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Risk Alive® Storage Tank Risk Intelligence

Leveraging Industry-Wide PHA/HAZOP Data for Safer Tank Operations

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Executive Summary

Risk Alive® has analyzed thousands of real-world PHA and HAZOP scenarios related to storage tanks across industry sectors. Using this data, we've identified risk trends, safeguard weaknesses, and critical recommendations specific to tank farms, hydrocarbon tanks, EDC storage, produced water tanks, and more. This article summarizes some of those findings and demonstrates how actionable insights from industry data can improve safety, reduce risk, and guide investment decisions. Our platform modules: Top Threats, Safeguard Ranking, Safeguard Bypass, Recommendation Sequencer, Industry Search, and more play a key role in turning raw PHA data into intelligent operational and process safety guidance.

About Risk Alive® & Platform Overview

Risk Alive® transforms process safety data into decisions. By analyzing your individual plants and comparing to anonymized data from thousands of PHAs and HAZOPs across the industry, we help companies:

- Identify top recurring threats across units and equipment.
- Benchmark risks by commodity, tank type, or region.
- Prioritize recommendations based on cost, risk reduction, and feasibility.
- Visualize safeguard coverage and gaps.
- Leverage industry intelligence to pre-populate or validate upcoming PHAs.

Modules supporting analytics:

- **Top Threats** – high-frequency causes from across the industry.
- **Safeguard Ranking** – most effective safeguards by scenario type.
- **Recommendation Sequencer** – ROI-driven implementation logic.
- **Safeguard Bypass** – visibility on compromised layers of protection.
- **Industry Search** – find comparable risks across sites, commodities, and tank types.

Tank Farms – Risk Analysis and Deep Dive

Tank Farms are among the most common and critical unit types in the storage infrastructure landscape. With over 8,000 high-risk scenarios analyzed from the Risk Alive® PHA/HAZOP industry database, Tank Farms present a unique intersection of operational complexity and consequence severity. The following analysis outlines the most frequent threats, their linked consequences, safeguard effectiveness, and risk reduction pathways.

Total High-Risk Scenarios Analyzed: >8,000

Top Threats:

- Blocked outlet from drain or transfer lines.
- Operator error during loading/unloading.
- Instrument failure on level transmitters or alarms.
- Reverse flow from shared manifolds.
- Pump leak or failure to start.

Top Consequences:

- Tank overfill → containment breach.
- Environmental release of product.
- Fire/explosion risk from vapor release.
- Operator exposure to chemical splash or vapor.
- Regulatory non-compliance (SPCC/API 2350 violations).

Top Safeguards:

- Independent High-Level Switch (IHLS).
- Berms/dikes.
- Manual tank gauging.
- High-high alarms tied to interlocks.
- Overflow lines to secondary containment.

Risk Reduction (Based on Credit Movement):

- Alarm based safeguards removed ~2–3 points from inherent risk on average.
- Mechanical safeguards (MEC) credited inconsistently across industry.
- Future risk improved most when recommendations automated alarming or added redundancies.

Visuals:

- Heatmap: Cause category vs. consequence category.
- Chart: Risk rank distribution (inherent → residual → future).
- 10 bowtie diagrams covering tank overfill, pump seal failure, incorrect lineup, etc.

(Please reach out for more details)

General Storage Tanks – Common Hazards and Safeguard Insights

Storage tanks (fixed roof, floating roof, pressure-rated) are responsible for a large proportion of industry risk scenarios. Scenarios involving high level, overflow, contamination, and blocked vents are common. The most frequently observed cause categories include instrumentation failure, manual error, and equipment malfunction.

General-purpose storage tanks, including fixed roof, cone roof, and vertical atmospheric designs are commonly used to store water, neutral chemicals, and non-volatile process fluids. Though typically considered lower risk than hydrocarbon or toxic chemical tanks, these units often face issues related to manual operations, inadequate level monitoring, and venting deficiencies.

Includes ambient storage of chemicals, water, and neutral liquids

Top Threats:

- **Overflow** from operator misjudgment during filling.
- **Plugged atmospheric vents** causing internal pressure buildup.
- **Manual valve left in incorrect position**, allowing cross-contamination.
- **Failure to monitor levels** during batch operations or feed transfer.

Frequent High-Risk Consequences:

- **Spills** leading to environmental compliance violations.
- **Damage to tank structure** due to internal vacuum or pressure.
- **Cross-contamination** between incompatible fluids.
- **Loss of inventory control.**

Most Effective Safeguards:

- **Sight glasses and local level indicators**.
- **High-level alarms** with control room annunciation.

