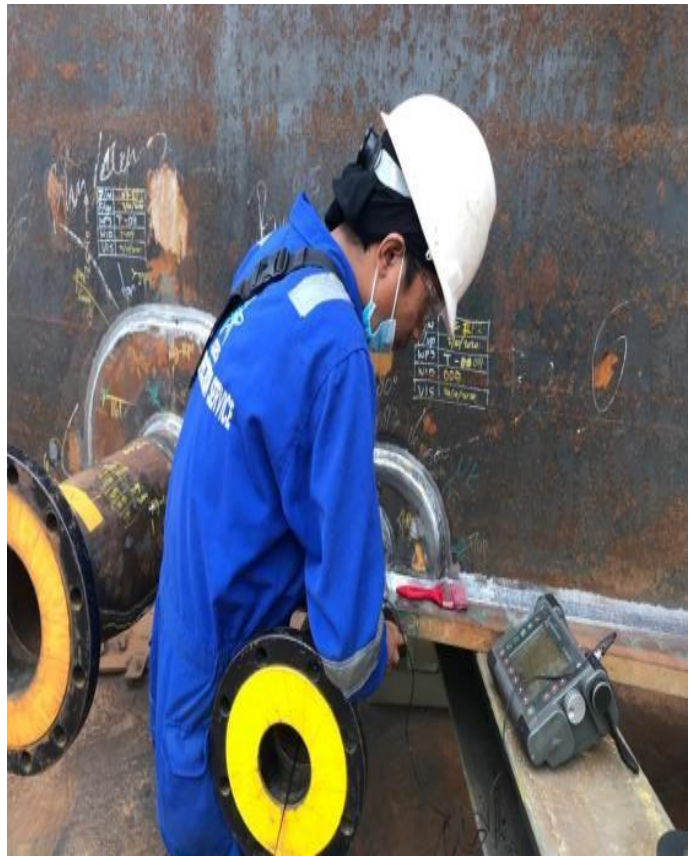
- Ultrasonic Testing



Testing, Monitoring

- Dye Penetrant Testing

- Magnetic Particle Testing

- Radiographic Testing

NDE 4.0 in Storage

- NDE 4.0 can be defined as "A Cyber-physical Non-Destructive Evaluation (including testing); arising out of a confluence of industry 4.0 digital technologies, physical inspection methods, and business models; to enhance inspection performance, integrity engineering, and decision making for safety, sustainability, and quality assurance, as well as provide relevant data to improve design, production, and maintenance through useful life. (Reference: "NDE 4.0 – From Design Thinking to Strategy")

- NDE 4.0. Aspects are of the new trends including 3D volume data creation and management of large files, component live data files, management of big data, real time monitoring of structure integrity of storage tanks with sensors, reliable inspection of individual components, NDE planning, and interpretation based on modelling, and remote NDE to include competence not available onsite.
- **Reliability – Extended life, unplanned maintenance, unplanned shutdown**
- Eliminate false positives, predict failures

