

# In-Service Inspection of Ammonia Storage Tanks

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*Personnel ready for mounting the Inspection System in habitat*

This paper describes technologies, methods and results of In-Service Inspection of Insulated Atmospheric Ammonia Storage Tanks, and provides valuable information, enabling the correct and beneficial choice of method for inspection of welds in Ammonia Storage Tanks.

## Abstract

In-service inspection of Ammonia Storage Tanks provides a significant economical benefit compared to decommissioning and traditional internal inspection of the tank.

In addition in-service inspection eliminates the potential threat to the integrity of the tank letting Oxygen inside the tank, which may initiate Stress Corrosion Cracking (SCC).

FORCE Technology has developed an Automated Inspection Solution for In-service Inspection of welds.

Our highly skilled workforce has since 2011 proven the benefits of the method through inspection of a number of Ammonia Storage Tanks around Europe.

The fast growing demand for accurate and professional inspection techniques, as well as detailed documentation of Ammonia Storage Tank Welds' conditions, drive continuous improvement of existing technologies and development of new tools to meet customers' needs.

## Introduction

Ammonia Storage Tanks are sensible to Stress Corrosion Cracking (SCC) if they are subjected to Oxygen.

Decommissioning of the tank, cleaning and opening will allow Oxygen to flow into the tank and hence pose a threat to continued use of the tank. When a plant only has one Ammonia Storage Tank a decommissioning may lead to considerable economical consequence. An in-service inspection of the tank will solve this.

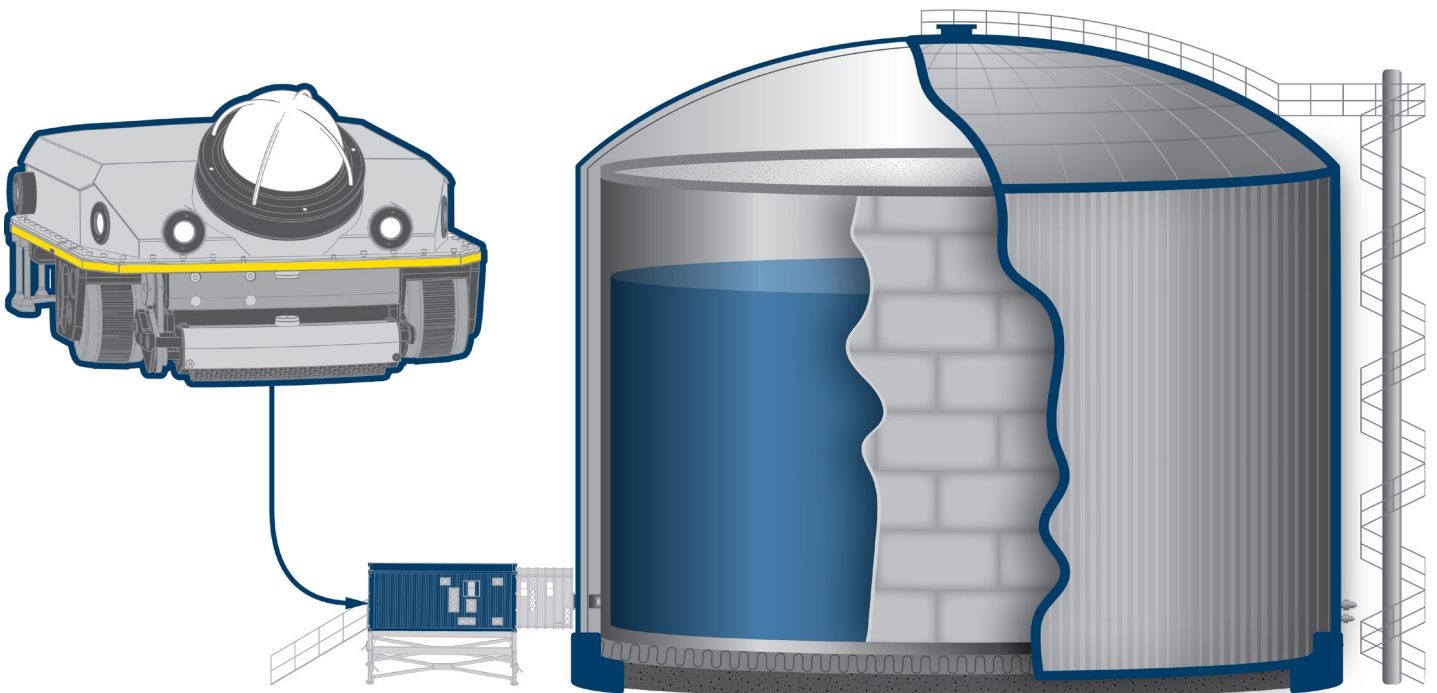
The development of the in-service inspection tool was initiated by a major producer of chemicals who owns a number of tanks worldwide. FORCE Technology has provided automated inspection services for this company for decades and since our inspection solutions are developed and built in-house we have a solid base for this development.

