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Q3-2025

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Intelligent Eyes in subsea Pipelines

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Subsea pipelines

are essential to the world's energy industry, transporting huge volumes of oil, gas, and chemicals safely across the ocean bottom. These pipelines work in some of the toughest environments on Earth — deep underwater, under high pressure, with shifting temperatures, and surrounded by corrosive seawater. Keeping them in good condition is a constant challenge.

As global energy demand grows and new offshore projects reach deeper waters, *the risks of pipeline failures increase.*

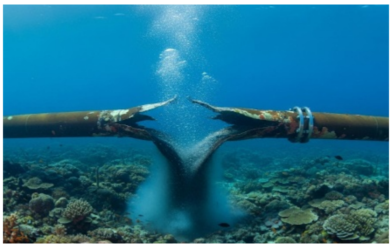
Traditional inspection methods, though reliable, often struggle to detect early problems in deep-water areas, especially when pipes are covered in coatings, marine growth, or buried.

That's why the industry is turning to smart inspection systems, advanced Non-Destructive Testing (NDT) technologies, and robotic tools to better manage and protect these critical assets.

Why Smart Inspections Are Important

Pipeline leaks or failures underwater can cause major damage — not only shutting down operations but also harming the environment, marine life, and company reputations.

A small, unnoticed defect can turn into a serious incident. The costs of emergency repairs, lost production, environmental cleanup, and regulatory penalties can be enormous.



Key risks include:

- Unplanned shutdowns and loss of production
- Environmental pollution affecting marine ecosystems
- Legal penalties and financial losses
- Expensive emergency repair operations
- Increased safety risks for personnel
- Higher carbon emissions from flaring or leaks

Today, governments and stakeholders demand safer, more responsible pipeline operations. Offshore operators must now invest in smarter, more advanced inspection and maintenance programs to protect their assets and the environment.

To meet these challenges, *companies are combining* robotic underwater vehicles with powerful NDT inspection tools. These modern systems allow for quicker, safer, and more accurate inspections in deep and difficult-to-reach places.

Unlike older manual techniques, robotic systems can move through complex underwater areas, handle extreme pressure, and work for long periods without risking human divers.

Benefits include:

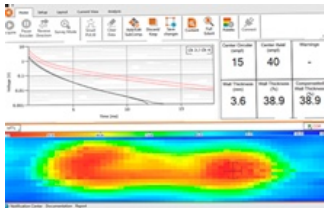
- Detecting corrosion, cracks, and weld problems early
- Measuring wall loss and pitting corrosion accurately
- Real-time monitoring and reporting
- Tracking defect growth over time
- Improving maintenance plans and asset life

A major advantage is the ability to combine several advanced inspection techniques into one robotic platform, providing more reliable results and reducing the chance of missing serious defects.

Key Advanced Subsea NDT Techniques

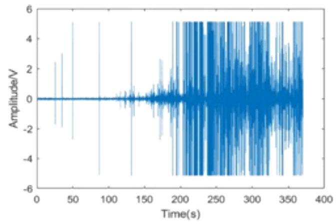
Pulse Eddy Current (PEC)

PEC is great for detecting corrosion hidden beneath insulation, coatings, or marine growth. It doesn't need surface cleaning. PEC sends electromagnetic pulses into the pipeline wall, and changes in how the current fades show areas where the wall is thinner due to corrosion.



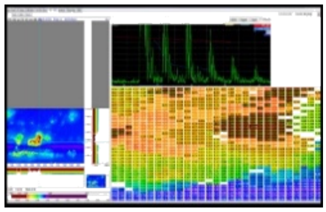
Acoustic Resonance Imaging (ARI)

This technique sends sound waves into the pipeline. If there's damage, corrosion, or pitting, it changes the sound frequency. ARI helps quickly locate isolated defects, even through thick coatings and marine growth, without touching the surface.



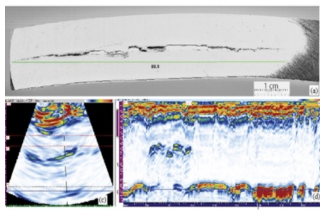
Automated Ultrasonic Testing (AUT) Corrosion Mapping

AUT scanning uses ultrasonic probes on robotic crawlers to measure wall thickness across large areas. It provides detailed corrosion maps, showing exactly where the wall has thinned. It's ideal for known damage areas or places where corrosion is likely.



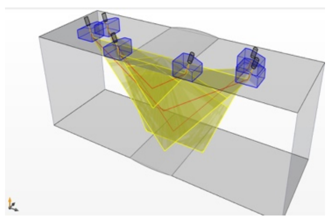
Phased Array Ultrasonic (PAUT)

PAUT uses an ultrasonic beam that can be steered electronically to inspect the full volume of the pipeline wall. It's excellent for finding cracks, pitting corrosion, and weld defects, especially in circumferential and seam welds. It creates detailed images of flaws inside the pipe wall.



Time-of-Flight Diffraction (TOFD)

TOFD is a proven method for accurately finding and sizing serious flaws like a small sharp pitting, weld cracks and lack of fusion. It measures the time it takes for ultrasonic waves to bounce off a flaw and return, making it especially useful for deep cracks and defects in weld seams.



Professionals behind the Technology

Even with advanced robots and smart inspection tools, the real reliability comes from experienced NDT professionals. Successful subsea inspections need careful planning — choosing the right techniques, setting up equipment properly, and making sure systems are ready for the specific underwater conditions at each site.

Skilled engineers and technicians are responsible for correctly positioning probes, setting scanning speeds, adjusting settings for water temperature, currents, and marine growth, and ensuring data is collected accurately.

Equally important are the experienced analysts who review and interpret the inspection data. They confirm the type, size, and exact position of each defect.

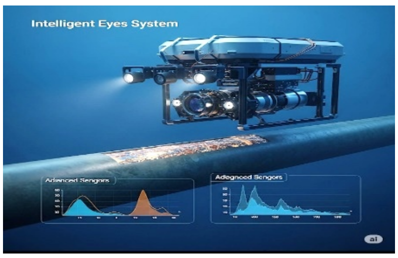
A poorly planned or misinterpreted inspection can lead to repeated offshore campaigns — which are extremely expensive and time-consuming.

To avoid this, inspection teams run regular validation checks, calibration tests, and use multiple NDT techniques at once. This improves the accuracy of findings, reduces false positives, and ensures reliable detection. After each inspection, data is carefully reviewed by experts, and only validated, high-quality results are used to make maintenance and repair decisions.

Real-World Results

Robotic NDT systems have already shown great success in the field. They can detect difficult problems like hydrogen-induced cracking, early pitting, and corrosion in hard-to-reach places. Operators using these systems report fewer unplanned shutdowns, better maintenance schedules, and longer pipeline service life.

They also help companies reduce safety risks and environmental damage. In addition, modern robotic systems contribute to digital transformation, providing data for digital twins, centralized monitoring systems, and predictive maintenance tools. This gives pipeline operators a complete, real-time view of their assets.

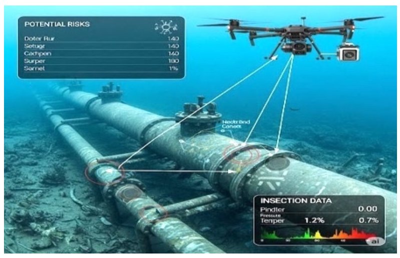


Smarter Eyes beneath the Waves

As offshore pipelines age and new deepwater projects emerge, the need for smart, automated inspection systems will keep growing. Robotic platforms equipped with advanced NDT techniques are no longer a luxury — they are a necessity for safe, efficient, and responsible offshore operations.

These intelligent systems aren't just improving inspections — they're changing how the offshore industry manages and protects its most valuable infrastructure. By catching problems before they become serious, these tools help companies avoid shutdowns, save money, extend pipeline life, and safeguard marine environments.

The future of subsea pipeline inspection is here. With smart robotics, advanced NDT, expert human judgment, and powerful data systems working together, offshore pipelines can remain safe, efficient, and reliable for decades to come.



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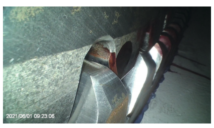

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Optimizing **Preventive Maintenance** in **Refineries,** Lessons from Two Pump Case Studies!

INTRODUCTION

Preventive maintenance optimization (PMO) is crucial in refineries and other strategic industries where unplanned downtime can be extremely costly. Maintenance strategies generally fall into **preventive maintenance** (tasks done before failure) and **corrective maintenance** (repairs after failure) A common assumption is that increasing time-based preventive maintenance will proportionally reduce corrective maintenance and sudden failures. In reality, however, **more maintenance is not always better** – the effectiveness of preventive tasks depends on an asset's failure behavior.

Studies have shown that only about **11% of equipment failures are age-related**, while the remaining 89% occur randomly with respect to operating age In other words, most failures do **not** follow a simple "wear-out" pattern, so a blanket increase in scheduled maintenance will not automatically improve reliability.

In fact, excessive or mis-timed maintenance can introduce new problems; as one reliability report noted, *"the myth of time-based maintenance providing reliability is busted – in reality, time-based maintenance can greatly increase the probability of an infant mortality failure"*

This article explores two real-world pump cases from a refinery's PMO program that illustrate how ***preventive maintenance must be tailored to the asset's reliability characteristics***. We analyze a reciprocating plunger pump (Case A) and a vertical multistage centrifugal pump (Case B), and explain why a high percentage of scheduled maintenance in Case A did not reduce breakdowns, while insufficient preventive care in Case B led to frequent failures. We will also discuss the underlying reliability distribution for each case, including the **Weibull shape factor** (**β**) and scale factor (**η**), to show how these parameters inform the optimal maintenance strategy.

