





Hervé Vaudrey – DEKRA SE I Antwerp – Sept. 2022



European Conference on Plant & Process Safety 2022

#### **Inspector Fainted**

#### EPSC Learning Sheet June 2022

#### What Happened:

During a tank inspection an inspector put his head inside a tank and fainted as there was a nitrogen atmosphere. Co-workers saved him from asphyxiation.





- Clarify the task and document the risk analysis. What will be done and how? What risks exist and must be excluded? The permit to work mentioned "tank inspection through the manhole". It was not recognized that this would require a tank entry.
- Prior to inspection the tank was cleaned with nitrogen gas and the manhole was opened. Operation did not consider the remaining Nitrogen as a hazard, did not place a sign "Do
- not enter" or prohibited tank entry physically. The inspector did not use an oxygen sensor to test the atmosphere before putting his head in the vessel.



- Filling your lungs with Nitrogen gas makes you faint very quickly and kills many in industry.
- Never do a tank entry alone and assure a person at the manhole is available for emergency response.
- Tank entry is a hazardous operation that requires good preparation including testing of the atmosphere.

#### Inert gas in a confined space is deadly

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## **Introduction & Goals**

Goals of this talk :

- Highlight the problem
- Provide solutions





### Confined Space is a KILLER Some stats & facts

- It is estimated that over 200 people die worldwide every year as a result of an accident in confined spaces.
- 2/3 of those accidents are caused by a toxic/asphyxiating atmosphere present before entering the confined space mainly H<sub>2</sub>S, CO & N<sub>2</sub>.
- 60% of deaths involve people who wanted to save others.
- 57% of employers have no emergency plan for rescue from a confined space. (Californian survey)

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Italy	16 398	17 375	18622	22 240	23 404	24 371	
Spain	12 283	13 153	13674	14 667	15 691	17 481	

# accidents leading to 4+ lost days reported as crushed, trapped, ... (Source: Eurostat)



# **Confined Space is a KILLER**

### Yet another sad example

In August 2022, a French worker died from  $H_2S$  intoxication 2 days after entering a 5m high pit in a biogas plant

## L'un des ouvriers intoxiqués dans une unité de méthanisation de l'Aisne est décédé

Ils étaient deux ouvriers à entrer dans une partie technique d'une unité de méthanisation d'Anguilcourt-le-Sart, dans l'Aisne, lundi 22 août. L'un d'eux est décédés mercredi 24 août.





### **Confined Space is a KILLER** Yet another sad example

- In September 2020, a fire started inside the upflow tower when the heat gun fell into a five-gallon bucket containing flammable resin. The Blastco workers inside the upflow tower successfully escaped the fire and evacuated the vessel.
- However, smoke and flames quickly spread to the connected downflow tower, fatally injuring two Rimcor workers there

CSB Video <u>here</u>





## **Confined Space : Cost of Safety**

It can <u>rightly</u> cost a lot !



#### NEWS RELEASE

**Release Number: Date:** May 19, 2022 2022-42

**Concord**—The Cal/OSHA Process Safety Management Unit has cited Valero Refinery of Benicia and three contractors a combined \$1,753,375 for serious safety violations following a confined space death of a 35-year-old worker who suffocated in a regenerator overflow well. Cal/OSHA inspectors cited three of the four employers with willful and serious violations after determining that they failed to follow confined space guidelines, including the failure to determine acceptable entry conditions for the employee, which resulted in exposure to an oxygen-deficient atmosphere.

Shortly before midnight on November 12, 2021, the worker lost consciousness after descending into a regenerator overflow well at the Benicia refinery to evaluate the condition of the well interior and perform cleaning operations in advance of a welding crew. He was found inside the regenerator suspended by fall protection equipment. A refinery emergency rescue team retrieved him. Benicia Fire Department and Valero Refinery Fire Department performed medical treatment on-site but were unable to resuscitate him.