Systematic Approach

Construction Testing Data, Routine Monitoring, Planned Maintenance

API 653

Millennial Methods

Use of robotics in scanning systems, Implement advanced technologies in imaging

4.0

AI in data analysis, Life Prediction & Extension

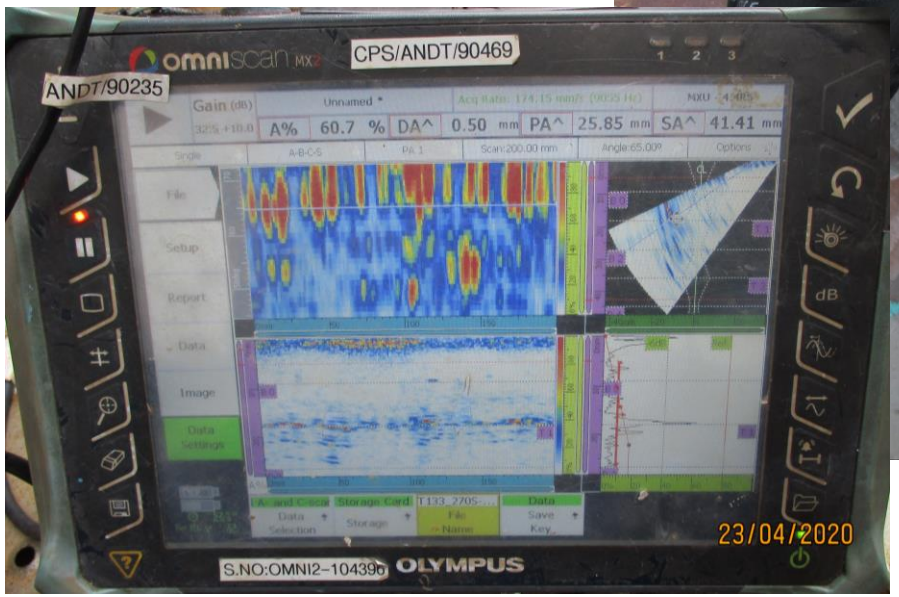
Revolutionary Change in NDT Methods for Storage

- **Switching from Radiography to Phased Array Ultrasonics**

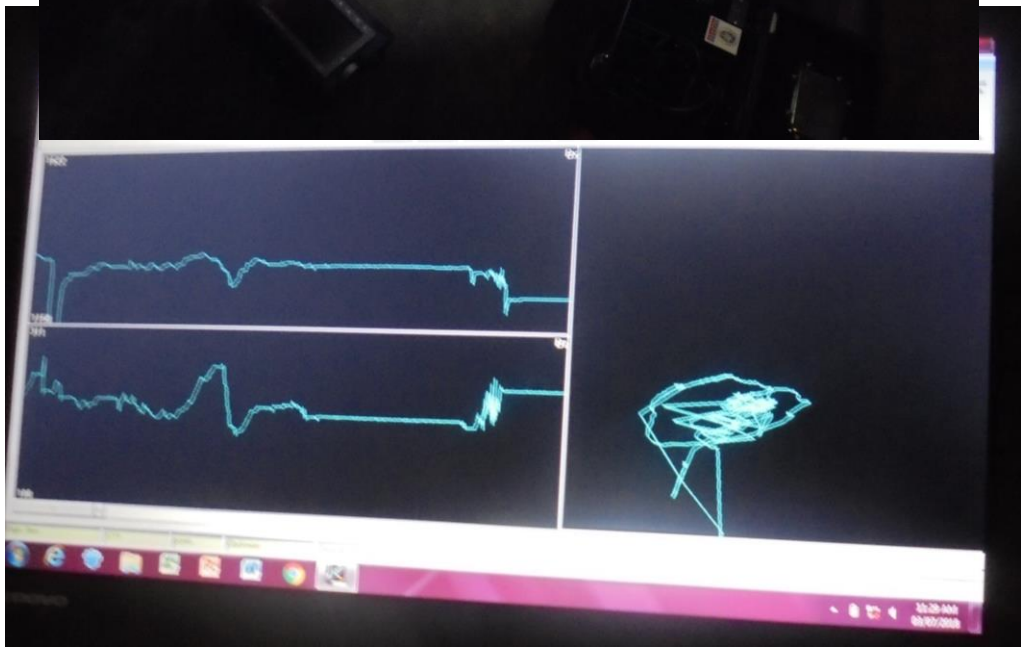
Need for Data, Need Data for Analysis, Need Data for Retrieval

