

Advanced Aboveground Storage Tank Inspections – In-Service Robotics Tank Inspections

By

Vineet K. Masuraha
Stacy Carr

Trinity Consultants
12801 North Central Expressway, Suite 1200
Dallas, TX 75243
(972) 661-8100
emails: vmasurah@trinityconsultants.com, and
scarr@trinityconsultants.com

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Abstract

This paper describes the advanced in-service tank inspection methods available for use in the inspection of aboveground storage tanks (AST) in the petroleum and petrochemical industry. ASTs are subject to several federal and state regulations requiring tank owners to perform tank floor/bottom integrity, seals system, and deck fittings inspections on a routine basis. The conventional procedure for this type of inspection requires tank owners to drain the tank and clean it with water or solvents, empty sludge residue, and manually inspect the tank. The impacts associated with draining and cleaning the tank, temporarily storing tank contents, waste disposal, excessive emissions, safety hazards, human subjectivity, inaccessibility and inaccuracy, and operational downtime make this procedure inherently a safety risk and undesirable for environmental and economic reasons.

Advanced robotics technologies for tank inspections, which do not require taking a tank out-of-service, are commercially available through several vendors. The robotics technologies use a remotely operated robotic inspection vehicle submerged in the tank liquid for tank floor/bottom and primary seal inspections. The remotely-operated high-resolution cameras are used from the tank top for the deck fittings and secondary seal inspections. The major advantages of using the robotic technologies over the conventional methods of performing tank inspections are improved safety, reduced environmental impact, enhanced quality, and reduced costs.

Introduction

This paper describes the tank inspection requirements (such as New Source Performance Standards [NSPS], 40 CFR 60), conventional inspection techniques (out-of-service, manual, confined space entry, and visual), advanced inspection technologies (in-service robotics), benefits derived from using these advanced technologies, and the status of approval of these technologies by regulatory agencies. The authors also review the unique challenges and implementation circumstances associated with advanced inspection technologies. Finally, the authors present a pilot study currently in progress for the application of advanced inspection technologies to an Internal Floating Roof (IFR) tank subject to NSPS Subpart Kb (Standards of Performance for Volatile Organic Liquid Storage Vessels) requirements.

Regulations and Background

The testing and monitoring requirements for IFR tanks subject to NSPS Subpart Kb (as outlined in 40 CFR 60.113b [a] [4]) are:¹

Visually inspect the internal floating roof, the primary seal, the secondary seal (if one is in-service), gaskets, slotted membranes and sleeve seals (if any) each time the storage vessel is emptied and degassed. If the internal floating roof has defects, the primary seal has holes, tears, or other openings in the seal or the seal fabric, or the secondary seal has holes, tears, or other openings in the seal or the seal fabric, or the gaskets no longer close off the liquid surfaces from the atmosphere, or the slotted membrane has more than 10 percent open area, the owner or operator shall repair the items as necessary so that none of the conditions specified in this paragraph exist before refilling the storage vessel with volatile organic liquid (VOL). In no event shall inspections conducted in accordance with this provision occur at intervals greater than 10 years in the case of vessels conducting the annual visual

inspection as specified in paragraphs (a)(2) and (a)(3)(ii) of this section and at intervals no greater than 5 years in the case of vessels specified in paragraph (a)(3)(i) of this section.

The proposed rule and notice of public hearing for 40 CFR Part 60 NSPS Subpart Kb, published on July 23, 1984, provides the background and rationale behind the ten-year inspection requirements.² An excerpt from the Federal Register (FR) Notice is provided below:

Some failures of the seal system may not be detectable during the visual inspection from the fixed roof. Holes and tears are most likely to develop on the portions of the seal not visible from the fixed roof. Additionally, visibility is limited by lighting and distance problems during the inspection from the fixed roof. Because an internal inspection may detect failures that would otherwise go undetected, there are advantages to requiring that the vessel be emptied and degassed, and an internal inspection of the controls be performed. Inspection of the control equipment from both the underside and top side of the internal floating roof can be performed when the vessel is emptied and degassed.

The EPA then examined the frequency at which inspections should be required. The controls required on the fixed roof vessels have a very low failure rate and are expected to last many years when installed properly. Data indicate that vessels are generally degassed on the average of once every 10 years for inspection as a typical practice. Therefore, if owners or operators were required to perform internal inspections on their vessels at least once every 10 years, this requirement would, on the average, cause no additional degassings of the vessel, and hence no additional emissions.

