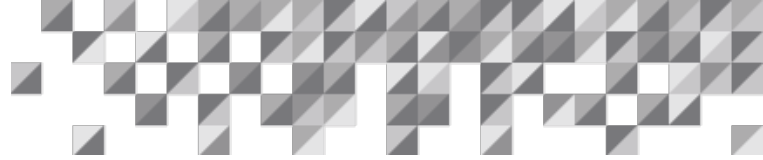


Rethinking Anhydrous Ammonia Safety for Food and Beverage

An ioMosaic White Paper

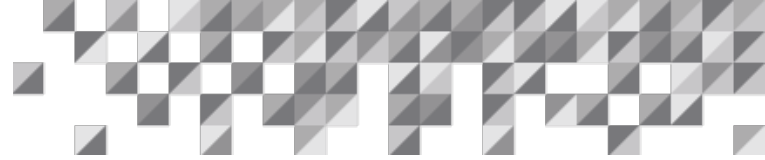
Date: October 23, 2026



Abstract

Facilities operating anhydrous ammonia refrigerated systems in the food-processing and cold-storage sectors face intensified regulatory oversight from the U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). Recent enforcement patterns indicate a critical shift in regulatory evaluation, transitioning from basic mechanical maintenance reviews to comprehensive audits of Process Safety Management (PSM) and Risk Management Program (RMP) frameworks.

This publication analyzes recent regulatory enforcement actions, evaluates common operational and technical compliance deficiencies, and highlights the structured process safety methodologies necessary to mitigate chemical incident risks.



Increased Enforcement on Anhydrous Ammonia Systems

EPA enforcement data from early 2026 demonstrates increasing regulatory attention on food and meat processors, as well as other business sectors with anhydrous ammonia refrigerated systems.

Under the EPA National Enforcement and Compliance Initiative (NECI) for Fiscal Years 2024–2027, “Chemical Accident Risk Reduction” was designated as one of six operational priorities [1]. The EPA website states these goals as:

- Address identified violations at high-risk facilities.
- Continue to develop credentialed inspectors nationwide.
- Criminally investigate violations as warranted, particularly where there is significant harm and culpable conduct.

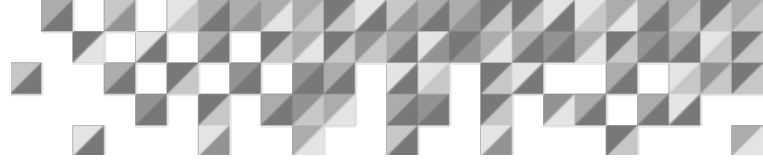
The refrigerated-ammonia industry has a well-developed network of refrigeration and regulatory-compliance specialists. However, increasingly complex expectations from OSHA and EPA require a broader approach. Facilities must now supplement refrigeration expertise with deep process-safety competency. Key focus areas include Process Hazard Analysis (PHA) facilitation, risk analysis, evaluation of Recognized and Generally Accepted Good Engineering Practices (RAGAGEP), management systems implementation, and independent compliance auditing.

Both EPA and OSHA regulators are looking beyond basic refrigeration maintenance of food, meat, poultry, and cold-storage operations and evaluating whether these facilities have implemented comprehensive Process Safety Management (PSM) and Risk Management Program (RMP) systems.

EPA RMP Enforcement Activity

EPA reported conducting 472 compliance-monitoring activities and finalizing 237 enforcement cases in 2025. Food processors are already prominent targets, as shown in EPA enforcement records:

- **JBS Foods:** On September 24, 2026, the U.S. Environmental Protection Agency (EPA) announced a \$308,765 settlement with JBS Foods for 11 separate violations of process safety deficiencies in its anhydrous ammonia refrigeration process [2]. These violations related specifically to process safety information (PSI), mechanical integrity (MI), emergency response, compliance audit, management of change, operating procedures, incident investigations, and addressing process hazard analysis (PHA) recommendations.



- **Home Market Foods:** On January 14, 2026, the U.S. Environmental Protection Agency (EPA) announced a \$1.1 million settlement with Home Market Foods involving alleged Clean Air Act (CAA) chemical safety violations under the Risk Management Plan following a 2022 catastrophic ammonia release that resulted in one fatality and one severe injury [3]. The violations also included lack of following recognized and RAGAGEPs, PHA deficiencies, MI-related gaps, as well as items associated with compliance audits. In addition to monetary penalties, the enforcement order mandated an independent third-party expert evaluation of key refrigeration systems.
- **Smithfield Packaged Meats:** On January 15, 2026, the EPA announced a \$138,506 settlement for alleged violations of the CAA §112(r) General Duty Clause [4]. Identified technical deficiencies included improper ammonia piping identification, inadequate mechanical impact protection, obstructed emergency valve accessibility, improper pressure-relief discharge locations, and missing emergency shutdown documentation.