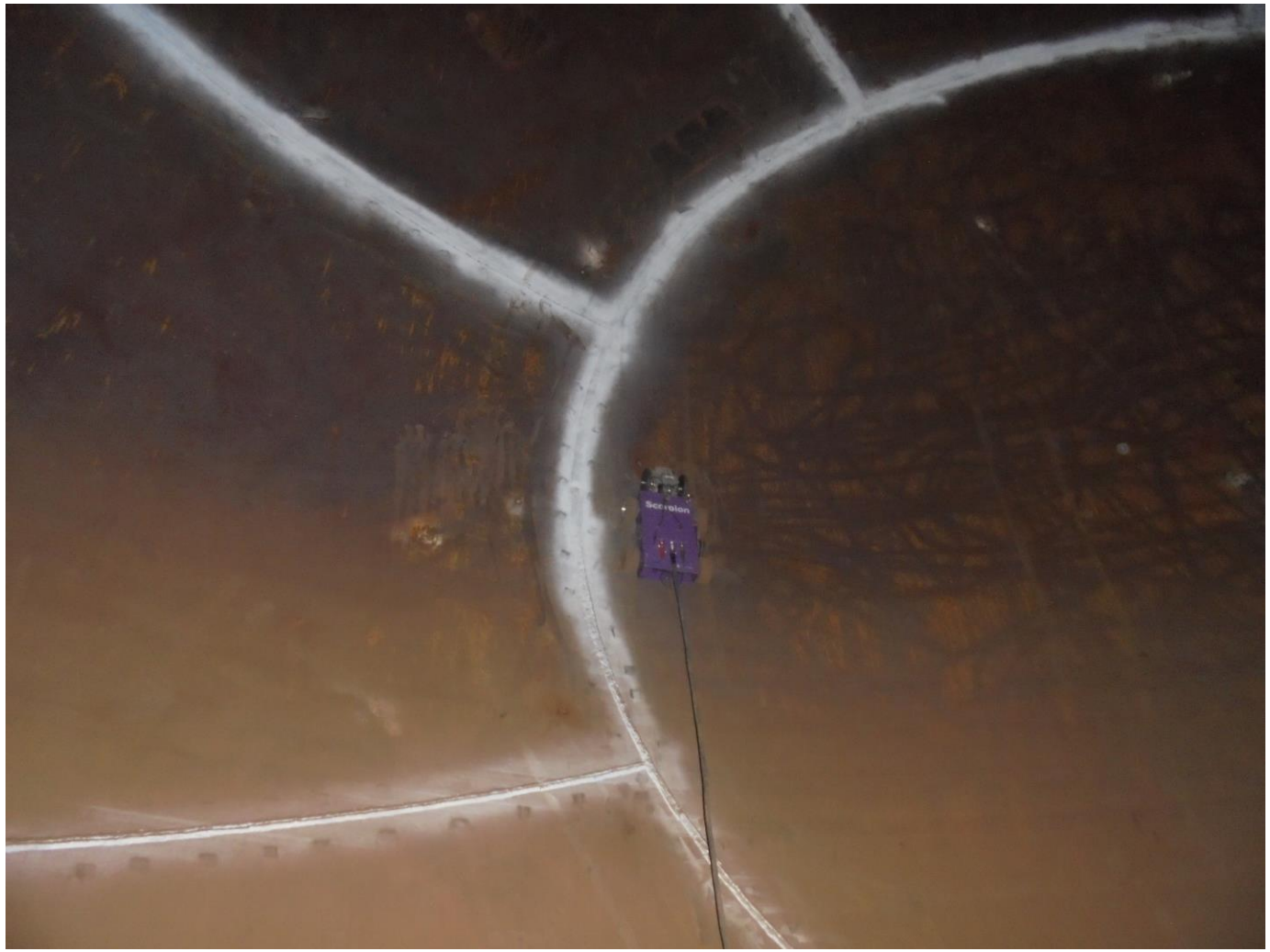
Inline testing (No Isolation of construction work)	Rapid Results, Repair Rectification, Single sided Inspection
Productivity - 4X	Cost factor (Justified with other costs- Scaffold)