### What can we do then ?

- DO NOT SEND HUMANS IN CONFINED SPACE : SEND ROBOTS AND DRONES INSTEAD !
- Several companies have edicted it as an intrinsically safe goal
- Several major companies are now aiming for "no more human entries in confined spaces", applying the "What You Don't Have Can't Leak" principle of Trevor Kletz.
- Insurance companies also pushing hard in that direction and will treat differently those that are progressively adopting those techniques when risk is reduced at the source.





### **Benefits of Robotic Solutions are multi-fold**

- Safety improvement: human safety (no human entry into confined spaces) as well as environmental safety
- Cost avoidance and reduction (also related to insurances)
- Minimized preparation needs (predominantly cleaning and work environment) for human entry of confined spaces, such as tanks and pressure vessels
- Reduced scaffolding
- Reduced removal and renewal of insulation
- Environmental performance improvement: reduce production of (toxic) waste,
- Avoid leakage and catastrophic events
- Increase the quality and content of an inspection









### **DEKRA SOLUTION APPROACH**

Avoiding Human Entries into Confined Spaces

Image: construction of the second s	Robotic Inspection	Online Monitoring & Inspection from outside	Virtual Reality & Augmented Reality
	<ul> <li>BIKE</li> <li>Vacuum Crawler</li> <li>Customized Visual Inspection Systems</li> <li>SCOUT 137</li> <li>MATRICE 300 Drone</li> <li>ELIOS 2 Drone</li> <li>Special Requests</li> </ul>	<ul> <li>RMS Corrosion Mapping</li> <li>Accutrak Corrosion Mapping</li> <li>FORCE AGS-2 Scanner</li> <li>Guided Wave</li> <li>OMS Wall Thickness</li> <li>OMS Corrosion under Insulation</li> <li>OMS Boiler Fatigue</li> </ul>	<ul> <li>SLAM &amp; 3D-LOC</li> <li>+ Future Collaborations</li> </ul>





Cage Drone for narrow spaces

Outdoor Inspection in Heights and 3D Mapping with Matrice 300 drone



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Structures with Scout DI drone

10

## **Special Requests**

Own **design solutions** for inspection challenges

In case special developments are necessary, DEKRA has 3 specialized mechanized NDT units in Sweden, Germany and Netherlands.

The first manipulator is designed for:

- Ultrasonic & eddy current testing
- Manipulator can climb into the inspection area
- Two probes holder for faster performance
- Minimum space 23 mm between pipe and obstacles
- The inspection includes detection, characterization, length and height sizing of longitudinal and circumferential defects in the pipe
- Designed to operate in narrow gaps
- Reduce time for inspection
- System and service from a single source

Second Manipulator VT Inspection.











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## **Typical applications**

- Coal fired boiler inspection
- Condenser inspection
- Storage tank inspections
- Circulating water filtration tank inspection
- Reactor inspection
- Subway tunnel inspection
- Pipe inspection
- ...and much more confined spaces where human entries should be avoided





## **DEKRA** as partner to avoid working in confined spaces

What can we deliver to our partners

- More than 1.400 enthusiastic NDT operators
- Unified training program in all participating countries
- NDT inspectors with robotic experience
- Experienced project management with proven track record in multiple plant shutdowns
- One central contact person towards our customer for all activities during delivery phase in whole Europe.



- One report form standardized for all involved units
- NDT, advanced NDT and robotized inspection from one supplier
- Full repeatability of the inspection results
- Interdisciplinary knowledge based on longterm experience in Material Testing, Inspection, Failure Analysis and Material Consulting.

- Innovative solutions, besides the strategical partnership for off the shelf robotic solutions
- DEKRA has three own NDT hubs (NL, GER and SWE) which can develop customer specific solutions.



- Team of robotic inspections with adeqated trainings with Europe wide same quality procedures
- DEKRA NDT is accredited acc. to ISO/IEC 17025 and certified acc. ISO 14001, as well as ISO 45001 or comparable.



### About the speaker



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## Hervé VAUDREY

### **VP Global Sales Management - DEKRA Corporate**

A passionate process safety professional with extensive chemical and pharmaceutical sector experience.