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CMRP, CRL, CAMA, BMI

Case Study A:

Reciprocating Plunger Pump – Over-Maintenance without Reliability Gains.

Asset Description: A

high-pressure reciprocating plunger pump in refinery service. This type of pump is critical for process operations and was subjected to an intensive time-based maintenance (TBM) regime.

Plant maintenance records showed that a large majority of this pump's maintenance hours (on the order of 42% of total maintenance time) were spent on scheduled preventative tasks – routine overhauls, component replacements, and inspections at fixed intervals.

Problem:

Despite the heavy emphasis on TBM, the pump did not show a reduction in corrective maintenance needs. Unplanned breakdowns continued to occur at a steady rate, accounting for roughly 43% of maintenance activities and significant downtime. In fact, the data suggested that **downtime and O&M costs were increasing** in tandem with the heightened maintenance frequency. This paradox – *more preventive work but no fewer failures* – was a red flag indicating that the maintenance strategy was misaligned with the pump's failure characteristics.

Figure 1

Analysis:

A detailed failure analysis revealed that the plunger pump's dominant failure modes were not strongly age-related. Instead, many failures were **random or occurred shortly after maintenance interventions**. For example, the pump's plunger seals and valves were being replaced on a fixed schedule, yet some of these components still failed unexpectedly in between scheduled overhauls.

In other cases, the act of performing maintenance itself introduced infant mortality issues (e.g. installation errors or disturbances leading to early-life failures of new parts).

A reliability distribution analysis was performed on the pump's failure data, and the best-fit model was a **Weibull distribution with a shape factor β around or below 1**, indicating a decreasing or roughly constant failure rate over time.

No. of Failures	CM	TBM	CBM	MTBF (Months)	Months/PM
139	190	183	67	2.205882353	1.648351648
	43%	42%	15%		

In reliability engineering terms, **if β = 1, the failure rate is constant (random failures), and if β < 1, the failure rate actually decreases with time**. This implies that the pump is more likely to fail when it is "new" (just after a maintenance intervention or installation of new components), and those that survive initial use tend to run reliably thereafter.

Essentially, the pump was exhibiting an **infant mortality or random failure pattern**, not a wear-out pattern. Under these conditions, performing overhauls too frequently provides little benefit and can even be harmful – each time the pump was opened up for preventive maintenance, it was returned to a "new" state that had a higher immediate risk of failure.

Industry best practices warn of this drawback: excessive scheduled maintenance can lead to **over-maintenance**, incurring unnecessary work and cost on components that may not need replacement, while also introducing new failure risks.

This case study confirms those warnings. As noted in the landmark RCM study by Nowlan and Heap, *the majority of failures are random* and **time-based overhauls will not prevent such failures – in fact, they may increase the failure rate immediately following the overhaul**. Case A's outcome underscores that **more TBM is not always better**.

The optimal strategy for this pump would be to scale back unnecessary scheduled tasks and focus on condition-based maintenance (CBM) or improved installation quality. By monitoring condition (for example, using vibration analysis, Ultrasound, or performance indicators) rather than overhauling on a rigid schedule, maintenance can be performed *"only when truly needed"* – addressing problems based on evidence of wear or degradation. This minimizes intrusive work and avoids injecting infant mortality failures, thereby reducing both downtime and maintenance costs.

Case Study B:

Vertical Multistage Centrifugal Pump – Under-Maintenance Leading to High Failures

Asset Description:

Case B examines a vertical immersed multistage centrifugal pump at the refinery. Unlike the previous case, this pump had a very **low percentage of time-based and predictive maintenance** applied.

Preventive tasks accounted for well under 25% of its maintenance activity; essentially, the pump was run to failure with only minimal routine checks. Little to no condition monitoring (vibration, temperature, etc.) was in place – what the case data refers to as low "CBM" (predictive maintenance) involvement.

Problem:

Because of the minimal proactive maintenance, the pump experienced a high frequency of breakdowns. The data showed that **corrective maintenance comprised the majority (≈60%) of its maintenance**. The pump's unplanned failures not only drove up repair costs but also caused extended downtime in the process unit whenever the pump failed unexpectedly.

In essence, this was the opposite scenario of Case A – here **too little preventive maintenance** was being performed. The expectation was that running to failure would maximize run time, but in reality it resulted in **frequent sudden failures and costly interruptions**, far outweighing the saved effort from deferring maintenance.

Figure 2

Analysis:

Reliability analysis of the centrifugal pump's failure history indicated a classic **wear-out pattern**. The Weibull distribution fitted to this pump's time-to-failure data showed a **shape factor β greater than 1**, meaning failure rate increases with time in service.

In practical terms,

components like bearings, bushings, and impellers in the pump were subject to cumulative wear and aging. As the pump operated over months and years, the probability of failure grew – especially once past a certain age (the **scale factor η** of the Weibull model gives the characteristic life by which ~63% of units would fail). With **β** > 1, **age was a real driver of failure**: this pump would predictably fail if left running long enough without overhaul. Such wear-out behavior is exactly when **time-based maintenance can be highly effective** – by scheduling an overhaul or critical part replacement at a fixed interval **before** the steep increase in failure probability, one can avert a large portion of unplanned outages.

No. of Failures	CM	TBM	CBM	MTBF(Months)	Months/PM
122	138	56	40	2.521008403	5.454545455
	59%	24%	17%		

In Case B, the maintenance strategy was not keeping up with the asset's inherent life cycle. The result was analogous to **operating beyond the asset's reliable life**, leading to breakdowns. A better PMO approach for this pump is to introduce a **scheduled maintenance plan or enhanced condition monitoring**.

For example, based on failure data (and possibly OEM recommendations), the refinery could establish a **periodic overhaul interval** aligned with the pump's wear-out age – this is often guided by statistical analysis or standards and best practices for similar pumps.

Even implementing basic **predicted maintenance** tasks (like routine vibration analysis, Ultrasound or inspections at set intervals) could detect early signs of wear so maintenance can be performed proactively. Industry standards emphasize that **time-based (predetermined) maintenance is justified when there is a clear age-related failure pattern**.

In this case, applying such standards would mean recognizing the pump's limited useful life and intervening on schedule. Had a proper time-based preventive maintenance been in place, the high percentage of reactive maintenance in Case B could have been significantly reduced, improving overall uptime.

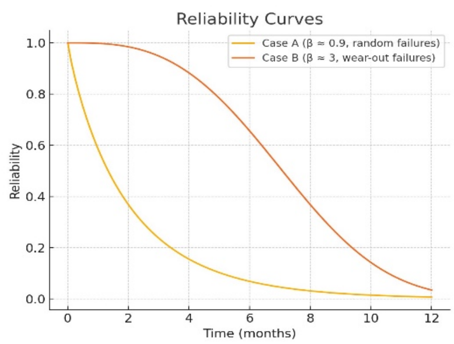
Reliability Modeling and Optimization of Maintenance Strategy

The contrast between Case A and Case B highlights a fundamental principle of reliability engineering: **maintenance strategies must match the failure distribution of the equipment**. A tool commonly used to model failure behavior is the **Weibull distribution**, which is characterized by two parameters – **shape (β)** and **scale (η)**. The shape parameter **β** is especially informative:

In implementing a PMO program, it is also important to consider the **consequences of failure and the cost of maintenance**. High-criticality assets (e.g. a compressor in a refinery) might warrant even proactive part replacements regardless of **β**, simply because any failure is intolerable. In contrast, low-criticality equipment might be run to failure even if **β** > 1, if the consequence is minor and repairs are cheap. Modern maintenance management aligns with **risk-based and condition-based strategies**:

many companies are **shifting from purely time-based schedules to condition-based maintenance to avoid unnecessary interventions**. This trend is supported by the advent of IIoT sensors and predictive analytics that can track equipment health in real time, enabling maintenance "**only when truly needed**". Still, time-based maintenance remains vital for equipment with known life limits or when condition monitoring is impractical.

The **optimal strategy is often a mix**: apply **time-based (scheduled) maintenance** for wear-out dominated items, and **condition/predictive maintenance** for random failure dominated items – all under a framework of continuous improvement. This aligns with the guidance of standards like **ISO 14224:2016**, which provides a framework for classifying maintenance types and stresses tailoring the strategy to the asset's failure characteristics.



CONCLUSION

The two case studies from the refinery's PMO program demonstrate that **preventive maintenance must be optimized, not maximized**. In Case A, a reciprocating plunger pump was essentially "over-maintained" with frequent time-based service, yielding no reduction in failures – a scenario attributable to the pump's random failure pattern and infant mortality issues. More PM in that case did not equate to higher reliability; instead, it added cost and downtime. In Case B, a vertical multistage pump suffered the opposite problem: under-maintenance in the face of an age-related failure pattern led to excessive corrective repairs. The lack of scheduled overhauls meant the pump was run into the wear-out phase, resulting in repeated breakdowns.

These examples reinforce a key reliability lesson: **the relationship between preventive maintenance and failure reduction is not one-size-fits-all**. It depends on the asset's failure distribution (e.g. the Weibull **β** factor) and the nature of its failure modes.

An effective PMO program uses data-driven analysis to find the "sweet spot" for each asset – identifying which equipment will benefit from regular overhauls and which are better served with condition monitoring or design improvements. Reputable frameworks and studies like **Reliability-Centered Maintenance (RCM)** provide criteria for this decision process, ensuring that each preventive task is justified by a real failure prevention benefit.

Additionally, standards and guidelines (ISO 14224, SAE JA1011 for RCM, etc.) encourage organizations to focus preventive efforts where they pay off, and avoid indiscriminate maintenance that doesn't reduce failures. By aligning maintenance strategies with the actual reliability characteristics of equipment, refineries and other industries can **increase uptime, reduce maintenance costs, and improve safety**.