## Design of an Ammonia Storage Tank

An Atmospheric Ammonia Storage Tank is designed with an inner tank without roof which holds the liquid Ammonia and an insulated outer tank with roof. The annular space between the tanks is filled with Ammonia vapor.

The temperature inside the tank is kept at  $-32\text{ }^{\circ}\text{C}$  in order to keep the Ammonia in liquid form.

FORCE Technology was given the task of developing an Automated Inspection System for inspection of welds in the inner tank in an Ammonia Storage Tank, while the tank was in service. The Inspection System should be able to operate in Ammonia vapor and at  $-32\text{ }^{\circ}\text{C}$ .



## History of P-scan

FORCE Technology developed the first automated Ultrasonic inspection system in the 70's and has continuously worked on the improvement of the system since.

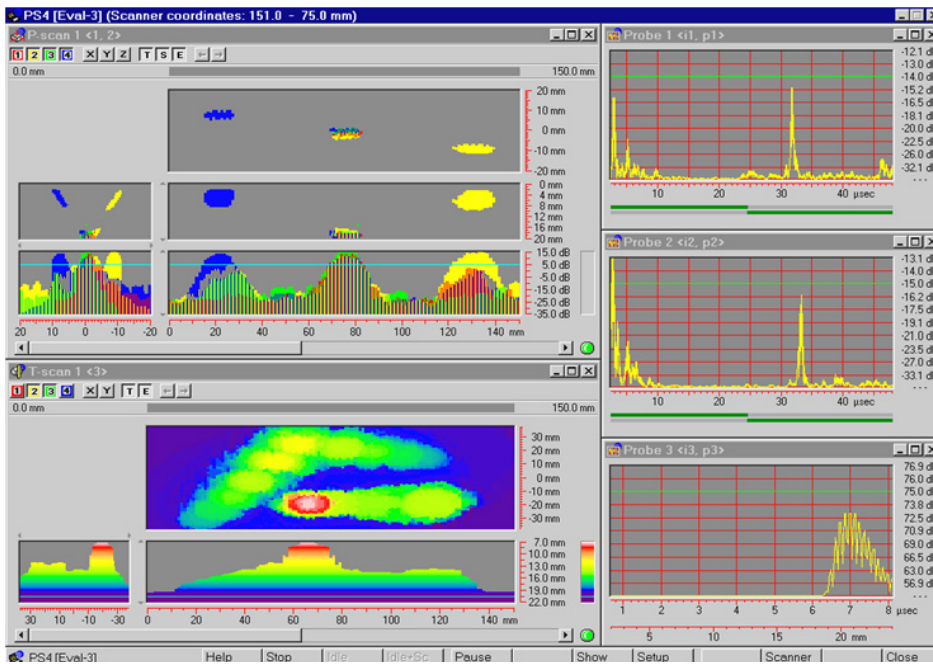
The automated inspection systems are marketed worldwide under the brand name P-scan.

The P-scan system is a computerized Ultrasonic System for automatic, mechanical or Ultrasonic and Eddy Current inspection of welds and materials, developed by FORCE Technology.

Through regular use in the industry, for applications in Chemical Industry, Power plants (conventional, nuclear, wind), Offshore industry (topside and subsea), Refineries, Shipbuilding etc., valuable experience is collected and continuously used to improve the tool.