RT-PAUT



ACFM Inspection during service of Mounted Bullets



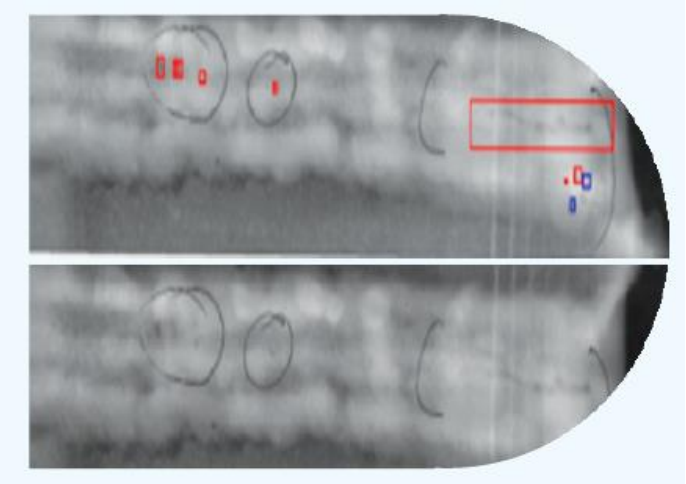


ACFM Inspection during service of Mounted Bullets

- It has been used for detection and sizing of surface breaking cracks in metallic components and welds.
- The ACFM probe introduces an electric current locally into the part and measures the associated electromagnetic fields close to the surface. The presence of a defect disturbs the associated fields, and the information is graphically presented to the system operator.
- The ends of a defect are easily identified to provide information on defect location and length. Through wall extent of the flaw plays an important role in determining structural integrity and the same is calculated using mathematical computation thus allowing an immediate evaluation of the implication of the indication.
- ACFM inspection was able to be performed through paint and coatings, hence it was a suitable method to be a faster and economic technique than other conventional technique

AI Enabled Tools

- Where Radiography testing was adopted to detect weld imperfections -porosity, slag, and cracks. Images need to be reviewed by Level 2 & interpreted with standards
- AI has been enabled to use neural network, which includes an optical density method to evaluate the image grayscale value, and a deep learning algorithm to detect IQI area and the values in the x-ray images. This is followed by indication prediction, which uses the welding seam detection method to do the segmentation both on horizontal and vertical. Then, the indication property measurement phase is used for edge detection, contour fitting of the size of individual region(s); Then, media axis transform determines the size of connectivity of 2D shape/region.

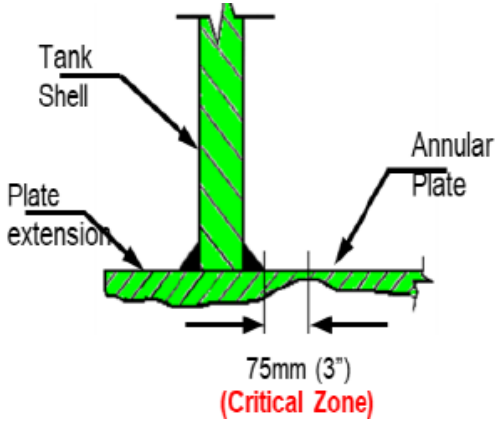


AI Enabled Tools

- The Other technology is use of PA along with a new image reconstruction technique FMC/TFM provides real-time digital images of greater quality. The application of trained AI networks for automatically evaluate the images based on simulation models is an improved aspect. The technology uses laser guided robot to maneuver the ultrasound PA sensors to access hard to reach locations to ensure 100% inspection.
- An intelligent model such as ANN makes it possible to develop real-time NDT applications and improve defect sensibility.