The ultimate goal of PMO is to move from a "more maintenance is better" mindset to a **"smarter maintenance is better"** approach – where every maintenance dollar and hour is spent in the most effective way possible to ensure reliability.

Through cases like these, it becomes clear that understanding an asset's failure behavior is the cornerstone of optimizing preventive maintenance and achieving world-class reliability performance in any plant.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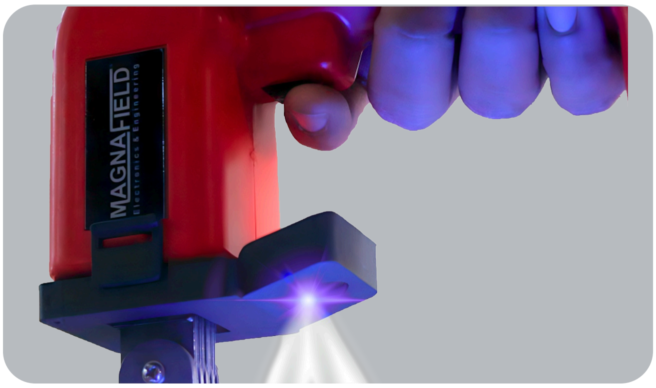

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What is ACFM Inspection?

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ACFM (Alternating Current Field Measurement) is a non-destructive testing (NDT) method used to detect and characterize surface-breaking defects in metal structures. It is widely used in industries such as oil and gas, offshore, power generation, rail, and structural engineering, where the integrity of metal components is crucial for safe operation.

ACFM operates by inducing an alternating current into the metal's surface. This current form a uniform current field. When there is a defect — a crack or a surface break — this current flow is disrupted, creating a disturbance in its path. This disturbance generates a corresponding variation in the magnetic field above the metal's surface. An array of sensors used to measure these magnetic fields.

The signals captured by the sensors enable the detection, sizing, and evaluation of defects, without the need for extensive surface preparation, direct metal-to-probe contact, or removal of protective coatings.

How ACFM Works — Principle of Operation

The main principle of ACFM is based on electromagnetic induction. An alternating current is fed into a wire or a fixture placed close to the metal surface. This generates a uniform current flow across the metal

Here is a more detailed breakdown:

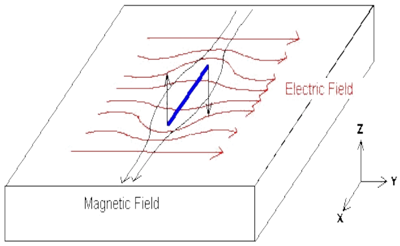
How it works:

Current Induction:
An alternating current introduced into the surface of the material being inspected.

Field Measurement:
Specialized probes measure the electromagnetic field that generated by the induced current.

Crack Detection:
When a crack is present, it disrupts the flow of the alternating current, causing a disturbance in the electromagnetic field.

Signal Analysis:
The measured disturbances in the electromagnetic field analyzed to identify and characterize the crack.



If there is a defect, such as a crack, it will interrupt or disturb the current flow. This disturbance then produces a perturbation in the electromagnetic field above the metal's surface.

A sensor, typically a combination of electromagnetic coils, measures these perturbations in two directions:

- **Bx (horizontal)** — related to the depth of the defect.
- **Bz (vertical)** — related to its length.

This data then processed by specialized software to produce a real-time view of the defect's size, depth, and location.

Applications of ACFM Inspection

ACFM is used in many industrial sectors, especially when traditional methods (such as liquid penetrant or magnetic particle testing) are less convenient or less accurate. Some key applications include:

- Inspection of offshore structures, platforms, and welds.
- Inspection of pressure vessels, storage tanks, and pipeline welds.
- Inspection of structural components in bridges, cranes, and ships.
- Inspection for defects under protective coatings or paint.
- Inspection in high-temperature or difficult-to-access locations.
- Detection of cracks in aircraft components.
- Inspection of power plants, including nuclear and fossil fuel plants.
- ACFM is primarily designed for detecting cracks that break the surface of the material.
- It provides information about both the length and depth of the crack.

Advantages of ACFM Inspection

✓ **Non-contact method:** ACFM does not require physical contact with the metal surface, which makes it faster, less invasive, and applicable through coatings.

✓ **Provides depth and length information:** ACFM not only detects defects but also assesses their depth and length — a crucial factor for evaluating structural integrity.

✓ **Safe and convenient:** ACFM can be used under water (with a remotely deployed sensor), in high-temperature environments, or in hazardous locations, without needing surface preparation.

✓ **Rapid scanning:** Large surface areas can be inspected quickly, reducing shutdowns or maintenance periods.

✓ **Environmentally friendly:** ACFM does not require chemicals, dye, or other consumable materials.

✓ **Repeatable and reliable:** ACFM signals can be recorded and kept for future comparison, adding to its utility for ongoing structural health monitoring.

✓ **Through Coatings:** ACFM can be used on components with protective coatings, paints, and rust without requiring removal of these barriers, which saves time and cost in surface preparation.

✓ **Surface Tolerance:** It has excellent surface tolerance, making it suitable for a wide range of materials and applications.

✓ **Versatile:** It can be used on a variety of conductive materials, including ferrous and non-ferrous.

Limitations of ACFM Inspection

✗ **Training and expertise:** Proper interpretation of ACFM signals requires extensive training and experience.

✗ **Sensitivity to surface conditions:** Large amounts of surface rust, heavy scaling, or debris can affect the signals and reduce the method's accuracy.

✗ **Limited penetration depth:** ACFM is primarily a surface or near-surface method; defects deep within the material may remain undetectable.

✗ **Higher equipment cost:** ACFM equipment and sensors can be more expensive than some conventional methods, which may be a consideration when choosing a testing method.

CONCLUSION

ACFM is a powerful, non-invasive, and reliable non-destructive testing method for detecting and evaluating surface defects in metal structures. Its ability to gauge both depth and length without requiring extensive surface preparation makes it a preferred choice in many industrial applications.

American Welding Society's Custom Training Programs: A Pathway to Success

AWS Instructor and SME delivering in-person training

By ***Dr Payel Dutta Chowdhury****, Marketing & Communications Content Specialist (International Business) for the American Welding Society*

In today's rapidly evolving job market, skill development is crucial for vocational careers.

It ensures employability, boosts earning potential, and fosters personal growth, enabling individuals to adapt to technological advancements and contribute to economic prosperity. Towards this direction, training can play a vital role in developing the skills and knowledge needed for effective performance, whether in a professional or personal setting. It enhances productivity, improves quality, reduces errors, and fosters a more confident and engaged workforce. Hence, training is considered a crucial investment that yields significant returns in terms of individual and organizational success.

The impact of training: How upskilling & reskilling benefit individuals and organizations

Training equips individuals with in-demand skills, making them more attractive to potential employers and increasing their chances of securing jobs, especially in competitive job markets. Skill development through training can lead to promotions, new opportunities, and increased earning potential. When individuals acquire new skills and become proficient in their roles, their job satisfaction and confidence naturally increase. In fact, skill development goes beyond professional growth; it can enhance critical thinking, problem-solving abilities, and adaptability, contributing to overall personal development. Training helps individuals stay relevant in a constantly evolving job market by equipping them with the skills to adapt to new technologies and industry changes.

Training benefits organizations too by improving productivity, enhancing employee satisfaction, and fostering a more competitive workforce. Well-trained employees are more efficient and productive, leading to better overall organizational performance. Training helps bridge the gap between required skills and the skills possessed by employees, ensuring the workforce is equipped to meet job demands. Organizations with a skilled and trained workforce are better positioned to compete in the market. Providing training and development opportunities can make employees feel valued and increase their loyalty to the organization. Training can foster a culture of continuous learning and improvement, leading to a more engaged and motivated workforce. Investing in training can be more cost-effective than relying solely on hiring new employees, especially when considering the costs of recruitment and onboarding.

Vocational professions and training

Vocational professions, in particular, significantly benefits from workforce training. Continuous learning and upskilling are crucial for professionals in these fields to stay relevant, competitive, and adapt to evolving technologies and industry standards. Periodic training helps them stay current with industry trends, acquire new skills, and enhance their job performance, ultimately leading to increased career opportunities and earning potential.

Like many other vocational occupations, welding is also a dynamic profession due to its diverse applications, continuous technological advancements, and the ongoing need for skilled professionals across various industries. The welding industry is constantly evolving with new technologies like robotic welding, laser welding, and automated systems. Welders need to adapt to these changes and learn new techniques to remain competitive. The need for specialized certifications and continuous training ensures that welders stay updated with the latest industry standards and practices.

AMERICAN WELDING SOCIETY'S

Focus on Lifelong Learning

The American Welding Society (AWS), with its focus on "developing the next generation of welders" (www.aws.org), draws its welding core values from its mission and vision to make a global impact. Significantly, one of the core values of AWS is "Encouraging continuous education as a fundamental activity of welding industry professionals throughout their careers", which highlights the organization's emphasis on lifelong learning. Towards this end, the organization offers a variety of custom training solutions that are tailored to meet the needs of individuals and companies.