Experienced lecturer in a wide range of process safety subjects in the last 20 years. He has given over 100 process safety trainings worldwide (France, UK, Spain, Netherlands, India, China) in French, English and Spanish

He's currently VP Global Sales at DEKRA Corporate looking after key accounts of the process industries and international tenders and contracts in that sector.

### DEKRA would be delighted to discuss further any robotic inspection matter



# Thank you, for taking care of SAFETY

For more information, please visit: www.dekra.com/en/confined-spaces





### **BIKE Magnetic crawler**

Inspection System with 3D Lock

![](_page_15_Picture_2.jpeg)

#### High Mobility

Ability to climb vertical walls, inside and outside pipe structures and pass over complex combinations of convex and concave step obstacles.

#### Lightweight & Compact

With a total weight of less than 10 kg it can be deployed through a 12" (300mm) man-way. Operation on outside pipe starts at 15" pipes (400mm).

#### Modular & Versatile

Can be equipped with inspection technology such as pan-tilt cameras, UT probes and ECT probes, allowing the operator to use the equipment he already has.

### • <u>3D LOC</u>

DEKRA is also using a special localization system, The system is able to localize itself and automatically links the captured image with the correct asset-coordinates. In normal sized pressure vessels and tanks the accuracy and repeatability is  $\pm 25$ mm ( $\pm 1$ "). Also, the technology provides full 3D spatial awareness of the robot in the asset and a 3D interactive robot control. For the operator this means precise and easy to use navigation capabilities. Inspection data such as Images, UT thickness measurements, Eddy Current Data etc. captured with a 3D LOC equipped robot are tagged with the position in the asset and integrated with the 3D Digital Twin.

![](_page_15_Picture_11.jpeg)

## Vacuum Crawler

Various inspection methods on smooth surfaces

![](_page_16_Picture_2.jpeg)

#### DEKRA is using vacuum crawlers from Invert Robotics to perform inspections on nonmagnetic surfaces like in glass lined vessels.

The hybrid version of Invert Robotics' inspection platform can be used on any smooth surface thanks to its 2 independent adhesion methods. Especially well-suited for use on sensitive surfaces or the inspection and maintenance of glass-lined vessels thanks to its adhesion redundancy capabilities.

DEKRAs' specialists are trained to use the robots that adhere to any magnetic surface, as well as coated, glazed or stain-less-steel surfaces.

Follow inspections and see the results even at a distance: our robotic platform sends images and findings to you as it crawls over the surface of to be inspected assets.

Wherever in the world they're needed, our small and robust robots – with ditto carrying case – can be deployed instantly and travel anywhere as check-in luggage.

We are capable to do following NDT techniques with our vacuum crawlers:

- VT Testing Spark Testing
- UT Testing Laser Surface Mapping

![](_page_16_Picture_11.jpeg)

## Digitalization for safe Inspections

SLAM example from Scout DI

![](_page_17_Picture_2.jpeg)

![](_page_17_Picture_3.jpeg)

#### Scout DI and DEKRA

Provide worry free, efficient and high quality "no entry" indoor inspection.

![](_page_17_Picture_6.jpeg)

#### Cloud based data management Live Stream, Secure data storage & housekeeping, Data sharing

![](_page_17_Picture_8.jpeg)

Off – site stakeholders and decision makers participate remotely Live Streming, Location tagging, Camera feed with

![](_page_17_Picture_10.jpeg)

#### Data Insights Global 3D map of internal structure, Location tagged data, flight path tracking

![](_page_17_Picture_12.jpeg)

![](_page_17_Picture_13.jpeg)

## Standard Cameras, Endoscopes and Crawlers

ATEX Zone I Inspection and fast deployment cameras and robots

![](_page_18_Picture_2.jpeg)