Consequently, since there are advantages to performing internal inspections on an internal floating roof storage vessel and since they are inspected routinely on the average of every 10 years, the proposed standards require an internal inspection of each internal floating roof storage vessel at least once every 10 years. If a vessel is emptied and degassed to repair a failure detected by an annual visual inspection, an internal inspection must be performed. This inspection will be substituted for the 10-year inspection, and another internal inspection will not be required for another 10 years. This requirement will result in one degassing where two would have occurred otherwise.

Although the United States Environmental Protection Agency (U.S. EPA) concluded that a 10-year cycle of inspection for new tanks would not impose an additional burden on facility operators on the average, there were dissenting opinions during the comment period, particularly from operators of smaller facilities. These included the comments described below:³

2.3.3.2 Ten-Year Inspection

Comment: Three commenters (IV-D-7, IV-D-20, IV-D-39) said that the requirement that IFRs be emptied and degassed at least once every 10 years is unreasonable for facilities with only one IFR or where acceptable alternate tankage is not available. One commenter (IV-D-7) requested that pipeline tank stations with only one IFR be exempt from these requirements or that an operationally compatible method to empty and degas the tanks be allowed.

The Agency did not find merit in the dissenting comments. Their response noted:

As stated in the previous response, tanks in the chemical industry are typically emptied, degassed, and cleaned every 5 years. Benzene storage vessels are typically emptied,

degassed, and cleaned on 10-year intervals. The Agency has determined that it is typical industry practice to clean tanks on a regular basis and that the 10-year internal inspection requirement is not an undue burden. The Agency has determined that no special provisions are necessary for pipeline tanks. In many instances, alternate tankage such as an EFR will likely be available. In any case, it is not unreasonable to require a facility with only one IFR to conduct a planned, internal inspection every 10 years. Further discussion with one of the commenters (IV-D-7) revealed that existing tanks were of concern. This NSPS will not affect existing storage vessels; therefore, no changes have been made as a result of these comments.

Conventional Inspection Methods (Tank Out-of-Service)

The conventional methods present serious safety and environmental challenges. The IFR tank is to be taken out-of-service, emptied, and degassed. This results in potential air emissions (or the need to collect and incinerate, or otherwise dispose of the vapors), operations downtime, possible generation and disposal of hazardous waste, cost of temporary storage of tank contents, and the cleaning and maintenance of the temporary storage vessel.

The detailed procedure in common use by industry in conducting the 10-year IFR tank inspection is outlined below in the following steps.

Step 1. Tank Preparation:

- Tank roof entry [made using confined space entry in order to set roof legs on high level (if allowed)]
- Alternative storage of product
- Product transfer
- Tank lock-out/tag-out
 - Valve alignment
 - Line blanking
 - Ventilation
 - Atmosphere monitoring
 - Emissions monitoring
 - Regulatory compliance documentation

Step 2. Tank Entry

- Safety plan review
- Confined space training
- Personnel protective equipment training
- Open permitting
- Personnel liability issue resolution

Step 3. Tank Cleaning

- Atmospheric monitoring during cleaning
- Transfer and processing from cleaning
- Waste generation reporting
- Waste transportation
- Waste disposal
- Tank degassing

- Pollution liability issue resolution
- Use of lifts or jacks to raise roof to set on high tank leg level in order to allow sufficient working space (if legs were not set on high level)

Step 4. Tank Inspections

- Tank bottom integrity
- Tank bottom settling
- Shell integrity
- Weld seam deterioration
- Roof integrity
- Seal tightness
- Deck fittings tightness

Step 5. Return Tank to Service

- Tank hydrotesting (if appropriate)
- Set legs on normal (low) level while roof is in float with water during hydrotesting
- Lock-out/tag-out removal
- Line blanking removal
- Valve re-alignment
- Product transfer
- If water was not used to float roof, set legs on normal (low) level after roof is sufficiently in float.