Popular AWS Custom Training Programs: Popular AWS Custom Training Programs include (but are not limited to)

Welding Inspection & Certification
Welding Inspection / Certified Welding Inspector (CWI); Welding Symbols & Welding Safety; WPS/PQR Development; Welding Coordinator

Industry-Specific Codes & Standards
AWS D1.1 Structural Welding Code – Steel; AWS D1.1 Welding Procedure Development; API 1104 Pipeline & Related Facilities; API 1104 Welding Procedure Development; API 570: Piping Inspection Code; API 571: Damage Mechanisms in Refining Industry; API 580/581: Risk-Based Inspection; AWS D17.1 Fusion Welding for Aerospace Applications; ASME Section IX; ASME B31.1 Power Piping; ASME B31.3 Process Piping – Design, Construction, and Mechanical; ASME B31.4 Liquid Pipelines and ASME B31.8 Gas Pipelines; Introduction to ASME Pressure Vessel Inspection (Section VIII Div. 1

Specialized Training
Certified Welding Supervisor (CWS); Certified Welding Educator (CWE); Resistance Welding; Welding Economics; HDPE/RTR Non-Metallic Piping Certification; Construction Contracting; Pre-stressed Concrete & Structural Welding; Methods & Materials for Construction Projects; Mechanical Testing of Welds and Base Metals

NDT Training
Introduction to NDE; Dye Penetrant Testing; PT Procedure development; Magnetic Particle Testing Basics; MT - Procedure Development

AWS also develops fully customized training based on client's unique needs.

AWS Custom Training Program Formats

Depending on one's needs and preferences, AWS offers flexible modes of training options. Clients can choose from in-person, online instructor-led, self-paced online, and dual format options.

i) <u>In-person training</u>: This format of training is delivered face-to-face by AWS instructors and SMEs in a focused classroom environment. It offers essential tools such as standards and codebooks, culminating in an in-class practice exam. In-person training is highly beneficial as it provides individuals with opportunities to gain real-world experience. Trainees also get the chance to learn from industry leaders and experienced professionals, get inspired by their career trajectory, and clarify their doubts immediately. They can connect with peers during the training program and expand their professional network.

ii) <u>Online Instructor-led training</u>: This virtual training format provides the opportunity for interactive learning sessions led by industry experts. It offers a blend of flexibility and engagement, providing personalized learning experiences. The interactive sessions allow for immediate feedback and foster collaborative learning among peers, offering an extended classroom experience tailored to client needs. The AWS online instructor-led training programs are offered throughout the year for each course, making this format a popular choice for both learners and organizations.

iii) <u>Self-paced online training</u>: This format provides complete flexibility and personalization by allowing learners to study at their own pace, revisit materials as needed, and tailor their learning experience to their individual needs and preferences. It offers an extensive range of courses that are aligned with AWS certifications and standards. The courses are presented through multimedia tools and interactive features. Learners can access these courses 24/7 from any internet-enabled device.

iv) <u>Dual format</u>: This format of training is ideal for individuals who want the flexibility to balance work, life, and education. Here, learners begin their training online as per their convenience and then join live instructor-led sessions to deepen their understanding and ask questions in real-time. The dual format option has been designed to adapt to the trainees' special requirements, schedule and availability.

3 STEP

Training & Certification Process

STEP 1:
Benchmarking Assessment

- AWS conducts a skills gap analysis to evaluate candidates' technical proficiency.
- Recommendations are provided for targeted training.

STEP 2:
Custom Onsite Training

- Delivery: Conducted by AWS-certified instructors at client's facility or a mutually agreed venue (e.g., company campus, hotel).
- Structure: Combines theoretical knowledge, hands-on practice (wherever required), and a final assessment.
- Duration: Tailored per program (TAT determined based on complexity and SME availability).

STEP 3:
Certification

- Trainees can enroll for AWS professional certifications post-training.

The American Welding Society's customized training programs offer significant benefits by aligning directly with specific organizational needs and employee skill gaps. The wide range of courses, different training formats, and delivery by expert instructors, ensure employee performance, boost morale, and improve overall productivity. By tailoring content and delivery methods, AWS makes sure that the training is relevant, engaging, and impactful, maximizing its impact on individual and organizational performance.

[To know more about the AWS Custom Training Programs, you may reach out to the author at p_pdchowdhury@aws.org]

Strengthening Certification: A New Era of Innovation for ASNT

By Paul Lang, ASNT Chief Global Strategy Officer and Executive Director of ASNT Certification Services LLC.

The landscape of Nondestructive Testing (NDT) certification is evolving significantly, driven by strategic partnerships, a renewed focus on training quality, and a proactive embrace of technological advancements. ASNT is at the forefront of these changes, working to ensure its certification programs remain robust, relevant, and globally accessible.

For over six decades, ASNT's Recommended Practice No. SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing has been the bedrock of employer-based qualification and certification for NDT personnel. Initially designed to offer a flexible, employer-driven model, SNT-TC-1A allowed organizations to customize their certification programs to meet specific operational and regulatory requirements. However, as the global NDT landscape evolves—with growing demands for standardization, transferability, and independent oversight—the time has come to reassess SNT-TC-1A's future role in the NDT industry.

SNT-TC-1A is a non-mandatory guideline document, providing a recommended framework for developing an employer's written practice for the qualification and certification of NDT personnel. Unlike its counterpart, ANSI/ASNT CP-189: ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel, a prescriptive standard with binding requirements, SNT-TC-1A was designed for flexibility. This adaptability has made it an attractive option for organizations needing customized approaches to NDT certification. Employers appreciate the cost-effectiveness, direct oversight, and customizability that SNT-TC-1A provides, empowering them to manage training, examinations, and certifications internally. Yet, this same flexibility has also led to significant inconsistencies in implementation across the industry.

Over the years, several structural vulnerabilities have surfaced within the SNT-TC-1A model. Among the most pressing concerns are:

- **Inconsistent implementation**: SNT-TC-1A is interpreted and applied differently across companies as a guideline rather than a standard, resulting in varied qualification processes and uneven competency benchmarks.
- **Minimal compliance practices**: Some organizations aim only for the bare minimum, compromising quality for reduced cost or convenience.
- Without third-party auditing or certification, the system relies entirely on internal documentation, making it susceptible to manipulation and fraud.
- Internal certifiers may face pressure to certify underqualified personnel, raising concerns about impartiality and competency.
- The quality and consistency of training programs vary widely. Organizations sometimes neglect proper recertification protocols, allowing certifications to become outdated.

These issues raise critical questions about the credibility, consistency, and global acceptance of certifications issued under employer-based models like SNT-TC-1A. The global NDT community is increasingly shifting toward third-party independent certification programs, such as ASNT 9712. This program is based on ANSI/ASNT CP-9712: Nondestructive Testing Qualification and Certification of NDT Personnel (2023), an identical adoption of ISO 9712: Non-destructive testing — Qualification and certification of NDT personnel. ANSI/ASNT CP-9712 aligns more closely with international standards and provides enhanced transparency, transferability, and public trust.

This doesn't mean that SNT-TC-1A is obsolete. On the contrary, ASNT recognizes its continued relevance, particularly for test methods and techniques not covered by third-party schemes. The future of NDT certification lies in a hybrid model, where baseline knowledge and competency are validated through third-party certification, while employer-based programs build upon that foundation with job-specific training and performance monitoring. While the next edition of SNT-TC-1A is scheduled for 2028, ASNT leadership is working to expedite the revision process, with milestones and KPIs (key performance indicators) already in development. ASNT has already taken steps to strengthen SNT-TC-1A. The 2025 Addendum to SNT-TC-1A (2024), published in June 2025, has initiated a renewed focus on revising and restructuring the document.

Raising the Bar with a New Authorized Training Organization Accreditation

In response to industry concerns regarding inconsistencies in training quality, ASNT has launched an Authorized Training Organization (ATO) accreditation program. This program aims to standardize the quality of NDT instruction by accrediting educational institutions such as universities, community colleges, trade schools, and other training providers.

The official launch of the ATO program took place in early April 2025, and interested organizations can access applications on the ASNT website. The program has already garnered significant interest underscoring the NDT community's desire for enhanced training credibility and consistency.

Expanding ASNT's Global Footprint

ASNT's global reach continues to expand through the success of ASNT India Pvt. Ltd., an entity established in 2023. ASNT India has been instrumental in offering certification exams, training programs, webinars, and industry events, significantly reinforcing the organization's presence in the region. ASNT Certification Services has a dedicated agreement with ASNT India to administer these exams, making certification more accessible and efficient for professionals in the region.

Charting the Future of NDT Certification in a Tech-Driven World

Looking ahead, technological advancements present both a challenge and an opportunity for NDT certification. Innovations in artificial intelligence (AI), augmented reality (AR), and virtual reality (VR) are revolutionizing the industry, yet they present complexities when applied to a certification framework developed over 50 years ago.