The P-scan system has documentation and storage facilities for all data related to each inspection operation, including visualization of the inspection results in the form of images of the material volume examined. Storage sources are e.g. hard disk, USB stick, or optical disk.





Example of data presentation in P-scan

### Excellent data and images

The P-scan system provides A-scan, B-scan, C-scan, T-scan (thickness mapping) and ToFD (Time of Flight Diffraction) mode, including averaging for sizing of defects. Furthermore, the system provides projection images of the object under examination, e.g. images of the weld or part of an object. In the three projection images, called TOP, SIDE and END views, the flaws which have been detected are automatically shown at their correct location.

### Capability

The Inspection System has 8 ultrasonic channels which can be fitted with any type of ultrasonic probe, shear wave, compression wave, creep wave or ToFD. The probes can be combined arbitrarily as required by the inspection procedure.

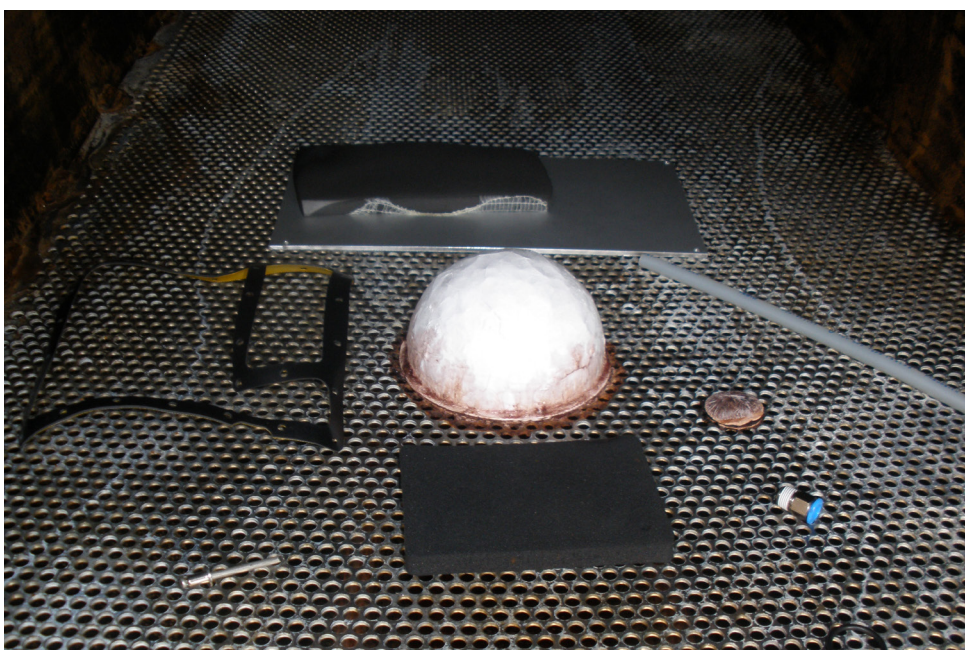
### Development of Inspection System

The development of the Inspection System required extensive testing of all components exposed to the Ammonia atmosphere.

A test chamber was developed for thorough testing of all parts before they were approved for use in the Inspection System.

Ammonia is very aggressive towards Copper, which is a very common component in electronics.

The Inspection Robot, cameras and motors are therefore constantly purged with Nitrogen to ensure that Ammonia does not intrude into any parts.



Parts in Ammonia test chamber

### Inspection setup

In order to access an Ammonia Storage tank while it is in service and filled with Ammonia, it is required to place a habitat at the manhole in the outer tank.

This habitat serves as an outer barrier while the manhole is open and has a controllable atmosphere. The habitat must be purged with Nitrogen while the manhole is open in order to avoid intrusion of Oxygen inside the tank. The habitat is also fitted with a system for flushing with atmospheric air before personnel enter the habitat.



*Habitat and tank with access sluice*

### Mounting of Inspection Tool:

The Habitat is filled with Nitrogen and when it has been verified that the Oxygen level is below the required level specially trained personnel in Chemical Protection Suits enter the Habitat. The suits are supplied with atmospheric air from an external source and exhaled air is expelled outside the habitat. The pressure inside the tank and habitat is equalized before the original manhole cover is removed.