- DEKRA Inspectors are also highly trained in use cameras and endoscopes to perform indirect VT Inspection in confined spaces;
- With our 3 development companies we developed high end and robust camera solutions – also with ATEX 1 certification;
- DEKRA is also capable of developing a specific solution for special inspection needs;
- The camera crawler vehicles for pipeline inspections from DN100 to DN1600 are robust and steerable. It comes with different sized camera and lightning systems depending on the asset that needs to be inspected.
- Also, DEKRA Specialists are well trained in push camera system. Push camera systems are one of the fastest and easiest ways for visual inspections. With a push camera, inspections of pipelines and containers can be carried out in the shortest possible time, and unnecessary disassembly is no longer necessary. Different camera heads are used for different applications. A small opening is sufficient to obtain large and wide views of components or pipelines. By using a wide variety of push camera systems, it is possible to achieve the best results. For example, weld seams can be inspected 360 degrees with a pan-tilt camera head and examined for a wide variety of defects. It is possible to inspect pipes with different diameters and lengths (up to 60m) for dirt, blockages, or damage.

![](_page_18_Picture_8.jpeg)

# Scout 137 Drone

Drone Inspection in Confined Space with SLAM

DEKRA has a cooperation with Scout DI to use the Drone System in confined spaces. The System has been specifically designed to have control, coverage, and situational awareness for your confined space inspection activities.

Often flying in GPS-denied environments, the Scout 137 has an onboard 3D Lidar in stead of a GPS. The Lidar serves as the perfect data source for the drone's indoor positioning while also providing a useful visual support to the drone operator.

The drone tether system provides power to the drone and allows stress-free inspection with no limitations on flight time. It provides a robust wired data link, where location-tagged inspection data flows back to the ground station and can further be streamed live to the Scout Portal, when an internet connection is provided.

![](_page_19_Picture_5.jpeg)

![](_page_19_Picture_6.jpeg)

![](_page_20_Picture_0.jpeg)

### Matrice 300 Drone

#### **Outdoor Inspection in Heights and 3D Mapping**

Drones help with the first step—inspections. By sending a UAV into a situation that would be dangerous for a person, like into a chimney or up a cell phone tower, our inspectors are able to collect visual data about the condition of an asset without having to expose themselves to potential harm.

DERKA is using drones for indoor and outdoor inspections. For our outdoor inspection we are using the DJI Matrice 300 RTK drone. We are capable of doing Thermography, Visual Inspections with RBG camera.

DEKRA is also using photogrammetry to create digital twins of our customer assets.

![](_page_20_Picture_6.jpeg)

![](_page_20_Picture_7.jpeg)

### Elios 2 Drone Inspection with Cage Drone for narrow spaces

DEKRA Inspectors are also using the Elios 2 cage drone to avoid human entry into confined spaces. The drone features 7 stability sensors specifically designed for indoor allowing it to hover in place and easily navigate through unstructured spaces.

It enables our inspectors to perform smooth inspections of long and repetitive features like welding, or beams. With the distance lock, Elios 2 remains at a set distance, ranging from 30 cm to 200 cm (1 - 6 ft) autonomously.

When it comes to visual inspections, data is what matters. So Elios 2 payload in the front cage-opening is fitted with a thermal and a 4K camera side by side. 12MP still and video recording gives you stunning detailed images with 0.18 mm/px resolution to spot the tiniest cracks from floor to ceiling.

To reveal textures and identify defects, inspectors use a lighting technique that creates shadows in asperities. Reproducing this technique with our new oblique lighting systems, looking for pitting, cracks, or build-ups becomes as natural as doing it with a flashlight.

![](_page_21_Picture_5.jpeg)

![](_page_21_Picture_6.jpeg)

## **Special Requests**

Own **design solutions** for inspection challenges

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Second Manipulator VT Inspection.

![](_page_22_Picture_13.jpeg)

![](_page_22_Picture_14.jpeg)

![](_page_22_Picture_15.jpeg)

![](_page_22_Picture_16.jpeg)

![](_page_22_Picture_17.jpeg)

### Inspection from Outside with RMS / Corrosion Mapping Avoiding Confined Space

Advanced UT Corrosion Mapping is performed utilizing the Silverwing equipment (Eddify). These equipment's uses sophisticated hardware, software integrated scanner control, data capture, data analysis and reporting tools. The software shows a real-time display of the ultrasonic A-scan, C-scan, thickness measurement and positional data, with a maximum resolution of 0.5 mm x 0.5 mm. All of this information is recorded when a scan is saved.