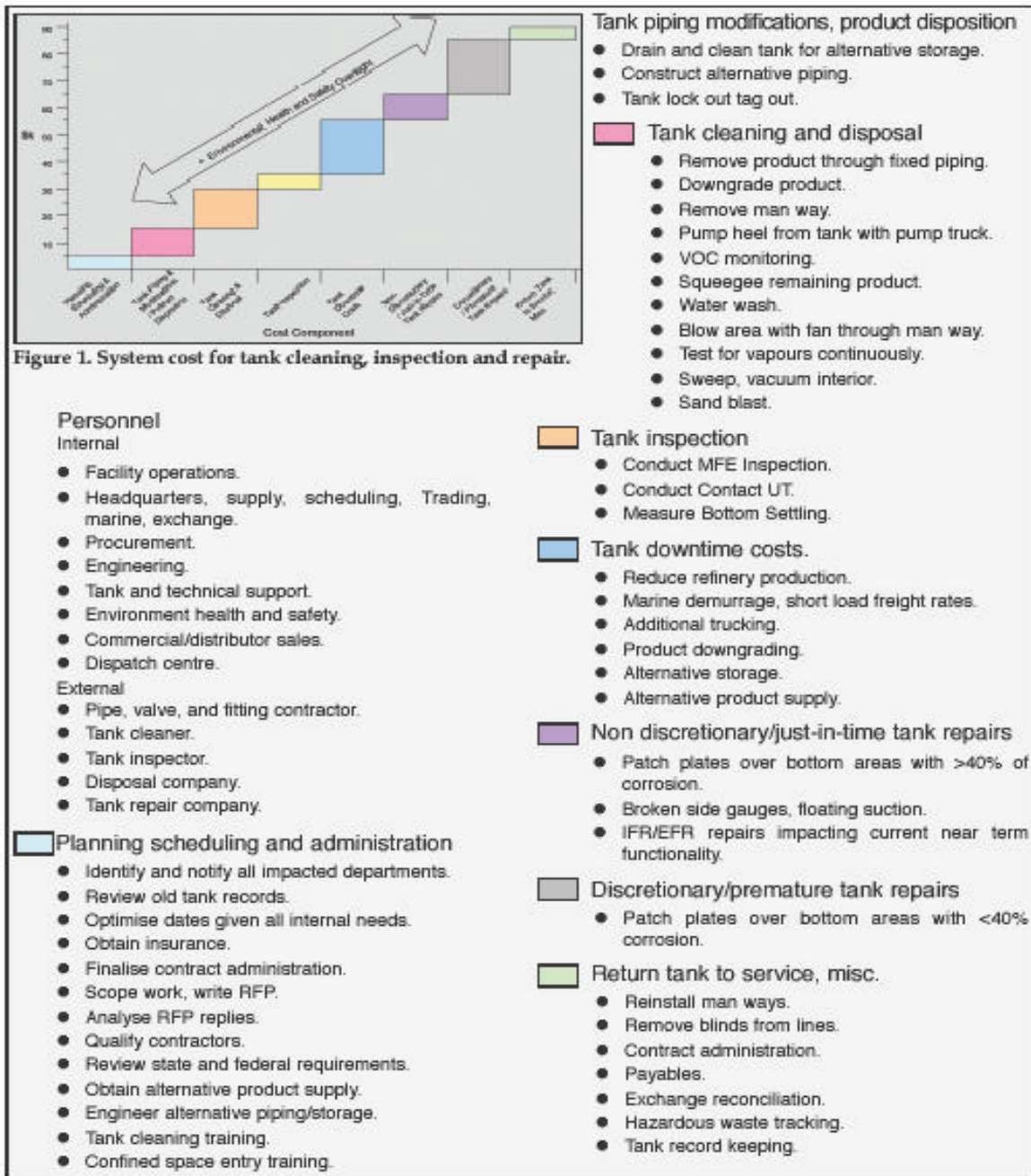
In addition to the manpower and personal protective equipment (PPE), conventional inspections require an array of equipment including hydroblasters and washing equipment, incineration blowers, methane tanks, particulate filtration and collection systems, vacuum truck and waste containment systems, and inspection and monitoring equipment.

The following factors are the typical economic considerations associated with the conventional inspection method:

- Safety training for personnel
- Environmental clean-up and excessive emissions
- Alternative tank storage for contents
- Quality of inspection
- Draining and refilling
- Hazardous and confined space entry
- Waste disposal

Table 1 shows the numerous factors that a facility owner must consider prior to conducting an out-of-service tank inspection.⁴

Table 1
Considerations for Conventional Tank Inspection Methods⁵



Alternate Inspection Technique (Tank-In-Service)

The new technology for the IFR tank inspections, which does not require taking a tank out-of-service, is commercially available through several vendors.⁶ InTANK Services, Inc. (InTANK) is a leading service provider for the robotic inspection equipment. The available technologies can generally be categorized under the following three functional groups.