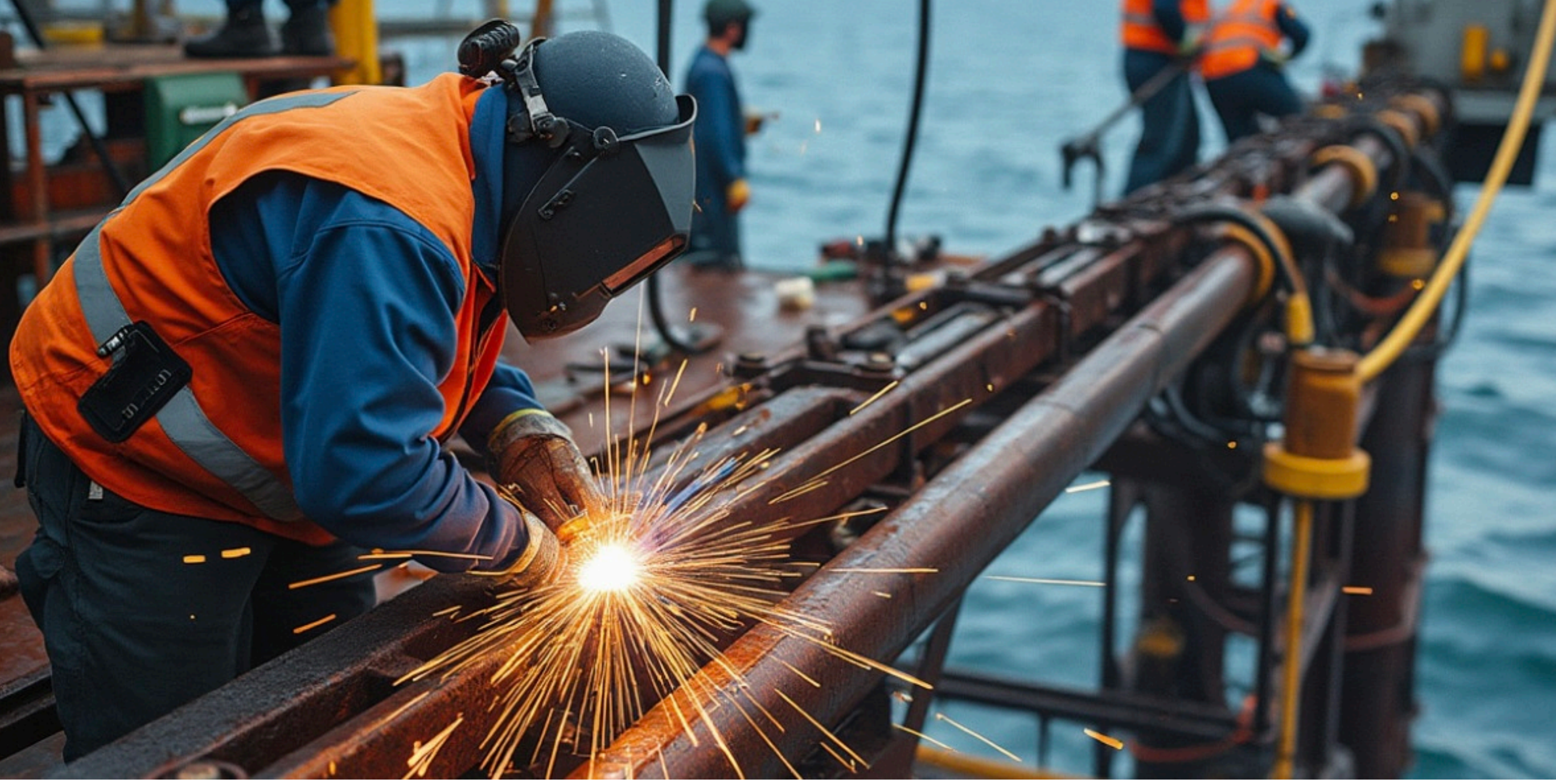
The NDT industry is at a critical point where we need to reassess how we evaluate competency. AI and AR are changing the game, and ASNT must adapt our certification methods to reflect these advancements."

ASNT is actively exploring ways to modernize competency assessment, recognizing that the traditional Level I, II, and III certification model may need to evolve to accommodate emerging technologies and new methodologies. The organization is committed to collaborating with industry stakeholders to develop a future-ready certification system that ensures continued excellence in NDT.

CONCLUSION

SNT-TC-1A has played a vital role in shaping the employer-based certification landscape, offering flexibility and practicality for decades. However, as the industry matures and global expectations rise, it must evolve. ASNT is making significant strides in enhancing certification programs, standardizing training, expanding its global reach, and proactively adapting to technological advancements.

By reaffirming its purpose, addressing its weaknesses, and integrating with independent third-party certification schemes, ASNT is laying the groundwork for a more credible, consistent, and future-ready NDT workforce. The journey ahead requires a cultural shift, investment in training and process changes, and a commitment to quality over convenience. However, with these efforts, ASNT will ensure that SNT-TC-1A and the professionals who rely on it continue to thrive in a rapidly changing world.



Digital Transformation of the Welding Process in Oil & Gas Pipeline Manufacturing

Authors
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INTRODUCTION

The oil and gas industry powers the world by providing energy and materials for products like plastics and chemicals. Pipelines are vital for moving oil and gas safely from production sites to places like refineries, power plants, or homes. Welding is a critical step in building these pipelines, as it joins pipe sections to create strong, leak-proof systems that can handle high pressure and harsh conditions. Traditional welding has challenges, such as human errors, slow processes, and safety risks. New digital technologies like IoT, AI, and machine learning are changing this. They help control welding better, catch problems early, and make pipelines safer and cheaper to build. This article explores how these tools are improving welding and what challenges the industry faces in using them.

Importance of Pipelines

Pipelines act like highways for oil and gas, carrying these resources over long distances. They must be strong to handle extreme conditions like high pressure, cold or hot weather, and corrosive materials. Building pipelines involves choosing the right materials (usually steel), shaping them into pipes, welding them together, and coating them to prevent rust. Each step must meet strict safety and quality standards to avoid leaks or failures.

Role of Welding

Welding is the process of joining pipe sections to form a continuous pipeline. The welds must be perfect to prevent leaks, which could cause environmental damage or safety hazards. Common welding methods include arc welding, submerged arc welding (SAW), and gas metal arc welding (GMAW). Skilled welders are essential, but mistakes can happen, leading to weak welds that might fail under pressure.

Challenges in Traditional Welding

Traditional welding has several issues that affect quality, speed, and safety. Main problems:

Human Error

Welders are skilled, but they can make mistakes due to tiredness or small differences in their technique. These errors can lead to:

- **Inconsistent Welds**: Even experienced welders may create welds that vary slightly, which can weaken pipelines.
- **Misaligned Pipes**: If pipes aren't lined up correctly, the welds may not hold up under stress.
- **Wrong Settings**: Welders set things like heat or speed. If these are off, welds can have cracks or other flaws.

Slow and Inefficient

Manual welding takes time, especially for large pipelines that need thousands of welds. Other issues include:

- **Time-Consuming**: Welders need breaks, slowing down projects.
- **Material Waste**: Mistakes mean some welds must be redone, wasting materials and time.
- **Limited Scalability**: Hiring more welders is not always possible, and training them takes time.

Safety Risks

Welding is dangerous. Welders face risks like:

- **Health Issues**: Fumes from welding can harm lungs, and bright welding light can hurt eyes or skin.
- **Fire and Explosions**: Welding near flammable materials, common in oil and gas, can cause fires.
- **Electric Shocks**: High electricity used in welding can be deadly if safety rules are not followed.
- **Physical Injuries**: Welders often work in tight spaces or high places, increasing the chance of falls or strains.

How Digital Tools Solve These Problems

Digital technologies are making welding better by reducing errors, speeding up work, and improving safety. Here's how:

Reducing Errors

New tools make welding more precise:

- **Robotic Welders**: Machines can weld pipes with the same quality every time, avoiding human mistakes. They follow exact instructions for heat, speed, and position.
- **Sensors**: These devices check welds as they're made, catching problems like cracks instantly and fixing them automatically.
- **Simulation Software**: Engineers can test welds on a computer before starting, ensuring everything is perfect from the start.

Increasing Efficiency

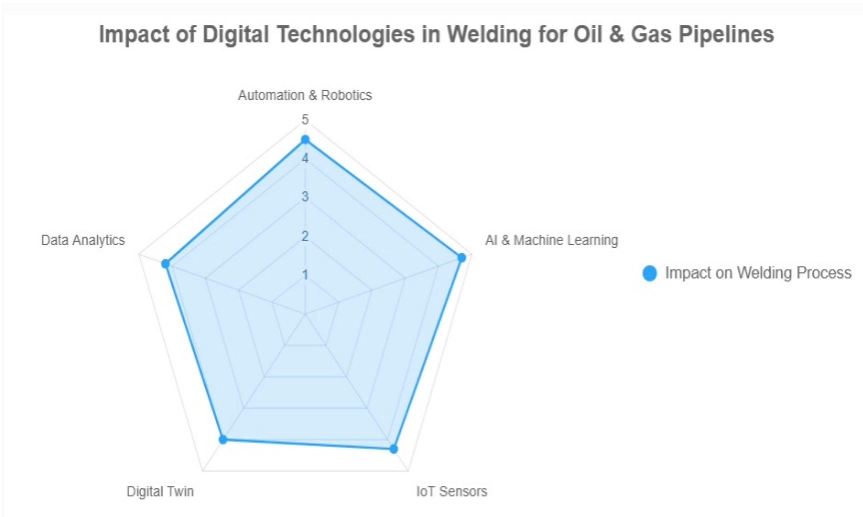
Digital tools make welding faster and less wasteful:

- **Automation**: Robots work without breaks, speeding up projects.
- **Remote Monitoring**: Managers can watch welding from far away and fix issues without stopping work.
- **Predictive Maintenance**: Data from machines can predict when equipment needs repairs, preventing breakdowns.

Improving Safety

Digital tools keep workers safer:

- **Less Exposure to Danger**: Robots handle hot, risky welds, so workers stay away from harmful fumes and bright lights.
- **Remote Control**: Welders can operate machines from safe locations.
- **Less Physical Strain**: Machines do heavy lifting, reducing injuries from awkward positions.



Key Digital Technologies in Welding

Several technologies are changing how welding is done in pipeline manufacturing:

Automation and Robotics

Robotic welders use advanced arms and sensors to create perfect welds every time. They are especially useful for long pipelines where consistency is key. Robots can work in dangerous areas, keeping humans safe, and they do not get tired, so projects finish faster.

Artificial Intelligence (AI) and Machine Learning (ML)

AI and ML make welding smarter:

- **Predicting Weld Quality**: AI uses data to guess how good a weld will be, reducing the need for manual checks.
- **Finding Flaws**: ML can spot tiny defects in welds using X-rays or sound waves, catching problems humans might miss.
- **Adjusting on the Fly**: AI tweaks settings like heat during welding to ensure strong welds.
- **Equipment Maintenance**: AI predicts when machines might break, allowing repairs before problems happen.