Critical zone rupture & failure

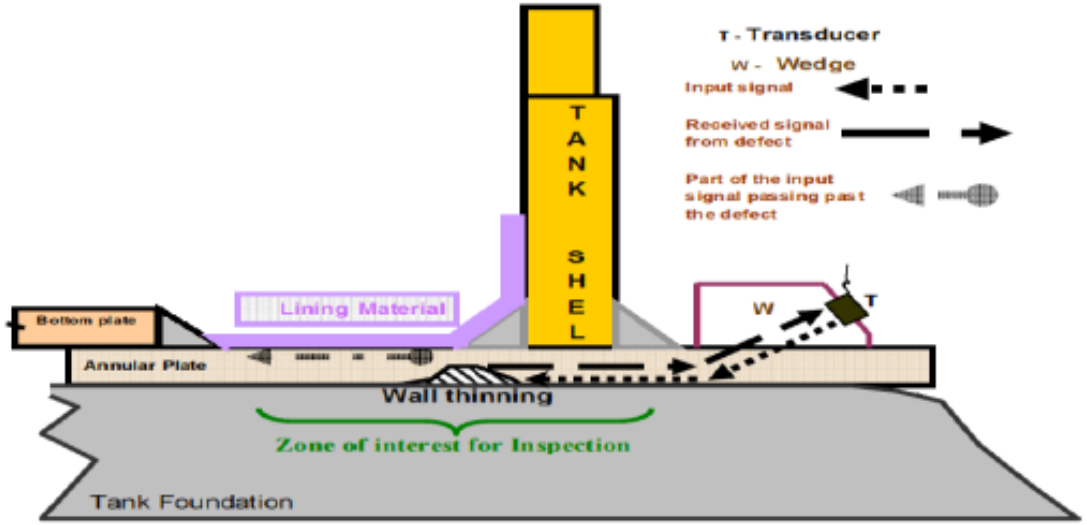
- Corrosion monitoring in the annular plate region of above ground storage tanks is a critical need of storage tank operators.
- This region is prone to accelerated corrosion due to additional stresses caused by weight of the tank wall and the increased possibility of water entrapment under the annular plate leading to tank ruptures.
- Identification of this corrosion can be very difficult during internal inspection due to corrosion location (bottom side and near shell-floor joint).
- Floor scanners cannot inspect at the toe of Shell to Annular Plate Inner weld. Traditional UT measurements have limited ability at the weld toe due to access restrictions.
- Significant amount of corrosion may actually be under the inner weld toe and this may be difficult to detect. Corrosion can be very localized (< 1%) of a tank circumference. An onstream tool to inspect this region is needed which can handle small projection chimes, poor surface condition and find corrosion close to the weld toe inside the tank to prevent failures