1. Advanced technologies available for tank bottom and integrity inspections
2. Advanced technologies available for rim seal inspections
3. Advanced technologies available for deck fittings inspections

This paper does not address or provide any specific information on advanced technologies available for the first category above (tank bottom and integrity inspections). However, the American Petroleum Institute (API) has established a maintenance and inspection standard, API 653, to provide guidance on an ongoing assessment of a facility's storage tanks. This standard addresses tank bottom and integrity inspections. In 1998, the API revised this standard to include "remote-sensing" techniques, stating:⁷

If the internal inspection is required solely for the purpose of determining the condition and integrity of the tank bottom, the internal inspection may be accomplished with the tank in-service utilizing various ultrasonic robotic thickness measurement and other on-stream inspection methods capable of assessing the thickness of the tank bottom, in combination with methods capable of assessing tank bottom integrity as described in 2.4.1.

Thus, the revised API 653 standard now allows the use of robotics as an alternative method for assessing the condition of a tank bottom/floor as long as certain conditions are met. As a result of this revision, quantitative tank bottom/floor remaining life data can now be integrated with the balance of the external inspection elements in order to provide a broader assessment of the tank's condition without taking the tank out-of-service. As a result of the API acceptance, several state agencies have allowed tank owners to conduct the tank bottom and integrity inspections using the robotics technology. For example, the New Jersey Department of Environmental Protection, Bureau of Discharge Prevention revised the guidelines for the inspection and testing of Above Ground Storage Tanks (ASTs). The revisions included the acceptance of the use of a robotics instrument to visually inspect the tank interior (i.e., bottom and shell) for API 653.

The robotics technologies for the second and third categories allow inspections for the primary seals, secondary seals, and deck fitting components required for NSPS Subpart Kb. With the availability of the robotics technology, a facility operator can fully comply with the provisions of NSPS Subpart Kb without removing the tank from service.

Rim Seals Inspection Technique

As shown in Figure 1, the inspection of the primary and secondary seals could be easily accomplished with the use of the On Stream Tank Inspection System (OTISTM) and the Quick-Look-Remote Inspection and Measurement System (QLRIMSTM), respectively.

InTANK designed two complimentary robotics devices that are used together for the inspection of seals on IFRs. Two different inspection approaches are necessary due to the dual seal design of many IFRs. One part of the seal is in contact with the product (the primary seal) and a second part is exposed to the vapor space of an IFR (the secondary seal). The primary seal is inspected using a remotely-controlled camera installed on a robotics floor inspection system. This system, the OTISTM, is deployed inside the tank's product (i.e., below the IFR). The secondary seal is inspected using a remotely-controlled high resolution camera with laser range finders. This system, the QLRIMSTM, is deployed from the manway of the fixed roof above the IFR. In all cases, the inspections are conducted while the tank is in-service, avoiding the need to drain and degas the tank, and eliminating the need for confined-space entry. The OTISTM primary seal inspection robot incorporates an

advanced camera system and measures seal gaps between the roof seal and the shell with great accuracy. The QLRIMS™, uses a laser ranging and measurement system that inspects the secondary seals of internal floating roofs while in-service and without manned entry. Both systems are designed to detect seal damage or failures (tears, holes, gaps between the seal and the shell, etc.) and measure the extent of the damage directly through the use of a laser rangefinder in the case of the OTIS™ or through extrapolating damage through the use of a nomograph, in the case of the QLRIMS™.

OTIS Inspection for Primary Seal Measurement⁸

The camera system of OTIS™ is capable of assessing the condition of an IFR's primary and penetration seals from a distance of over 30-feet through clear products (e.g., light crudes, gasoline, and certain intermediates). The vehicle has a camera and a light source for illuminating objects in the near field of the robot. The light and camera are mounted on a tilting assembly pivoting about a rod held by brackets attached to the vehicle. The camera and light source are focused upward onto the tank sidewalls and the underside of the floating roof along the edge of the primary seal. The camera enables visual assessments of the condition of the primary seal between the tank sidewall and internal floating roof. Using available light or flooding the vapor space with artificial light allows the camera to detect extremely low levels of light that may leak through the gaps created by a failed seal.

Figure 2 shows photographs taken from the OTIS™ seal inspection system. The primary seal test conducted with OTIS™ was accomplished in a 93-foot diameter x 40-foot high gasoline tank with an IFR. The tank contained approximately 32-feet of product with another 8-feet of vapor space between the IFR floor and the product. The floating roof had a failed center column penetration seal. The seal gap shown in Figure 1 was physically measured to be equal to 1/8-inches. A clear light leak can be seen from this image demonstrating the sensitivity of the OTIS™ camera to light sources over 30-feet from the face of the camera. This capability was confirmed in laboratory testing.