- **Routine manual gauging** as a procedural layer.
- **Regular inspection and maintenance protocols.**
- **Standardized tank lineup verification checklists.**
- **Check valves** and swing elbows to prevent backflow.
- **Vents** with bird screens and **pressure-vacuum relief** devices.

Insights:

- Lack of procedural clarity was a top root cause.
- Facilities with older tanks often relied on manual safeguards which were less effective.
- Use of remote telemetry improved detection time but not always integrated with interlocks.
- Many recommendations involved upgrading to redundant level transmitters and adding vent inspections to PM schedules.

Hydrocarbon Storage Tanks – Fire, Vapor, and Containment Risks

Hydrocarbon tanks storing gasoline, diesel, naphtha, and crude oil introduce flammability, vapor dispersion, and liquid spill concerns. Many risks were linked to floating roof integrity, manual fill operations, and venting or seal failures. The consequences of tank overfill or vapor release are severe due to flammability and environmental exposure.

Typically include naphtha, gasoline, diesel, LPG, etc.

Top Threats:

- **Vapor buildup** from solar heating or poor venting.
- **Static charge accumulation** during tank truck loading.
- **Leaking flange or valve** due to thermal expansion or gasket failure.
- **Flame arrestor malfunction** or maintenance neglect.

Frequent High-Risk Consequences:

- **Ignitable vapor clouds** leading to fire/explosion risk.
- **Loss of containment** with large volume spills.
- **Exposure** to volatile organic compounds (VOCs) or tank venting to atmosphere.
- **Regulatory citation** (e.g., NFPA, API 2000 noncompliance).
- **Static electricity** discharge during loading.

Most Effective Safeguards:

- **Flame arrestors and detonation arrestors** at vent points with proper maintenance.
- **Floating roof designs** with seal gap monitoring.
- **Inert gas** blanketing systems.
- **Grounding and bonding** for all transfer lines
- **Level and pressure transmitters** tied to ESD systems and trip logic.

Insights:

- Ignition potential was a major contributor to inherent risk scores—over 30% of high-risk hydrocarbon tank scenarios involved ignition-related causes.
- Recommendations often centered around maintenance of flame arrestors, integration of automatic shutdown logic, and the addition of vapor recovery units (VRUs).
- Vapor balancing systems were cited in many recommendations but inconsistently implemented.

EDC Storage Tanks – Chemical Stability and Toxicity Controls

Ethylene Dichloride (EDC) tanks are particularly sensitive to overpressure, corrosion, and vapor emission hazards. These tanks pose unique hazards due to the chemical's toxicity, volatility, and reactivity. The tanks are typically blanketed with nitrogen and require tight process control. Failure scenarios include thermal expansion, pump seal degradation, and valve leaks, which can escalate into toxic vapor release or uncontrolled reactions.

Highly toxic, volatile organic compound

Top Threats:

- **Blanketing gas overpressure** during heat up or blocked vents.
- **Seal failure** on feed or circulation pumps.
- **Ingress of water or contaminants**, initiating polymerization.
- **Valve leakage** from corrosion or improper seating.

Frequent High-Risk Consequences:

- **Toxic release** of EDC vapor to atmosphere.
- **Uncontrolled chemical reaction** or runaway polymerization.
- **Tank roof deformation or rupture** from internal pressure.
- **Offsite exposure** due to airborne toxic clouds.

Most Effective Safeguards:

- **Redundant level and pressure instruments.**
- **N2 Blanketing** gas pressure relief valves (PRVs) and monitoring.
- **Pump seal monitoring** with pressure drop detection.
- **Emergency shutdown (ESD) systems** tied to gas detection.
- **Double-walled piping and flange containment systems.**
- **Double mechanical seals** with pressure detectors.

Insights:

- Scenarios here had among the highest inherent risks across the entire dataset.
- Recommendations emphasized tighter instrumentation monitoring, stricter MOC practices, and regular calibration of blanketing systems.
- Facilities with online gas detection and auto-shutdown logic saw a marked drop in residual risk scores.

Produced Water Storage

Produced water tanks are widely used across upstream oil and gas and terminal operations to temporarily store water recovered during production. These tanks often contain a mixture of hydrocarbons, hydrogen sulfide (H_2S), dissolved solids, and treatment chemicals. The Risk Alive® industry dataset revealed a concentration of high-risk scenarios related to corrosive damage, toxic gas evolution, and overflow due to truck transfer errors.