The RMS Corrosion Mapping scanner utilizes an ultrasonic beam directed through a water column into the test specimen. The spring loaded probe holder keeps the probe on the surface maintaining constant pressure.

High temperatures assets up to 200°c could be inspected.

#### **Typical applications**

- Storage tank shells and roofs
- Horizontal storage tanks
- Pipelines
- Pressure vessels
- Spheres

Semi-Automated technique – to be used from external of the vessel, once a problematic area has been identified with an visual inspection internally.

![](_page_23_Picture_11.jpeg)

![](_page_23_Figure_12.jpeg)

![](_page_23_Picture_13.jpeg)

# ACCUTRAK AUT Solution/ Automated Corrosion Mapping

Avoiding Confined Space

Automated Steerable 3-Axis Scanner/Crawler for Corrosion Mapping, TOFD & Phased Array Weld Inspection. The AccuTrak truck assemblies rotate in multi-axis to allow near-perfect wheel contact to a flat or curved surface using its two powerful X-axis drive motors and magnetic wheels to help propel the scanner and umbilical vertically with little load, even when crossing over weld seam. The AccuTrak is also capable of performing automated weld tracking to track the scanner to the centerline of a weld automatically.

#### Typical applications,

- Tank corrosion mapping
- Flaw detection inspections
- Weld exams / line B and C-scans
- Axial OD pipe scanning
- Vessel weld scanning
- Center mount weld scanning
- Spiral weld inspection

![](_page_24_Picture_11.jpeg)

![](_page_24_Picture_12.jpeg)

![](_page_24_Picture_14.jpeg)

## Force AGS-2 scanner and P-Scan stack

Avoiding Confined Space

The AGS-2 is a steerable, general purpose magnetic wheel XY scanner. It is primarily designed for remote controlled weld inspection and corrosion mapping of ferritic pipes, large structures and areas with difficult access.

#### **Features**

- Use of standard modular scanner components
- High X and Y speed operation
- Geometrical flexibility
- Curved Y-modules is available as option for longitudinal inspection of pipes
- Steerable by means of a remote control
- Automatic tracking by means of optional inclinometer
- Guiding by means of magnetic guide strip and optional analog guide/proximity sensors.

#### **Output is in Excel**

Typical statistical evaluation: for each 200 mm scan length; Specification of minimum and mean values as well as ultrasound C-images.

![](_page_25_Picture_13.jpeg)

### **Guided Wave** Avoiding Confined Space

Also referred to as "Long Range Ultrasound".

"guided waves in the low-frequency" range

Area of application: CUI (insulated lines), underground lines, road and tank wall penetrations), conditionally also for CUPS

Requirements: Accessibility to an area must be given (positioning of the test rings)

Range: up to approx. 50 m on both sides of the test ring

Restrictions: The test range generally ends with fittings -reduced by pipe clamps, sockets and casings -up to 150°C possible test range very dependent on local conditions and media

![](_page_26_Picture_7.jpeg)

![](_page_26_Picture_8.jpeg)

## **UT Wall Thickness**

Online Monitoring System

#### Internal Corrosion/Erosion

# Improve insight with two orders of magnitude

Our methods cover:

- No need for repeated access to hazardous or hard to reach areas, just install once and get updated information every week, day or even hour
- Monitor sections high in a column or buried under the road, saving cost and keeping staff safe.
- Closely and safely follow up on degradation found during inspection, getting a reliable corrosion rate estimate within weeks, not months.