The OTIS™ provides a more precise and consistent inspection than visual techniques. The high light sensitivity of the OTIS™ camera can detect minute gaps in the primary seal at high gauge and provide a recording of the seal integrity at mid and low gauge. Additionally, nomographs can be produced by measuring actual seal gap separations and relating them to direct gap measurements from the camera image.

With this technology, the following objectives are met:

- Primary seal assessment with high resolution optical clarity (i.e., visible gaps, seal detachment, holes, or openings, and tears)
- Complete video record of primary seal assessment using the OTIS™-G AST floor inspection scanner

Figure 3 shows the OTIS™-G seal inspection scanner, which is capable of performing qualitative measurement with high-resolution digital images.

QLRIMS Inspection for Secondary Seal Measurement⁹

The camera and laser system of QLRIMS™ is capable of quantitatively and qualitatively measuring an IFR's primary seals to 1/8-inches from a distance greater than 100-feet in the vapor space of the AST. That is, the equipment can both detect and record seal integrity and provide precise measurements of seal gaps against which it can be compared to the measurement requirements of NSPS Subpart Kb.

To inspect a secondary seal with QLRIMS™ the camera with integrated lasers is suspended from a pole. The other end of the pole remains outside of the vapor space. It is held by a tripod positioned above the manway. The camera laser sources are positioned around the camera lens in a regular array, such as four lasers in a polygonal (e.g., square) array with each beam forming a corner of the array.

The laser beams are aligned substantially parallel and straight. The QLRIMS™ laser beams do not distort or bend when projected through the vapor space of an internal floating roof tank. A fifth laser is mounted on the camera housing along one side of the grid. The fifth laser is offset to project at an angle θ in the range from about +1 degree ($^{\circ}$) to about +3 $^{\circ}$ (or about -1 $^{\circ}$ to about -3 $^{\circ}$) from an axis parallel to the axis of projection of the lasers in the regular grid.

The lasers project an illumination pattern of a series of spots in a square grid with each spot separated from an adjacent spot by 80 millimeter (mm). When the laser sources are projected onto the target at an angle, the distance of separation between two of the spots may be different for two of the parallel sides, but may remain 80 mm between the other two parallel sides, such that the illumination pattern of spots forms a rectangle rather than a square.

A fifth laser projects a spot that is spaced apart from one of the spots by a distance of “x.” The “x” distance may be calculated by simple trigonometry using a software algorithm. With this algorithm, it is possible to calculate the distance between the camera and the target upon which the illumination pattern is formed, as well as the distance of “x,” based upon predetermined parameters: (1) the angles θ and λ , which may be the same or different, and (2) the separation between the lasers, and (3) the spacing of the spots in the illumination pattern (based upon measured parameters). If the illumination pattern forms a rectangle by connecting the spots formed at the corners, the distance for measurement “x” is selected as the spot for “x” formed along the side between spots that measures 80-mm. If both sides along which the spot is formed correspond to 80-mm, the camera and laser sources are projected perpendicularly toward the target, and determinations of “x” can be made with reasonable accuracy.

Figure 3 also shows the QLRIMS™ inspection device, which provides capability to inspect a secondary seal without manned entry into the tank. The device is intrinsically safe (certified by Entela) and portable.

Figure 1
OTIS™ for Primary Seal Inspection and QLRIMS™ for Secondary Seal Measurement¹⁰