OSHA Enforcement Activity

Parallel to EPA actions, OSHA has executed targeted enforcement under the PSM standard (29 CFR 1910.119) within meat processing and other refrigerated ammonia systems. OSHA citation logs demonstrate the comprehensive nature of these inspections:

- **Tyson Prepared Foods:** January 21, 2026: OSHA issued a serious citation under 29 CFR 1910.119(d)(3)(ii) for deficiencies involving inadequacies in the documentation demonstrating that equipment complied with Recognized and Generally Accepted Good Engineering Practices (RAGAGEP), including those published by the International Institute of Ammonia Refrigeration (IIAR). The penalty was \$3,404.40 [5].
- **Double R Brand Foods LLC:** March 13, 2026 (Inspection Nr: 2392305): OSHA issued a serious citation under 29 CFR 1910.119(g)(1)(i) after an employee operated the ammonia refrigeration system before receiving required process training. The proposed penalty was \$14,895 [6].
- **The Pictsweet Company:** April 21, 2026 (Inspection Nr: 1861029.015) OSHA issued a serious citation under 29 CFR 1910.119(d)(3)(ii). The employer did not document that equipment complies with recognized and generally accepted good engineering practices (RAGAGEP). The proposed penalty was \$25,200 [7].
- **Taylor Farms New England, Inc.:** May 15, 2026 (Inspection Nr: 1860927.015): OSHA issued a serious citation under 29 CFR 1910.119(j)(4)(iv) because required mechanical integrity inspection/test documentation was not maintained for their ammonia refrigeration equipment. The proposed penalty was \$12,059 [8].



Why Specialized Process Safety Expertise Matters

Relying solely on a refrigeration contractor is not equivalent to maintaining an effective PSM/RMP program. As shown above, regulatory actions demonstrate that facilities must treat ammonia refrigeration as a covered hazardous chemical process, not merely as an operating utility or routine maintenance item. Regulators are scrutinizing the complete management structure surrounding the process, including:

- Process Safety Information (PSI) and RAGAGEP compliance
- PHAs and operating procedures
- Employee training and Mechanical Integrity (MI) programs
- Management of Change (MOC) and incident investigation protocols
- Compliance auditing, emergency planning, and documentation retention

For any facility handling refrigerated ammonia, an independent PSM/RMP gap assessment can identify regulatory and RAGAGEP deficiencies before they are flagged during an OSHA or EPA inspection—or exposed by a hazardous ammonia release. Here are three particular risk management actions we recommend taking:

- **PHA recommendation closure audits:** Evaluate overdue recommendations, interim safeguards, documented resolutions, and implementation schedules.
- **Mechanical integrity and RAGAGEP gap assessments:** Examine inspection records, pressure-relief systems, equipment deficiencies, equipment installations versus recognized engineering design standards, and process and instrumentation diagrams (P&IDs).
- **Integrated PSM/RMP compliance reviews:** Verify that PHA, MOC, PSI, operating procedures, compliance audits, as well as resolution of findings are current per standards.

OSHA PSM and EPA RMP Elements Compliance Breakdown for Industrial Ammonia Refrigeration

Any facility that handles 10,000 lbs or more in a process is regulated by both OSHA PSM and EPA's RMP Program 3 standards. To establish a fully compliant PSM/RMP program, facilities operating anhydrous ammonia refrigeration systems must go beyond basic mechanical maintenance and satisfy all 14 mandatory elements of OSHA's 29 CFR 1910.119 standard, as well as EPA's RMP requirements. The following table breaks down each element alongside its specific technical focus area for industrial refrigeration systems.