![](_page_27_Picture_8.jpeg)

#### Benefits

- Degradation rate estimate improves two orders of magnitude
- More accurate replacement/repair planning
- Keep equipment running until a planned shutdown
- Optimize integrity operating windows, rather than mitigate corrosion

![](_page_27_Picture_14.jpeg)

### **OMS Wall Thickness**

![](_page_28_Figure_1.jpeg)

### **CUI** Corrosion under Insulation Online Monitoring System

# Integral approach to one of industry's biggest challenges

Our services cover:

- CUI-specific risk analysis
- Specific and qualified expertise regarding regulation, NDT, coating, insulation and QA/QC
- NDT selection and planning to minimize related cost (e.g. scaffolding)
- Visual inspection, conventional NDT and Advanced NDT techniques combined
- Permanent monitoring of high risk locations

![](_page_29_Picture_8.jpeg)

#### Benefits

- Reduce loss-of-containment incidents and unplanned downtime
- Fact-driven, risk-based inspection
- Leverage the benefits of advanced NDT & CUI inspection tools
- Reduced overall cost of CUI management

![](_page_29_Picture_14.jpeg)

## **Boiler Fatigue**

Online Monitoring System

#### **Pressure Equipment**

# Monitor your pressure equipment's lifetime

Our methods cover:

- Monitoring temperature and pressure cycles to predict fatigue of pressure equipment
- Combine process control data, targeted IIoT sensors and Digital Twin models
- Customized regulatory watching tool
- Overview of all connected assets and their remaining life predictions
- Combine with SPICA creep monitoring and/or wall thickness monitoring

![](_page_30_Picture_10.jpeg)

### Benefits

- Clear overview of safe remaining service life of pressure vessels
- Optimize integrity operating windows, rather than mitigate damage
- Save time and money reducing downtime for repair and maintenance

![](_page_30_Picture_15.jpeg)

### **DEKRA SOLUTION APPROACH**

Avoiding Human Entries into Confined Spaces

Image: construction of the second s	Robotic Inspection	Online Monitoring & Inspection from outside	Virtual Reality & Augmented Reality
	<ul> <li>BIKE</li> <li>Vacuum Crawler</li> <li>Customized Visual Inspection Systems</li> <li>SCOUT 137</li> <li>MATRICE 300 Drone</li> <li>ELIOS 2 Drone</li> <li>Special Requests</li> </ul>	<ul> <li>RMS Corrosion Mapping</li> <li>Accutrak Corrosion Mapping</li> <li>FORCE AGS-2 Scanner</li> <li>Guided Wave</li> <li>OMS Wall Thickness</li> <li>OMS Corrosion under Insulation</li> <li>OMS Boiler Fatigue</li> </ul>	<ul> <li>SLAM &amp; 3D-LOC</li> <li>+ Future Collaborations</li> </ul>

# Digitalization for safer Inspections

**SLAM** Simultaneous Localization and Mapping

- Minimum preparation required
- ☑ Good 3D Screening
- Point clouds can be used to create 3D files by meshing
- No correlation between missions
- No baseline for data storage
- Low accuracy due to noise
- High computing power required

- Accurate 3D Model required before deployment
  - High preparation effort incl mission planning
    - No "live" pointcloud

Accurate Localization and Navigation in Confined spaces

![](_page_32_Picture_12.jpeg)

**3D LOC** 

![](_page_32_Picture_13.jpeg)

## **Digitalization** for safe Inspections

### ASSET IN 3D

![](_page_33_Picture_2.jpeg)

Existing CAD

### **PLANNING AND SIMULATION**

- Detailed preparation is key for a successful robotics deployment
- Trained operators are a must
- DEKRA performs deployment / proof of concept

### DEPLOYMENT

- No human entry in confined spaces
- No scaffolding
- Remote operated

![](_page_33_Picture_12.jpeg)

![](_page_33_Figure_13.jpeg)

![](_page_33_Picture_14.jpeg)

![](_page_33_Picture_15.jpeg)

![](_page_33_Picture_16.jpeg)

![](_page_33_Picture_17.jpeg)

![](_page_33_Picture_18.jpeg)

![](_page_33_Picture_19.jpeg)

### **DEKRA SOLUTION APPROACH**

Avoiding Human Entries into Confined Spaces

![](_page_34_Picture_2.jpeg)

### Additional Solutions with Collaboration Partners of DEKRA

![](_page_34_Picture_4.jpeg)