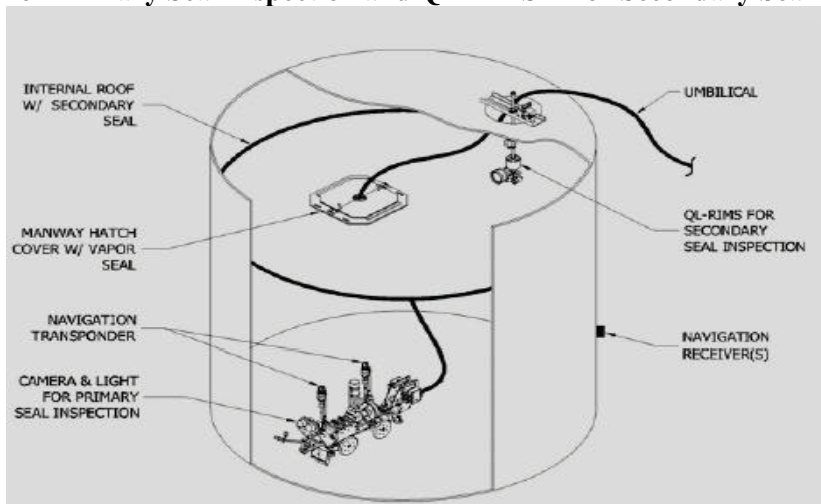
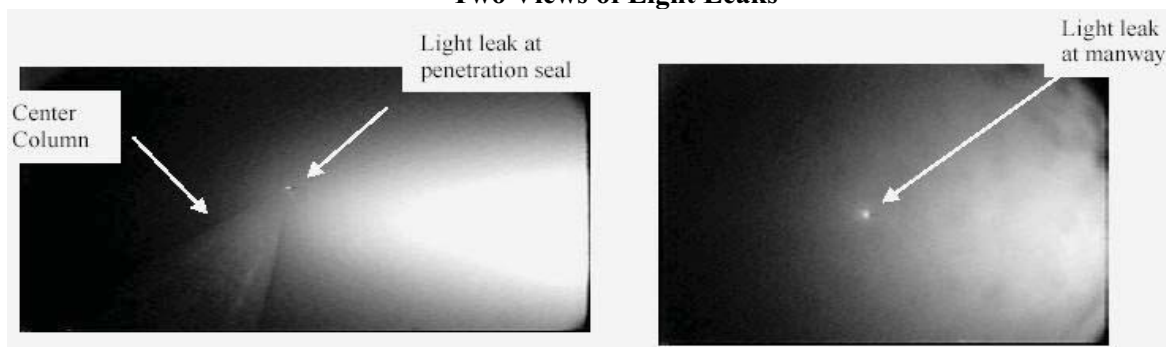
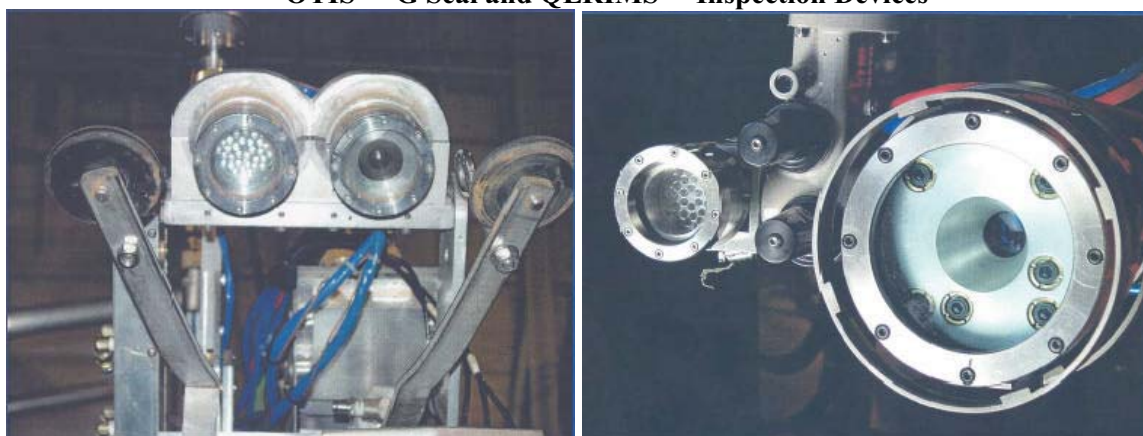


Figure 2
Two Views of Light Leaks¹¹



[The left hand photograph is a penetration seal gap taken from OTIS™ while on the tank floor during a light test from within the product. The right hand photograph is the same penetration seal light test from within the product.]

Figure 3
OTIS™-G Seal and QLRIMS™ Inspection Devices¹²



Deck Fittings Inspection Technique

With the combination of technologies for the camera and laser system of QLRIMS and the camera system of OTIS, the commercially available robotics system are also capable of quantitatively and qualitatively measuring the deck fittings from a distance greater than 100-feet in the vapor space of the AST from the top of the fixed roof and the bottom of the tank bottom.¹³ However, according to the commercially available vendor the robotics technology train may not be able to inspect the components that are not visible either from the top or the bottom side of the tank. The inspection procedure for deck fittings is the same as explained in previous sections.

Benefits

The selection of robotics technology is a major advancement in achieving the environmental objectives balanced with economic needs. The robotics technology performs inspections as well or better than the currently approved conventional methods of performing tank inspections. There are a number of reasons and advantages for inspecting aboveground IFR tanks by using robots while tanks are full of product and on-stream. The rationales and benefits for selection of this technology as an alternative to visual inspection are discussed below.