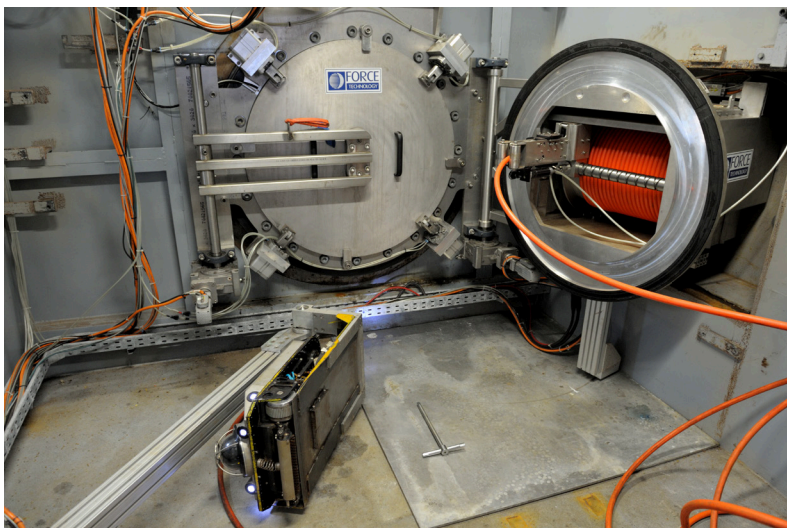
When the cover has been removed the flange face is cleaned

### The complete inspection system consists of:

- Habitat, mounted on the manhole of the outer tank. The habitat contains the remote operated Deployment Tool and Inspection Robot. The habitat acts as outer barrier when the manhole is open and has a controllable atmosphere and pressure to ensure Oxygen does not ingress and the over pressure in the tank is maintained.
- 6' container with electronics and glycol supply for the inspection system.
- 20' container with control room and small machine shop for maintenance and repair of the inspection system.

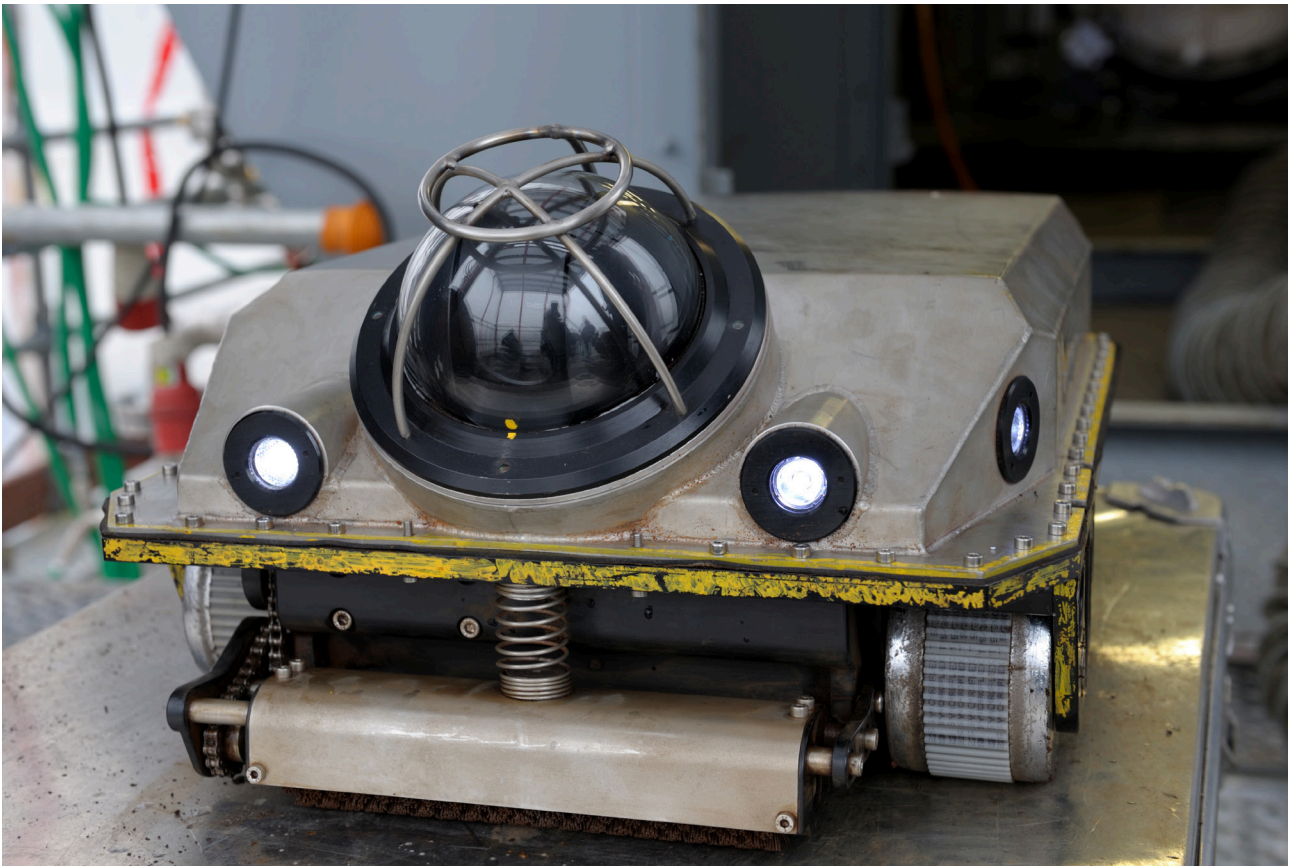
and an intermediate flange is mounted. This is done to ensure enough room between habitat wall and the Deployment Tool. The Deployment Tool flange is mounted together with the remote controlled Sealing Cover, camera and calibration plate in the annular room. Once completed the remote controlled Cover is closed and the tank is sealed.