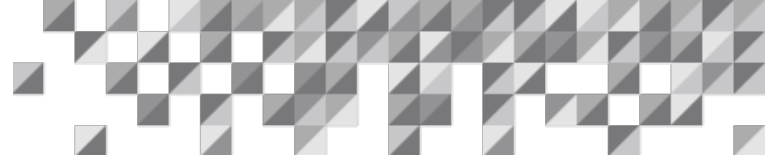
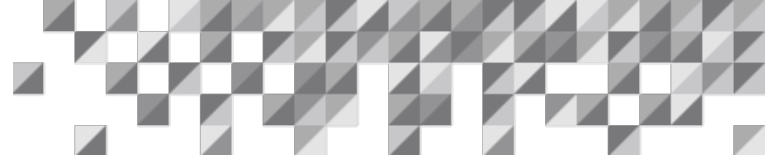


Table 1: Key Elements for Industrial Ammonia Refrigeration

OSHA PSM /RMP Element	Technical Focus Area
1. Employee Participation	Involve system operators, maintenance personnel and technicians in PHAs, incident investigations, and development of operating procedures.
2. Process Safety Information (PSI)	Maintain technical data on ammonia toxicity, system safe operating limits, materials of construction, piping & instrumentation diagrams (P&IDs), safety relief design basis, and RAGAGEP design basis (e.g., IIAR standards).
3. Process Hazard Analysis (PHA)	Conduct structured hazard evaluations (e.g., HAZOP, What-If) every 5 years to identify potential release scenarios and engineering controls required. Ensure actions from previous PHAs are being addressed in a timely manner. For RMP, an off site consequence analysis (OSCA) is required in addition to the process hazard identification and risk analysis.
4. Operating Procedures	Create documented, written instructions for system startup, routine operation, emergency shutdown, temporary operations, and safe work boundaries. Ensure operating procedures are current and certified annually.
5. Training	Provide documented initial and refresher training (at least every 3 years) for operators on system safety, health hazards, and operating procedures.
6. Contractors	Document contractor pre-qualifications. Evaluate contractor safety records, inform contract workers of the hazards, and ensure contractors follow safe work practices.
7. Pre-Start Safety Review (PSSR)	Before introducing ammonia into new, modified, or re-commissioned equipment, perform mandatory safety walkthroughs and documentation checks.
8. Mechanical Integrity (MI)	Establish documented inspection, testing, and preventive maintenance protocols for compressors, pressure vessels, piping, relief valves, ventilation, and ammonia detectors, as well as other critical safeguards identified in a PHA.
9. Hot Work Permit	Issue authorized written permits for torch cutting, welding, grinding, or spark-producing operations on or



OSHA PSM /RMP Element	Technical Focus Area
	near ammonia refrigeration process equipment, piping, pressure vessels, or insulated system components.
10. Management of Change (MOC)	Implement a formal evaluation and approval process before making physical, technical, or operational changes to the refrigeration system.
11. Incident Investigation	Perform root-cause investigations within 48 hours for any actual or near-miss ammonia release to prevent recurrence.
12. Emergency Planning and Response	Develop a comprehensive Emergency Action Plan (EAP), coordinate with local emergency responders (LEPC), and train employees on release response.
13. Compliance Audits	Conduct an independent safety and documentation audit at least once every 3 years to verify full compliance with all elements of both PSM and RMP.
14. Trade Secrets	Ensure process safety details are available to engineers, operators, audit teams, and local emergency responders while maintaining confidentiality.

Plant operators and compliance directors can utilize this breakdown as an executive checklist to identify procedural gaps, ensure RAGAGEP alignment, and prepare for targeted EPA and OSHA inspections. Any facility handling anhydrous ammonia above the OSHA and EPA threshold quantity of 10,000 lbs. is legally required to comply with each of these mandatory elements.

A Sampling of Our Work in Refrigerated Ammonia

The ioMosaic team's work ranges from power plants, refineries, chemical manufacturing plants, food processing plants, LNG, wastewater treatment plants, and biofuel producers to semiconductor manufacturers. We've pioneered many of the current risk assessment techniques for processes that handle ammonia and other hazardous chemicals. View a sampling below:

Electrical Power Plant, United States of America

Our professionals conducted HAZOP studies of the power plant's ammonia unloading, storage, and use in the deNOx system for their flue gas, and conducted a Construction Hazard Assessment (CHA) for a new flue gas desulfurization unit that was being installed adjacent to the ammonia storage and unloading facilities. We then completed a PSM compliance audit for their ammonia processes. The team also prepared a list of critical instruments associated with the ammonia



process, conducted a Layer of Protection Analysis (LOPA) to determine the required Safety Integrity Level (SIL) for these instrumentation systems, and developed a PHA standard.

An electronic Management of Change (MOC) system, tied to related workflows such as Process Safety Information (PSI) and PHA, was needed to manage its documentation facility-wide. The Process Safety Enterprise® cloud-based platform by ioMosaic was implemented at the facility, simplifying the process of creating and tracking of MOC documents, access to related data, and the approvals process.