Improved Safety

All of the conventional inspection techniques mentioned in previous sections exposes personnel to the hazards of confined space entry. They also entail the risk of explosion and fire from accumulated vapors and potential for damage of the top surface of the floating roof. In addition, equipment-related confined space restrictions, such as the need for explosion-proof lighting, ventilation equipment, and air monitors also increase costs and make the process time-consuming. Even industry's best management practices can not eliminate the safety, health, and environmental challenges of conventional inspection processes.

The proposed alternative technique eliminates the safety issues associated with the seals and deck fitting inspections. This method allows for a high quality inspection under the circumstances where manned entry is not possible or not desired, improves the level of safety, reduces health risk exposures and the possibility of accidents, and eliminates the need for confined space entry.

In addition, the robotics systems, constructed of non-sparking materials, minimize the potential for property damage from the inherently explosive atmosphere at the tank roof. The vendors of these commercially-available technologies apply rigorous testing and ongoing auditing to support their safety certification process. As part of the product safety testing process, these vendors will certify these devices against fire, parts failure, and engineering deformities.

Pollution Prevention and Environmental Benefits

The out-of-service inspections for IFR tanks require cleaning and degassing the tank. Cleaning and degassing are necessary to allow workers to enter the tank to conduct the inspection. The degassing emissions are those emissions that will be released from the tanks' vapor space prior to cleaning, and sludge emissions are released from the tank in the process of removing sludge from the tank during cleaning.

U.S. EPA estimates total emissions of approximately 1.1 tons from degassing a tank of 200,000 gallons (gal) capacity.¹⁴ This document also states:

Depending on the method of disposal, the sum of the cleaning and degassing emissions may be greater than the emission reductions obtained from the implementation of control options. For this reason, it may be necessary to minimize the environmental impacts associated with cleaning and degassing by requiring IFR tanks to implement the control options when the tanks are out-of- service for their regulatory scheduled cleaning.

Another possible source of secondary emissions is the treatment, storage or disposal of tank sludge and the rinsate from tank cleaning. The regulatory status of the sludge and rinsate depend on the composition of tank contents. The sludge generated from the tank cleaning process may be up to 90 percent liquid. Independent of any VOC emitted from the liquid portion of the sludge, 3,000 gal of solid waste will be produced from cleaning a 200,000 gal tank. This material may be RCRA hazardous wastes.

The inherent derivative benefits from automated robotics inspections are eliminating the need for degassing, as well as the requirement to collect the emissions and waste materials. Therefore, these reduced emissions and waste are considered when evaluating the costs of the alternative inspection techniques.

In addition to the VOC reductions, a paper published in Independent Liquid Terminals Association (ILTA) annual operating conference (1999) states:¹⁵

According to the Texas Natural Resource Conservation Commission, substantial greenhouse gas emissions occur during tank cleaning operations. The use of in-service inspections will source reduce these greenhouse gas emissions by eliminating the need to drain, vent and clean tanks prior to inspection. In order to avoid releasing greenhouse gases, such as benzene and other chemicals on the Toxic Release Inventory, operators will typically burn the evacuated fumes with methane and other gases to eliminate the VOC release. Nevertheless, incineration generates significant CO₂ emissions.

Resource Issues	Current Technology	In-Service Tank Inspection	In-Service Savings
CO ₂ and VOCs (tons)	102.3005	.3003	102.0002
SO ₂ (tons)	0.0253	0.0028	0.0225
NO _x (tons)	0.1720	0.0124	0.1596
Particulate (tons)	0.0328	.0025	.0302
Product Waste (Btu)	1,260,000,000	84,000,000	1,176,000,000
Man Hours in Confined Space	1,200	0	1,200

The above table represents typical pollution prevention and energy savings calculations that are associated with an in-service robotics inspection of a 30 m. (100 ft.) diameter 13.8 m. (45 ft.) tall tank containing diesel. These calculations assume best practices are being used to ventilate and thermally treat VOCs.

As shown above, in-service tank inspections have been proven to result in reduced emissions and environmental impacts.

Higher Quality

The reliability of conventional inspection procedures is dependent on visibility and human's subjectivity and accuracy. The alternative inspection technique improves the quality of inspections by recording high resolution imagery. The robotics inspections utilize an advanced camera and laser systems, which measure the seal gaps and inspects the seals and deck fittings for damage or failures with great accuracy.