The atmosphere in the Habitat is normalized and the Deployment Arm, Inspection Robot and Cover with Cable Reel is mounted. When completed the system is ready for inspection.



*Inspection setup in habitat*





*Inspection robot with camera and cleaning brush*



*Control room and shop in front of habitat*

## Inspection of welds

### Purpose

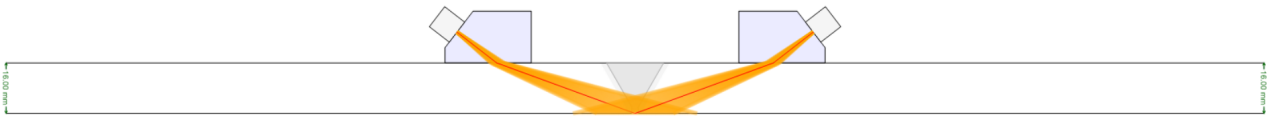
The main purpose of the inspection is to verify that no service induced indications are present in the welds. Welding defects can also be detected, but it is normally assumed that their size is below the original acceptance criteria, and therefore shall not be taken into consideration during development of an Inspection Procedure.

### Inspection Setup

A typical setup for inspection of welds consists of a detection setup with 2 sets of shear wave probes, 1 set perpendicular to the weld and 1 set in a small angle to the weld. The probes are placed on each side of the weld. The figure below shows a setup with 70° probes focused on the inner surface perpendicular to the weld.

### Procedure

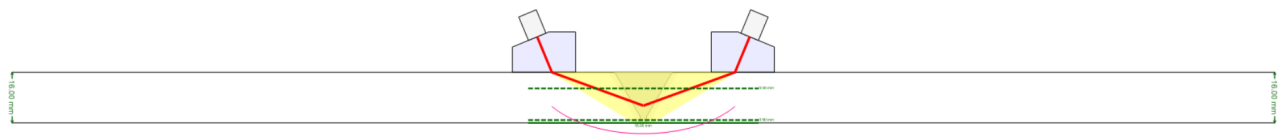
The main issue in the inspection is the concern for SCC in the welds on the inside of the tank; these cracks can be both parallel and transverse to the weld. The Inspection Procedure is therefore developed with focus on detection and sizing of cracks in the welds or heat affected zone (HAZ), and open to the inner surface.