Asset:	Inspection Method:	Mechanized/ Robotic Equipment: Internal Inspection	Advanced NDT Equipment: External Confirmation Testing	Personal Qualification
Storage Tanks (Above Ground)	(X-Ray, normally not mandatory but possible)			
Annular Plates	UT/PAUT/TOFD Inspection	BIKE & Vacuum Crawler	Olympus, Eddify, Zetec	ISO 9712 - UT: VT: ECT (Level 2)
Teal. Dettern				
		Floomap Scanner (Manual) & ATEX Tremole scanner		
Nozzle Welds	EC/ ACFM (internal weld inspection)	BIKE & Vacuum Crawler	Eddify/Olympus	ISO 9712 - UT; VT; ECT (Level 2)
Internal Piping	UT mapping (C-Scan)	BIKE & Vacuum Crawler	automated)	ISO 9712 - UT; VT; ECT (Level 2)
Bottom Plate (Fillet Welds)	UT spot measurement (wall thickness)	ATEX 1 automatic scanner	Scorpion B-Scan Crawler	ISO 9712 - UT; VT; ECT (Level 2)
Tank Shell	Remote visual using camera	BIKE & Vacuum Crawler		ISO 9712 - UT; VT; ECT (Level 2)
Tank Shell (Vertical Welds)	UT Testing	BIKE & Vacuum Crawler	ACCUTRAK	ISO 9712 - UT: VT: FCT (Level 2)
Full Internal Scan	3D Laser Scan	Scout DI	Manual Scan	Manufacturer Trained/ Certified
		Endoscopes, Full HD Cameras, crawlers, ATEX 1		
External Piping	VT Inspecion	cameras	BIKE & Vacuum Crawler	ISO 9712 - UT; VT; ECT (Level 2)
	1	1		
Storage Tanks (Below Ground)				
Annular Plates	UT/PAUT/TOFD Inspection	BIKE & Vacuum Crawler		ISO 9712 - UT; VT; ECT (Level 2)
Tank Bottom	Floorscan	Floormap Scanner (Manual) & ATEX 1 remote scanner		
Nozzle Welds	EC/ ACFM (internal weld inspection)	BIKE & Vacuum Crawler		ISO 9712 - UT; VT; ECT (Level 2)
Internal Piping	UT mapping (C-Scan)	BIKE & Vacuum Crawler		
Bottom Plate (Fillet Welds)	UT spot measurement (wall thickness)			
Tank Shell (Internal)	Visual camera	BIKE & Vacuum Crawler		ISO 9712 - UT; VT; ECT (Level 2)
Tank Shell (Vertical Welds)	UT Testing	BIKE & Vacuum Crawler		ISO 9712 - UT; VT; ECT (Level 2)
Full Internal Scan	3D Laser Scan	Scout DI	Manual Scan	Manufacturer Trained/ Certified
	VT Inspecion	Endoscopes, Full HD Cameras, crawlers, ATEX 1 cameras		ISO 9712 - UT: VT: ECT (Level 2)
Pressurized Tanks/Vessels				
Nozzle Welds	UT/PAUT/TOFD Inspection,	BIKE & Vacuum Crawler	Olympus, Eddify, Zetec	ISO 9712 - UT; VT; ECT (Level 2)
	UT/PAUT/TOFD Inspection, X-Ray, Digital X-			
Circular & Long Welds	Ray	BIKE & Vacuum Crawler	Olympus, Eddify, Zetec, ACCUTRAK	ISO 9712 - UT; VT; ECT (Level 2)
Tank Shell (Insulated)	PEC (CUI detection)		PMC Crowler, DALIT increation (comi or fully)	
Tank Shell (Non-Insulated)	UT mapping (C-Scan), X-Ray, Digital X-Ray		automated)	ISO 9712 - UT; VT; ECT (Level 2)
Pining	X-Ray, Digital X-Ray	Isotone Crawler		ISO 9712 - UT; VT; ECT; RT (Level
	Acoustic emmision testing			<u>~,</u>
			Endoscopes, Full HD Cameras, crawlers, ATEX 1	
	v i inspeción	BIKE & Vacuum Crawler	cameras	ISO 9712 - UT; VT; ECT (Level 2)

![](_page_35_Picture_1.jpeg)