Internet of Things (IoT) Sensors

IoT sensors are small devices that collect data during welding:

- **Real-Time Checks**: Sensors monitor heat, pressure, and weld quality, fixing issues instantly.
- **Equipment Health**: Sensors warn when machines need maintenance, avoiding sudden breakdowns.
- **Data for Improvement**: Collected data helps companies improve welding techniques over time.
- **Remote Oversight**: Managers can check welds from anywhere, reducing the need for workers in risky areas.

Digital Twin Technology

A digital twin is a virtual copy of the welding process. It lets engineers:

- **Monitor Welds**: See how welds are performing in real time.
- **Test Changes**: Try new settings virtually before using them in real life.
- **Plan Maintenance**: Predict when equipment needs fixing to avoid downtime.

Data Analytics

Data analytics uses information from sensors to make welding better:

- **Spotting Problems**: Data shows if welds have issues, like cracks or weak spots.
- **Optimizing Work**: Analytics helps set the best heat or speed for each weld.
- **Tracking Quality**: Data ensures welds meet safety rules and can be checked later if needed.

Benefits of Digital Transformation

Digital tools bring many advantages to welding in pipeline manufacturing:

Better Quality and Precision

Sensors and AI catch mistakes early; ensuring welds are strong and consistent. This reduces weak spots that could cause leaks, making pipelines safer and longer lasting.

Safer Workplaces

Robots and remote controls keep workers away from dangerous tasks. Sensors also warn about risks like equipment failures, preventing accidents before they happen.

Faster Work

Automation speeds up welding, and data helps optimize processes, so projects finish quicker. This is especially important for large pipelines that need thousands of welds.

Lower Costs

Digital tools save money by:

- Reducing mistakes that lead to rework.
- Using materials and energy more efficiently.
- Preventing costly equipment breakdowns with predictive maintenance.

More Sustainable

Digital welding reduces waste by making precise welds that do not need fixing. It also uses less energy, helping the environment and meeting eco-friendly goals.

Challenges of Adopting Digital Tools

While digital tools are powerful, using them isn't easy. Here are the main hurdles:

High Costs

- **Expensive Technology**: Robots, sensors, and AI systems cost a lot to buy and set up.
- **Training Workers**: Employees need training to use new tools, which takes time and money.
- **Uncertain Returns**: It's hard to know when the investment will pay off, especially for smaller companies.
- **Old Systems**: Many companies use outdated equipment that doesn't work well with new technology, requiring costly upgrades.

Data Security

- **Cyberattacks**: Digital systems can be hacked, risking sensitive data or equipment control.
- **Data Accuracy**: Keeping data correct across systems is tricky and can lead to mistakes.
- **Rules and Regulations**: Companies must follow strict data laws, which adds complexity.

Workforce Challenges

- **Skill Gaps**: Workers may not know how to use digital tools, requiring extensive training.
- **Resistance to Change**: Some employees fear new technology will replace their jobs or change their work.
- **Complex Tools**: New systems can be hard to learn, slowing down work if not user-friendly.

Lack of Standards

There are no global rules for using digital tools in welding. This causes problems like:

- Equipment and software not working together.
- Higher costs to fix compatibility issues.
- Slower adoption of new tools due to confusion over best practices.

Future Trends and Opportunities

Digital welding is evolving, with exciting trends on the horizon:

AI and Predictive Maintenance

AI will get better at predicting equipment problems and ensuring perfect welds. This will reduce downtime and make pipelines last longer. However, AI systems are expensive and need lots of data to work well.

Augmented Reality (AR) for Training

AR lets welders practice in a virtual world, learning skills without risking mistakes. This is safer and helps new welders learn faster, improving quality and reducing errors.

Block chain for Traceability

Block chain creates a secure record of every step in welding, from materials to final welds. This ensures quality, prevents fraud, and makes it easier to meet safety rules. However, integrating block chain with current systems is challenging.

Conclusion

Digital transformation is changing welding in the oil and gas industry for the better. It makes welds stronger, work faster, and workplaces safer while cutting costs and waste. Technologies like AI, IoT, and robotics are leading the way, but challenges like high costs, training needs, and data security must be addressed.

In the future, digital tools will become standard in pipeline welding, driven by the need for efficiency, safety, and sustainability. Companies that invest in these technologies and train their workers will build better pipelines and stay competitive. By working together, the industry can overcome challenges and create a smarter, greener future for pipeline manufacturing.

Fire Risks and Safety Measures in Road Transport of LPG Tanker Trucks.

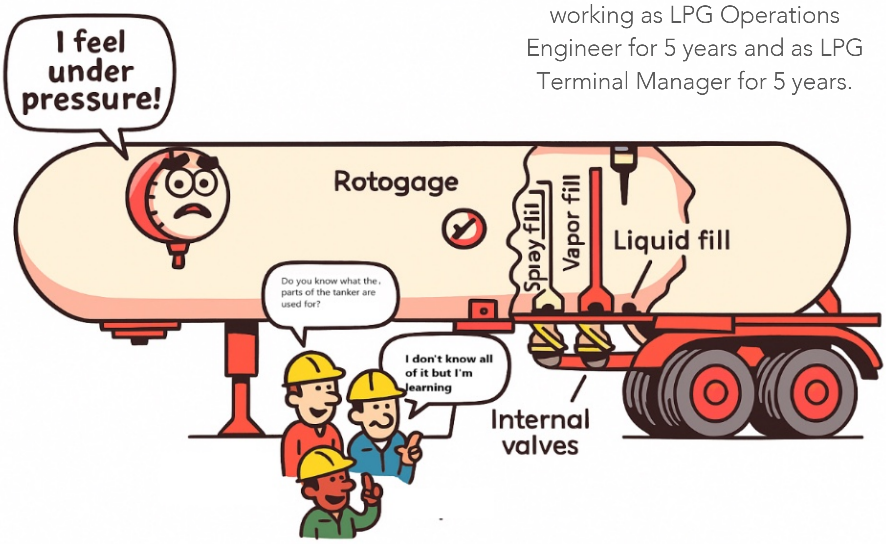
Liquefied Petroleum Gas (LPG) plays a critical role in energy supply chains, especially in countries heavily reliant on road transportation. The widespread use of LPG in residential, industrial, and automotive sectors necessitates a robust logistics network, where road tankers serve as the backbone for inland transport. However, the flammable nature of LPG introduces significant fire and explosion hazards that require careful management.

Fire incidents involving LPG road tankers, although infrequent, can have catastrophic consequences. High temperatures, intense thermal radiation, and potential BLEVE (Boiling Liquid Expanding Vapor Explosion) events make such accidents particularly dangerous for both drivers and surrounding communities. These risks underscore the importance of understanding, preventing, and effectively responding to fire hazards in this sector.

This article focuses on identifying the fire risks associated with road LPG tankers and outlines the technical, procedural, and regulatory safety measures implemented to mitigate these dangers. It emphasizes the need for comprehensive fire prevention strategies tailored to the unique challenges of road-based LPG transport.

1. Technical Features of Road LPG Tanker Trucks

Technical Specifications and Safety Equipment of Road LPG Tanker Trucks. Tanker trucks that transport LPG by road are designed and manufactured in accordance with national and international regulations regarding the transport of hazardous materials (e.g. ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road). These transport vehicles must meet special engineering criteria in order to transport liquefied petroleum gas (LPG) safely under pressure.

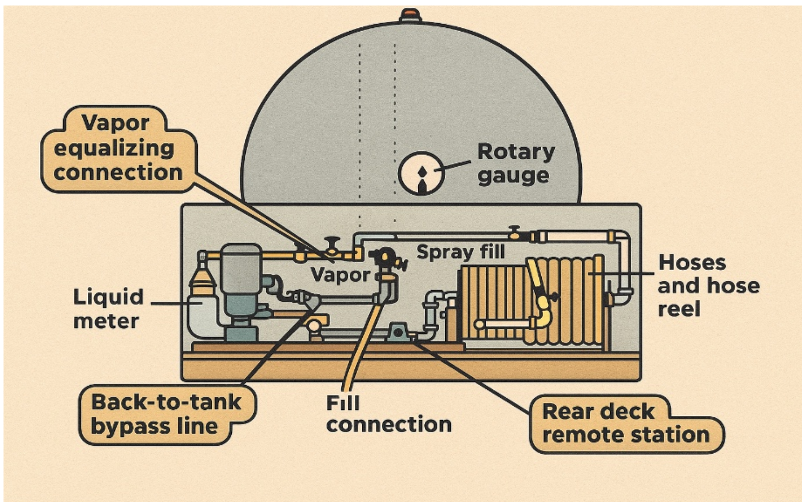


I was born in Ankara, Türkiye in 1987, I have been living in Türkiye/Hatay for many years. I graduated from Akdeniz University in 2010 as a Mechanical Engineer, and in 2012 I completed my master's degree in heat transfer & fluid mechanics at Mustafa Kemal University. I have been working as a mechanical engineer in the sector for 13 years. I worked in the field of production and manufacturing for the first 3 years of my profession, and then for 2 years, I worked in project-based maintenance-repair and capacity increase works in Oil&LPG terminals. I have been working at Milangaz for the last 8 years. I have been working as LPG Operations Engineer for 5 years and as LPG Terminal Manager for 5 years.

a. **Tank Structure and Material Properties**: LPG tanks used in tankers are generally cylindrical in section and horizontally positioned and are manufactured using high-strength alloy carbon steel. The tank body is tested with non-destructive testing (NDT) methods to provide resistance against both internal and external effects (radiographic testing, penetrant testing, hydrostatic testing, etc.). In addition, the outer surfaces are protected with paint against corrosion.

b. **Pressure Relief Valves (PRV)**: When the pressure in the tank exceeds a certain pressure set value, it automatically opens and provides a controlled discharge. Pressure safety valves are activated in over-pressure conditions such as fire or overfilling and are very critical equipment for the integrity of the tank.

c. **Emergency Shut-Off Valves (ESV)**: These valves, usually integrated into the tanker's bottom or inside connections of the tank, are closed remotely or automatically in the event of an accident or leak, cutting off the LPG flow. They must be closed position while the vehicle is moving on the road.



d. **Level Indicators**: These are systems that allow the LPG level in the tank to be monitored. The level on the tank can be monitored with systems called Rochester or Rotogauge.

e. **Pump and Transfer Systems**: The pumps used during LPG transfer are mounted on the tanker and are used to supply gas to customers. Transfer hoses used during supply are special hoses resistant to LPG that comply with the relevant standards.

f. **Excess Flow Valves**: In the event of a connection line break or unexpected high flow rate, it automatically cuts off the LPG flow in the line.