Cost Reduction

Robotics technology offers several direct and indirect cost savings. The direct cost savings are achieved by the reduction or elimination of hazardous waste disposal costs, environmental and personnel exposure costs, and alternative storage costs. The indirect cost savings are achieved by shortened turnaround schedules that eliminate tank outages and loss of productivity. The total direct and indirect costs vary depending on the tank size, product, sludge and sediment content, alternative tankage availability, and a host of environmental factors.

Summary of Benefits

In summary, the reasons for selection of robotics technology as an alternative inspection method for NSPS Subpart Kb (40 CFR 60.113b [a][4]) requirements are listed below.

1. Reduces safety risks during the inspection process.
2. Promotes reduction of pollution (VOCs and HAPs).
3. Eliminates the need for taking the tank out-of-service and planning for alternate storage and waste management.
4. Results in higher quality inspections (i.e., increased accuracy) than the conventional method.
5. Reduces the cost of inspection.

Status of Approval and Conclusions

The general provisions of the NSPS allow the regulatory agencies to accept alternative compliance programs if the facility operator can demonstrate that the alternative meets the specific regulatory requirements for the equipment. Several oil and gas companies are in the process of obtaining agency’s approval of alternate inspection programs under 40 CFR 60 Subpart Kb Section 113b (a) (4) using an advanced robotics inspection technology. These alternate inspection methods would allow these companies to conduct inspections under safe conditions with reduced emissions and costs. Table 2 provides a comparison between the conventional and alternate inspection techniques.

**Table 2
Summary Comparison**

	Conventional Inspection Technique (Out-of-Service)	Alternative Inspection Technique (In-Service)
Procedure		
Tank draining, cleaning, waste management, other requirements	Required	Not required
Confined space entry – training, ventilation, and monitoring	Required	Minimal confined space entry
Alternate storage	Required	Not required
Tank degassing and cleaning emissions	Required	Not required
Recommissioning and refilling	Required	Not required
Benefits		
Effectiveness of Inspections	Limited for tank top inspections	Reliable and effective
Accuracy	Subject to human subjectivity, accessibility, and safety challenges	Greater accuracy
Environmental impacts	VOCs and HAPs emissions	Minimal emissions
Cost effectiveness	Very expensive	Reduced costs

The robotics technology described in this paper serves as a method that is equal to or an improvement upon current inspection techniques. The robotics inspection technique has been recognized as an alternate inspection technique by the U.S. EPA Region II, North Carolina Department of Environment and Natural Resources (NC DENR) for NSPS Subpart Kb inspections, and New Jersey Department of Environmental Protection (NJ DEP) for tank integrity inspections.

A letter from Mr. Daniel Manasia, Air Compliance Branch, U.S. EPA Region II, supports and endorses the use of robotics technology.¹⁶

Mr. Morris expressed to me that he could see no reason why a robotic inspection would not satisfy the NSPS for storage tank inspections, since the rule only required that “visual” inspections be performed. The seal gap analysis, required by EPA guidelines, can also be accomplished with laser measurements, as provided in your supporting documents.

A letter from Mr. Myron G. Whitney, Regional Air Quality Supervisor, NC DENR, also supports and endorses the use of robotics technology.¹⁷

The second alternative method would employ a remote controlled robot equipped with a camera to be submerged inside the tank and inspect the primary seal from the bottom side. This method is acceptable and also slightly preferable to the manned method both for safety reasons and for accuracy since the space above the floating roof can be flooded with light that will readily aid in detecting gaps in the seal.

Authors of this paper recommend that if the reader intends to use the robotics technology in-lieu of the NSPS Subpart Kb inspection requirements, then proper endorsement and authorization must be obtained prior to conducting the inspection using this technology. The authors also do not take any responsibilities related to the limitations and services of vendors providing these commercially available technologies.

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About The Authors

Vineet K. Masuraha (corresponding author - vmasurah@trinityconsultants.com) is a Consultant and Stacy Carr is a Senior Consultant (scarr@trinityconsultants.com) at Trinity Consultants, 12801 North Central Expressway, Suite 1200, Dallas, TX 75243. Mr. Masuraha and Ms. Carr both provide specialty-consulting services, including NSPS, Maximum Achievable Control Technology (MACT), and New Source Review (NSR) permitting issues, to oil and gas (upstream and downstream) clients.

Mr. Masuraha's experience includes emissions and control strategies, compliance management systems, regulatory and feasibility analyses, ambient air dispersion modeling and monitoring, and state and federal air quality permitting. Ms. Carr's experience includes permitting, compliance auditing, training, emissions inventories, regulatory compliance analyses, regulatory impact evaluation, and compliance management.