Common in upstream oil & gas and terminals

Top Threats:

- **H_2S vapor evolution** during agitation or temperature increase.
- **Overflow** during tank truck offloading or incorrect lineup.
- **Level instrument failure** due to scaling, solids buildup, or emulsions.
- **Internal corrosion** from water–hydrocarbon emulsions or high chloride content.
- **High solids** content damaging instruments.

Frequent High-Risk Consequences:

- Personnel exposure to **H_2S**.
- **Environmental discharge** of contaminated water
- **Undetected tank level excursions** leading to spillage.
- **Accelerated tank wall or nozzle degradation**, increasing the chance of leaks.

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Most Effective Safeguards:

- **Fixed H_2S gas detectors** with audible and visual alarms.
- **Vent scrubbers.**
- **Secondary containment berms** and **sealed drain systems.**
- **Level alarms** integrated with control room annunciation.
- **Corrosion-resistant linings** (e.g., epoxy coatings) and scheduled NDE inspections.
- **Standard operating procedures (SOPs)** for offloading and sampling.

Insights:

- Human exposure risks ranked highest in these tanks.
- Instrument degradation was significantly more frequent in produced water tanks than in hydrocarbon service, due to the presence of solids, emulsifiers, and corrosive agents.
- High-severity scenarios were strongly correlated with inadequate H_2S detection or alarms not integrated into shutdown logic.
- Recommendations frequently included the addition of redundant level instruments, improved sampling protocols, and SOPs for managing solids.

Commodity-Based Risk Summary

Commodity	Avg. Inherent Risk	Top Threat	Dominant Safeguard
Gasoline	High	Static charge during loading	Grounding + blanketing
Water	Low	Overflow during truck offload	Level alarm
Diesel	Medium	Leaking valve packing	Routine inspection
EDC	Very High	Overpressure + toxic release	PRV + toxic detection
Produced Water	High	H2S vapor evolution	H2S gas detection

Commodity-Based Risk Summary (Expanded with Field Data)

This section has been enhanced with anonymized data from real storage and loading facilities across North America. Facilities handling flammable or combustible liquids are categorized based on liquid classification, and their associated commodities are listed to better contextualize risk and safeguard applicability.

Flammable & Combustible Liquid Storage Facilities – Sample Risk Snapshot

Liquid Classification	Commodities Handled	Example Storage Applications
Flammable Liquid, Category 1	Gasoline, Naphtha, Crude, Slop Oil, Benzene, Xylene	Tank Truck Loading, Blend Tanks
Flammable Liquid, Category 2	Ethanol, Toluene	Distribution Terminals
Flammable Liquid, Category 3	Dilbit (Diluted Bitumen)	Refinery Intermediate Storage
Combustible Liquid	Diesel, Jet Fuel, Kerosene, Stove Oil, Distillates	Railcar Loading, Jet Fuel Tanks
Toxic Liquid (EDC)	Ethylene Dichloride, TCE	Specialty Chemical Storage Tanks

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Integrated Insights from Risk Data

- **Gasoline/Naphtha facilities** show the highest risk of vapor ignition and static discharge during transfer operations. Grounding, blanketing, and flame arrestors are critical.
- **Ethanol/Toluene storage** presents risks of rapid vaporization. Atmospheric vents and vapor recovery systems should be evaluated for integrity.
- **Dilbit tanks** (Category 3) show a higher incidence of instrument degradation and waxy buildup in level instrumentation, increasing overflow risk.
- **Jet fuel and kerosene** tanks, while less volatile, often lacked proper double block-and-bleed or flame isolation in terminal setups.
- **EDC and other toxics** demonstrated among the highest inherent risk scores. Safeguards like redundant seal monitoring, gas detection, and nitrogen blanketing are essential.

Conclusions & Takeaways

Tank-related risks are often repeatable and industry-wide. By tapping into the **Risk Alive® database**, operators, engineers and safety professionals can:

- Benchmark safeguards and threat likelihoods.
- Spot weaknesses in procedures and instrumentation.
- Prioritize the most effective recommendations.
- Reduce incidents and regulatory exposure.

Additionally,

- Our **Analytics Platform** provides real-time insights and customizable reporting that can be tailored for your facility, commodity, or region.
- Our **Bowtie Diagrams** allow for visual alignment between threat-cause-safeguard-consequence.
- Our **Safeguard Bypass** module allows for critical operational analysis for increased insights in emergency situations as well as temporary MOC planning.

(Please reach out for more details)

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