2. Causes of Fire and Risk Reduction Methods in LPG Tanker Accidents

Liquefied Petroleum Gas (LPG) tankers used in transportation pose serious safety risks because they carry highly flammable products. Traffic accidents involving these tankers are one of the most important causes of LPG-related fires. Mechanical damages that occur in such incidents can lead to leaks in the tank or pipe system where the LPG is located. Impact forces, especially in accidents, can damage the structural integrity of pipes, fittings, valves or the tank, causing the gas to spread uncontrollably into the environment. Leaking LPG starts to burn rapidly when it comes into contact with a suitable ignition source and can cause explosions.

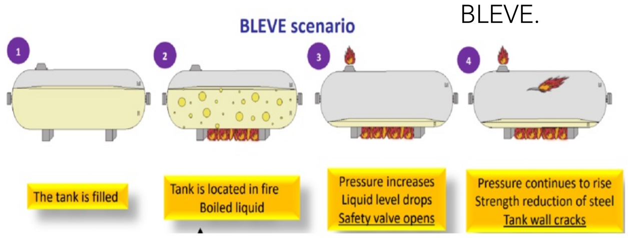
Not only traffic accidents, but also operational errors made during the loading and unloading operations of tankers are important factors that create a fire risk. Negligence such as incorrect connections, damaged or incompatible use of hoses in these processes can cause LPG leaks. In addition, factors such as aging of equipment used in tankers, lack of regular maintenance or technical malfunctions also increase the risk of leakage and fire. Errors related to human factors, such as non-procedural operations, carelessness or inadequate training, can further increase these risks.

In order to prevent all these risks, first of all, potential hazards and possible risk scenarios must be systematically analyzed.

In this context, risk assessment methods such as HAZOP (Hazard and Operability Analysis) and FMEA (Failure Modes and Effects Analysis) can be used. It is of great importance to establish appropriate technical and organizational barriers against the identified risks. These barriers include safety valves and emergency shut-off valves. In addition, the implementation of periodic maintenance programs, regular training of personnel, emergency drills and the establishment of an effective safety culture also play a critical role in minimizing risks.

3. Fire Scenarios in LPG Trucks

One of the most dangerous fire scenarios encountered in LPG (Liquefied Petroleum Gas) facilities is known as BLEVE (Boiling Liquid Expanding Vapor Explosion). BLEVE typically occurs when an LPG tank is exposed to external heat, especially fire. In such cases, the liquid LPG inside the tank rapidly vaporizes, causing a sudden and dramatic increase in internal pressure. If the tank's pressure relief systems are inadequate or out of service, the pressure may exceed the tank's structural limits, resulting in rupture or explosion.



The effects of a BLEVE are extremely destructive. Upon explosion, fragments of the tank are propelled at high speed into the surrounding area, causing severe injuries and secondary damage. The intense thermal radiation released after the explosion poses a fatal risk to human life and can ignite surrounding equipment and structures. Additionally, BLEVE can damage nearby tanks and facility components, triggering a domino effect that may escalate the situation.

Another critical fire scenario involves fires that occur during the transfer of LPG. These incidents are often caused by mechanical failures such as hose rupture, loosening of flange or coupling connections, seal wear, or assembly errors. Although the initial leak may appear minor, the low flash point and wide flammability limits of LPG make it highly susceptible to ignition from any spark or static discharge in the vicinity. When pressurized LPG is released and vaporizes, it can ignite rapidly, resulting in a jet fire. The presence of open flames, hot surfaces, or electrical equipment near the transfer line can significantly increase the speed and intensity of fire spread.
Fires involving transportation vehicles also pose serious risks. In LPG tankers, a fire that begins in the engine compartment or one caused by overheated brake systems can quickly spread to the tank area. If the fire is not brought under control swiftly, the tank may heat up, creating the risk of a BLEVE.

Such incidents present a major threat to driver safety and can have severe environmental consequences.

4. Emergency Management for LPG Tanker Accidents (Overturned)

The process of rescuing an LPG tanker that has been involved in a collision or has overturned is a highly dangerous undertaking. In order to ensure the safety of the individuals involved, as well as the safety of the operation, it is essential that those involved in the rescue are adequately trained, equipped, and that there is effective coordination with the emergency services.

In the event of an emergency, it is imperative that the relevant authorities, namely the LPG Emergency Services, encompassing both the fire department and the police, are informed without delay. It is of the utmost importance to emphasise that the management of such incidents should be entrusted exclusively to trained professionals, as their expertise are essential in ensuring the safety.

The primary concern is invariably the safety of individuals in the vicinity. In order to ensure the immediate security of the scene, it is imperative to implement a comprehensive evacuation protocol, encompassing all individuals within a designated safe perimeter, which is typically a minimum of 500 metres away.

Furthermore, it is crucial to ensure that all ignition sources are meticulously removed from the immediate vicinity of the site, and all potential leak points on the tank are meticulously examined. The inspection process entails the use of auditory perception from a safe distance, in addition to visual confirmation of any indications such as frost or vapour clouds. In the absence of any leaks, the tanker is approached and detailed gas leak checks are conducted. In addition, a thorough inspection of the piping and valves is imperative to ascertain the functionality of the tanker's emergency shut-off valves. It is imperative that the damage status of the tanker is thoroughly and accurately assessed, as this will inform the subsequent response actions of the emergency response team. A series of actions must be taken prior to the tanker being returned to its standard position. Prior to the execution of the lifting operation, it is imperative that the liquid LPG contained within the tanker be meticulously transferred to an alternative, secure tank. Secondly, the LPG vapour contained within the tank must be transferred to an alternative tank by means of a compressor.

Concurrently, the remaining LPG gas within the tank must be inertised with nitrogen. The mobile gas flares can serve as an effective solution if there is safe distance. It is imperative that a comprehensive and meticulous lifting plan is devised for the overturned tank, with the objective of averting any potential damage to the tank's equipment, including pipes and valves. The overturned tanker should be transferred to a designated safe area by a rescue vehicle that is appropriately equipped for the task.

Emergency LPG Transfer from a Damaged LPG Tanker Following an Accident

Emergency transfer of LPG from a damaged tanker should only be carried out by authorized, experienced, and trained LPG professionals. During the entire process, continuous coordination and communication must be maintained with fire departments, police, and relevant environmental authorities.

The accident site must first be secured with an extended safety perimeter. Wind direction should be identified to establish the hazard zone, and personnel should be positioned accordingly.

The damaged tanker must be thoroughly inspected for potential leaks using visual examination, acoustic listening, gas detectors, and foam tests. Particular attention should be paid to identifying any cracks, dents, protrusions, or structural deformations on the tank surface or valves.

Tank integrity is critically important. Under no circumstances should the tanker be lifted or moved using cranes or other lifting equipment before it is completely emptied, as this could lead to further damage or create additional hazards. If the conditions are deemed safe for LPG transfer, preparations can commence. To eliminate the risk of static electricity, both the damaged and receiving tankers must be individually grounded.

All transfer equipment used must be spark-proof and comply with ATEX standards.

If the operation is conducted at night, sufficient ATEX-certified lighting must be provided, and all personnel must be equipped with appropriate Personal Protective Equipment (PPE).

The receiving tanker should be positioned on level ground, preferably at a lower elevation than the damaged tanker, and placed upwind to minimize exposure to any potential LPG vapors. Hoses used for the transfer must be suitable for LPG service and equipped with breakaway couplings for additional safety.

Before initiating the transfer, tank pressures must be checked and adjusted if necessary. If a compressor is used, the vapor phase from the damaged tanker can be utilized to push the liquid LPG into the receiving tanker. However, using compressed nitrogen is considered a safer method. In this approach, the damaged tanker is pressurized with nitrogen, and the liquid LPG is transferred to the receiving tanker. During the entire process, the pressure in both tanks must be constantly monitored, and precautions must be in place to prevent over-pressurization.

Once the transfer is complete, it must be ensured that all liquid LPG has been removed from the damaged tank. If any liquid remains, the nitrogen inside the tank must be carefully vented, as nitrogen is a non-condensable gas and can cause a dangerous increase in internal pressure. If the product cannot be salvaged or transferred safely, the LPG inside the damaged tanker should be destroyed in a controlled manner using mobile flare units to render the tank safe.

Mobile Gas Flare: In emergencies involving liquefied petroleum gas (LPG) truck accidents, a mobile gas flare system plays a crucial role in ensuring safety. When such accidents occur, the potential for gas leakage poses a severe threat of explosions or fires if left unattended. To mitigate this risk, the mobile gas flare system is swiftly deployed to the accident site. Its purpose is to safely burn off the LPG in a controlled manner, minimizing the possibility of uncontrolled ignition. This proactive measure not only safeguards emergency responders but also protects the surrounding community from potential harm.