Example of Pulse-Echo probe setup

### Time of Flight Diffraction technique (ToFD)

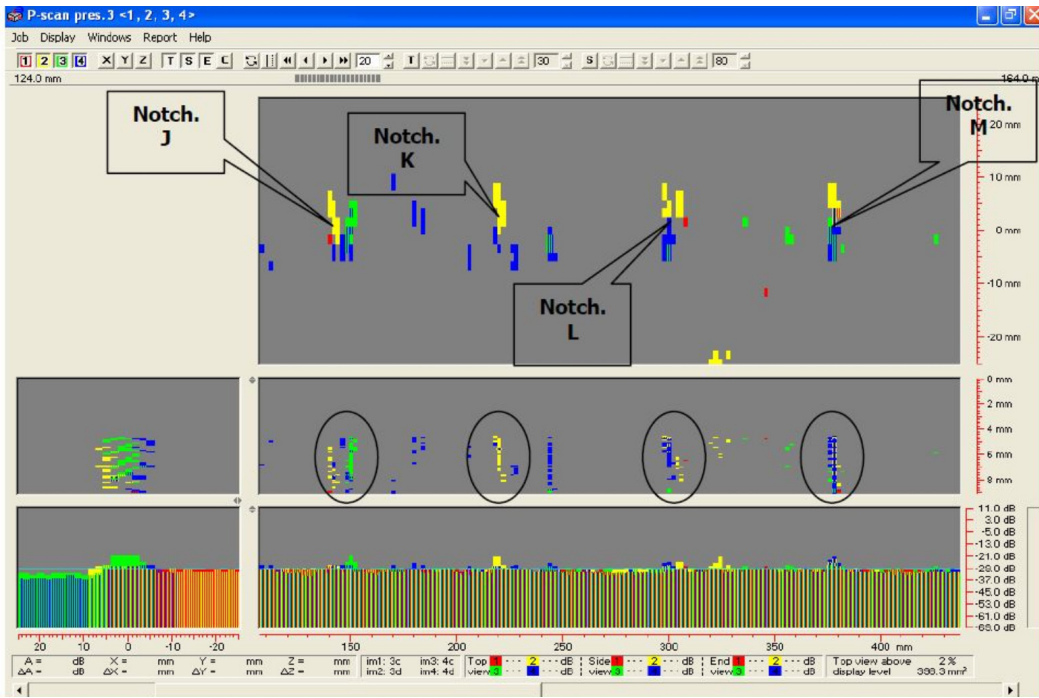
For sizing is used Time of Flight Diffraction technique (ToFD) with one set focused on the inner surface. The figure below shows a setup with 70° probes focused on the inner surface.



Example of ToFD setup

In order to ensure full coverage of the weld and heat affected zone, the whole probe setup is transversed.





Scanning result of 32 mm test plate with defects perpendicular to weld 2-5 mm height

### Qualification of inspection system

The Inspection System has been qualified by testing a number of test plates with different thicknesses and artificial defects of varying sizes.

The test plates were welded with similar welds as a Storage Tank and with artificial defect parallel and transverse to the weld. The qualification showed that defects down to 2 mm height can be detected.

### Safety issues

Although as many processes as possible are automated and controlled remotely, personal is still required to open the manhole and mount the remote controlled hatches.

Detailed procedures are laid out for this work and it is the same specially trained personnel who carries out this task at each site.



Mounting of Inspection System in habitat



### **Conclusions**

The FORCE Technology Ammonia Storage Tank Inspection system has since 2011 proven to perform valuable inspection on various Welds in Storage Tanks, of different sizes and plate thickness.

The Inspection System is fitted with 8 Ultrasonic channels which can be fitted with any type of Ultrasonic probe, shear wave, compression wave, creep wave or ToFD. The probes can be combined arbitrarily as required by the inspection procedure.

FORCE Technology participates in projects involving extensive specialised knowledge, from the initial concept until delivery of the turnkey project.

At completion we document that the customer will gain the expected functionality, efficiency and value-generation.

### **References:**

For download of further material please visit our website [www.forcetechnology.com/ammoniatankinspection](http://www.forcetechnology.com/ammoniatankinspection)

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