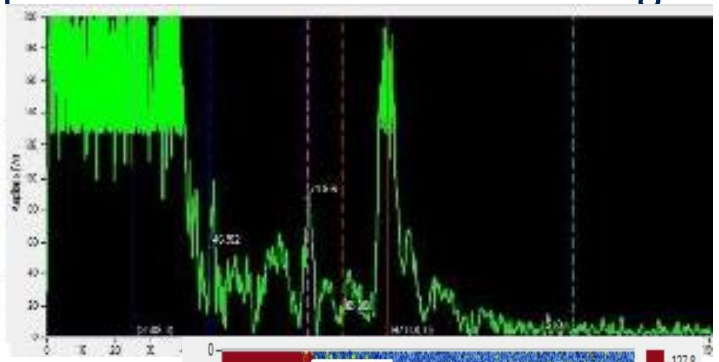


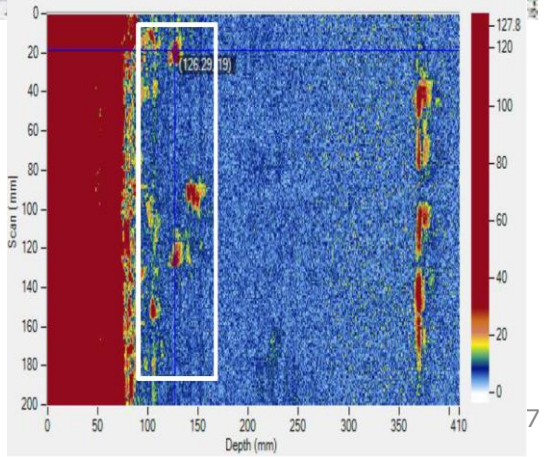
Source: Escon Dhvani

NDE 4.0 for Critical Zone

- A new concept for the improved inspection of corrosion at annular plate in the near shell wall region of storage tanks using a short-range ultrasonic guided wave technique that uses a collection of Higher Order Modes Clusters, called here as ***HOMC****has been developed and verified at several field sites by Escon Dhvani research team. Ultrasonic guided waves, once generated will be reflected from corrosion in the plate. Inspection can be carried out from outside the tank using the accessible portion of the plate. Weld toes, uneven surfaces or paint coatings do not come in the way of inspection using HOMC technique. A robotic scanner called TAPS (Tank Annular Plate Scanner) has been developed and tested for automating the inspection process.







Source: Escon Dhvani

System Reliability

- Robotics and automation improve safety through dependable POD by virtue of reducing human factors and increasing precise execution. In addition, robots can protect the inspector from risks associated with confined space and hazardous areas
- AR improves visualization of anomalies, leading to faster and more reliable interpretation; AI has the potential to significantly reduce false calls through data correlations and increase the accuracy of diagnoses.

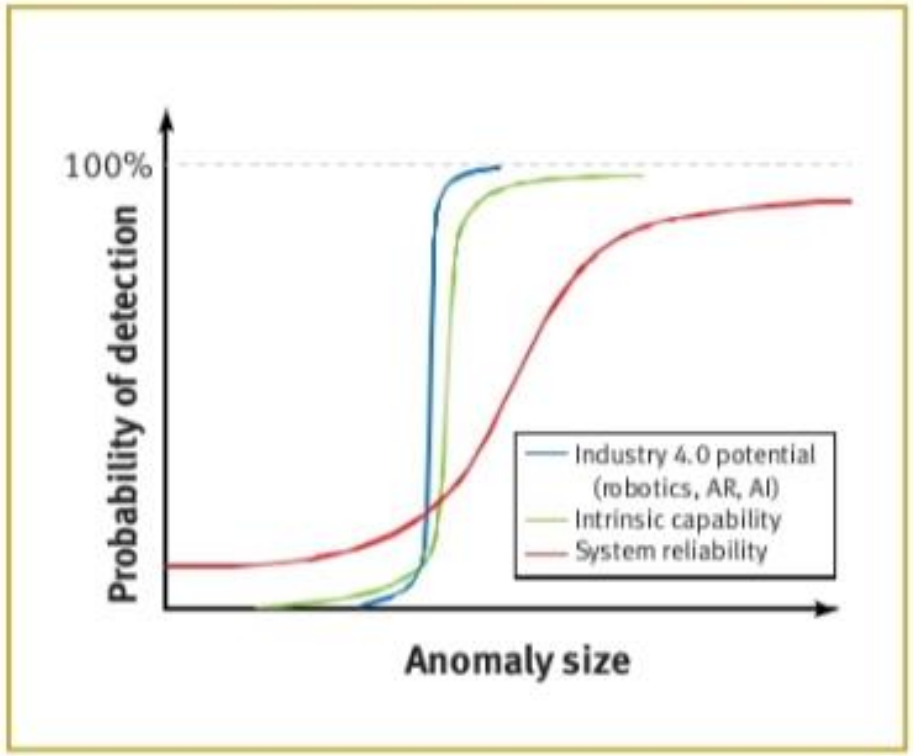


Figure 1. Industry 4.0 technologies have the potential to move system reliability closer to intrinsic capability, and even go beyond, making the POD curve rise up steeply toward the 100% mark.

Ref: Purpose & Pursuit of 4.0, July 2020 ME

Conclusion

- NDE 4.0 improves reliability to near 100% and it summates the physical technologies, It creates economic value by assuring the safety of storage infrastructure and assets. I do expect a complete monitoring system to be established for storage with a cradle to grave system includes the continuous API 653 monitoring and life extension program.

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