Emergency Management for LPG Tanker Accidents (During LPG Leaks)

A leaking LPG tanker accident poses a great danger due to the highly flammable and potentially explosive nature of liquefied petroleum gas (LPG). The first and foremost priority is to ensure the safety of all people in the vicinity. Since the risk of exposure to LPG vapors is serious, it is imperative to immediately evacuate the incident area and retreat to a safe distance. Evacuation areas should be determined in the opposite direction of the wind direction and the distance should be carefully adjusted according to the weather conditions and the amount of LPG released. All ignition sources that may increase the risk of fire and explosion, such as open fire, electrical equipment and smoking, should be eliminated immediately.

The use of personal protective equipment (PPE) is mandatory for all team members performing emergency intervention. The gas density of the environment should be carefully measured with gas detectors before the intervention, and only trained and equipped personnel should approach the leak.

If the source of the leak can be detected and controlled, the priority is to close the valves or isolate the damaged section with clamps or another method. The type of leak is also a critical factor; liquid LPG leaks can have a cooling effect, so special methods such as wet cloths can be used. In addition, tools that have a risk of sparking should definitely be avoided and non-sparking equipment should be used.

In cold regions, it is generally not recommended to apply water directly to liquid LPG, because water can cause LPG to evaporate and spread more quickly. However, moistening the leak area with pulverized water can reduce the LPG concentration in the air and reduce the risk of fire.
After the leak is completely controlled, ongoing gas level monitoring in the environment should be carried out and possible risks should be followed meticulously. These comprehensive measures are essential to minimize the effects of the accident and protect human life.

5. Emergency Management for LPG Tanker Accidents (During Fires)

In the event of a fire involving an LPG tanker, rapid, coordinated, and structured emergency response is critical to minimize risks to life, property, and the environment. The first step is to immediately activate the emergency response plan and notify local fire departments, emergency services, and relevant authorities. Establishing a safety perimeter around the tanker to prevent unauthorized access and protect responders from potential explosions is essential. Firefighting efforts should focus on preventing BLEVE (Boiling Liquid Expanding Vapor Explosion) by continuously cooling the LPG tanker with large amounts of water applied to exposed surfaces. If flames are not directly impinging on the tank body, especially the vapor space, the situation is more manageable. However, if flames contact the tank body and sufficient cooling cannot be maintained, the emergency zone must be evacuated immediately, as a BLEVE could occur at any moment.

In LPG tanker fires, warning signs and time for evacuation are often minimal. Classic indicators such as bulging, discoloration, or metallic ringing may not be visible or may appear too late. BLEVE events progress very rapidly; a tank may look intact one moment and be shattered and engulfed in a fireball the next.

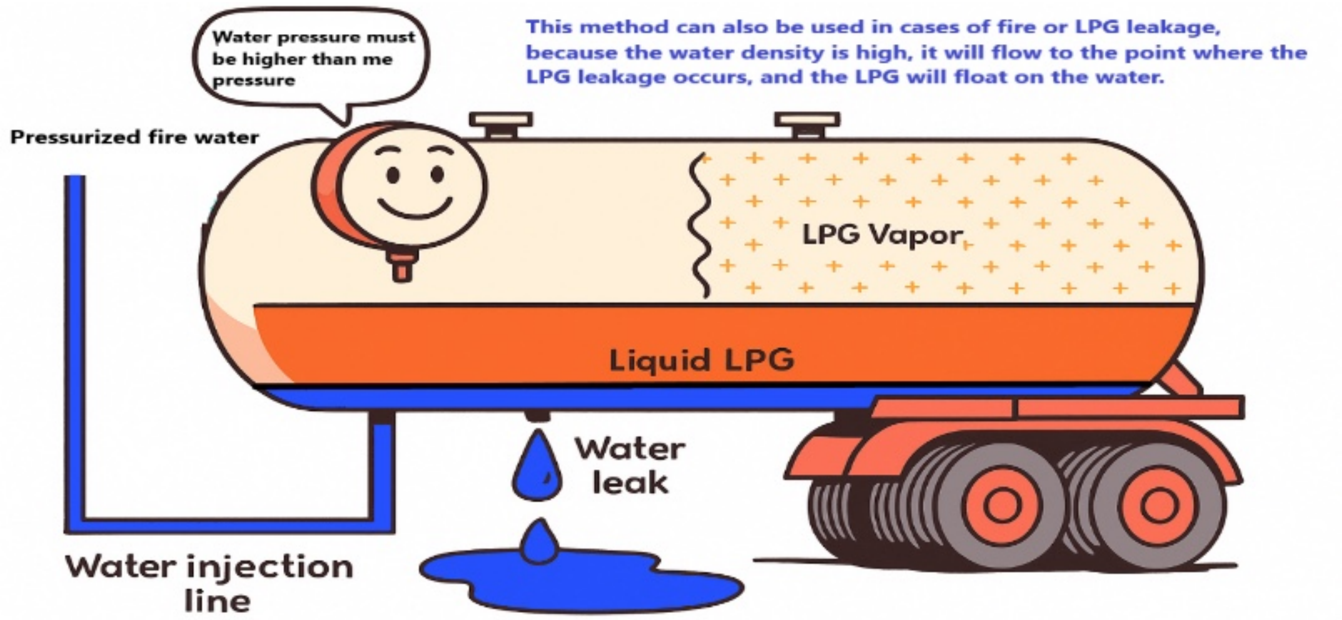
A critical early warning sign is the activity of the pressure relief valve (PRV or PSV). Initially, the PRV may open and close intermittently depending on where and how the fire affects the tank. If the PRV continues to cycle for a while, it may indicate limited fire exposure or that the fire has reached the liquid level both dangerous conditions.

However, a PRV that remains continuously open is a severe red flag. It indicates falling LPG liquid levels, loss of internal cooling, weakening steel strength, and vapor space heating conditions that set the stage for BLEVE.

Listen also for increasing PRV noise or prolonged flames, as these signal rising internal pressure. Keep in mind, though, that in real incidents these cues can be subtle or missed entirely. The harsh reality is that there may be no second chance. When in doubt, keep a safe distance.

Emergency Water Injection of LPG Leak

When something happens and you're faced with an uncontrollable liquid LPG leak you have very few options. Depending on the size of the tank and the volume of the release, a liquid LPG leak can quickly create a large hazard area requiring large area evacuations, limit your ability to safely extricate trapped accident employees or identify the location of a leak. In this situation you can use water injection method ıf all conditions are proper.



Injecting water into a LPG tank is a leak management option that most responders and operators have not considered. Water injection, just like all response tactics, requires special knowledge, identified tactical objectives, the proper tools and training. When a leak occurs in the tank, especially in the nozzle flange gasket, weld seam or valve body, the LPG leak cannot be stopped by emergency shut-off valves. In such cases, it will be necessary to flood the tank. When water is injected into the tank, since water will down to the bottom of the tank due to the density difference and the LPG will be displaced upwards. With this operation, the LPG leak will be replaced by a water leak. Thus, the LPG leak will be replaced by a water leak. LPG leakage will be end. While designing such a system, should be attention, the water pressure should be higher than the vapor pressure of the LPG inside the tank. Water injection is the process of forcing water into a tank using a water supply capable of producing more pressure than the LPG tank's internal pressure. Also a check valve should definitely be used in the water injection lines. Otherwise, LPG can flow to water line and the situation may become more dangerous. As a result, with this method, LPG leakage can be prevented and stopped when water is injected into the tank. If there is a fire, ıt can stop fire, thus It is one of the most basic barriers that can prevent BLEVE.

CONCLUSION

The transportation of LPG by road tanker trucks carries inherent risks due to the highly flammable nature of the product and the complexity of operations involved. While such incidents are relatively rare, their potential consequences ranging from large-scale fires to catastrophic BLEVE events demand a rigorous and multidimensional approach to safety. Technical integrity, operational discipline, and regulatory compliance must work in harmony to reduce fire-related hazards in LPG logistics. This study demos that fire scenarios in LPG tanker incidents often stem from mechanical failures, human errors, or inadequate maintenance practices. Components like pressure relief valves, emergency shut-off valves, and level indicators play a pivotal role in early risk detection and mitigation. However, even with advanced safety equipment, the effectiveness of risk control measures is ultimately dependent on the human factor adequately trained personnel, emergency preparedness, and situational awareness are essential to preventing escalation. Response strategies must be designed with flexibility, competency, and rapid execution in mind. Interventions such as mobile gas flaring, inerting with nitrogen, and, in critical cases, water injection into tanks are powerful tools to control hazards and prevent BLEVE. These methods underscore the importance of not only preventive strategies but also active incident management. The safe transportation of LPG by road hinges on a combination of engineered safety systems, proactive risk assessment, and well-coordinated emergency management. Continuous training, technological investment, and knowledge-sharing among stakeholders can significantly enhance the safety culture within the industry. In doing so, both operational continuity and public safety can be upheld even under the most challenging conditions.

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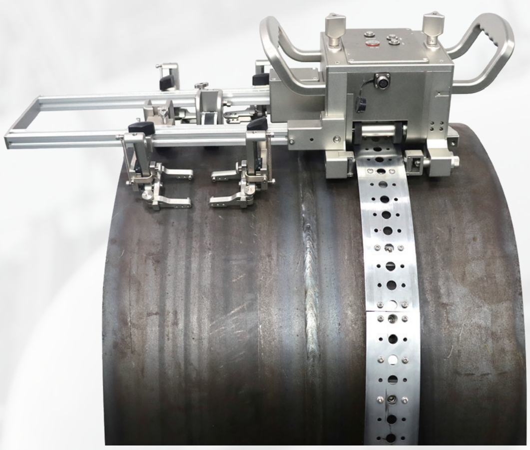

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