Ammonia Transfer Facility, Singapore

For an ammonia supplier to the petrochemical complex on Jurong Island, Singapore, ioMosaic prepared a Quantitative Risk Assessment (QRA) for the addition of a 4,000 MT refrigerated ammonia storage tank. The QRA was prepared in accordance with the Singapore Pollution Control Department (PCD) guidelines for QRA studies, which included the preparation of risk contours for a specified hazard endpoint. The supplier had delayed submitting the required QRA, which left an extremely short turnaround time for preparing the QRA. Because of our unequalled experience in QRA, we were able to meet the client's deadline, to which no one else would commit.

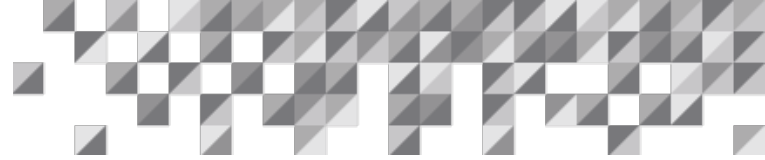
Specialty Chemical Facility, United States of America

For a specialty chemicals facility of an international company, we conducted a QRA of the operations handling their nine most hazardous chemicals, including: acetylene, acrylonitrile, anhydrous ammonia, dimethylamine, dimethylchlorosilane, methanol, methytrichlorosilane, toluene, and trichlorosilane. Scenarios were developed based on historical plant experience and generic failure data. Their frequencies were estimated using a LOPA technique.

The consequences of the scenarios were calculated using Process Safety Office® SuperChems®, our state-of-the-art consequence hazard modeling software. Consequence hazard zones were calculated for explosion overpressure, pool fire, and fireball thermal radiation and toxicity. All of these outcomes were combined in the form of a societal risk profile. We also developed a cumulative risk profile (i.e., f-N curve) for offsite risk and a separate profile for onsite risk. We reviewed the consequence and frequency analyses to identify pre- and post-release mitigation measures that could be implemented to reduce the level of risk. These measures were developed into recommendations and summarized in the final report.

International Ammonia Plant

For an international producer of ammonium nitrate, we conducted an offsite QRA of their ammonia production, storage, and use in support of their ammonium nitrate and urea production operations.



The analysis also included a comparative risk assessment of their existing single-containment refrigerated ammonia storage tank with the proposed option of a new smaller double-containment tank. This analysis demonstrated that the smaller double containment tanks would significantly reduce offsite risk.

Third Party RMP Submissions

Several clients had lost or do not have in-house PSM or EPA RMP expertise. This resource gap left the facilities without knowledge of how to navigate EPA's online RMP submission process. EPA requires an RMP submission update at a minimum of every five (5) years and more frequently under certain changes or facility modifications. These clients identified and approved ioMosaic as their "Preparer" in the RMP*eSubmit software. ioMosaic was able to gather and prepare required information for the clients, serve as the "Preparer" of their RMP to ensure full compliance and documentation occurs prior to deadlines based on highly skilled RMP preparer experience. ioMosaic has assisted many clients in navigation and submittal of the RMP via EPA's secure network, the Central Data Exchange (CDX).

Software for PSM

Process Safety Office® PSMPPro® software provides process safety and risk professionals with an integrated suite of tools for Process Hazards Analysis (PHA), auditing, consequence analysis, risk analysis, facility siting, and pressure relief and flare systems evaluation and design.

One of the main advantages of PSMPPro® over other commercially available software is that it contains pre-populated templates and checklists for conducting risk analyses for many industries, including Ammonia Refrigeration, using different techniques such as HAZOP, What-if?, and Checklist (including Facility Siting and Human Factors). Users have the option to centrally manage and distribute these templates to users within their own organization, which we find simplifies study management when an organization requires a specific template to be shared. Users can customize all pre-populated templates to meet their specific needs, such as adding or removing columns, specifying the number of columns, creating specific hierarchies, etc.

Because PSMPPro® is structured similarly to the interface in Microsoft Excel, it is a very user-friendly tool that requires little time to master. As a stand-alone application, it enhances the performance of PHA studies, provides more flexibility, simplifies installation for administrators, and is fully backward compatible with previous iterations. [Visit our website](#) to view the complete list of templates and new features that are constantly evolving and aligned with current industry processes.

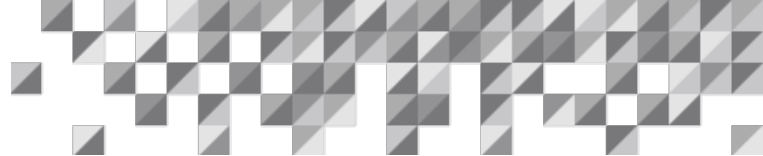
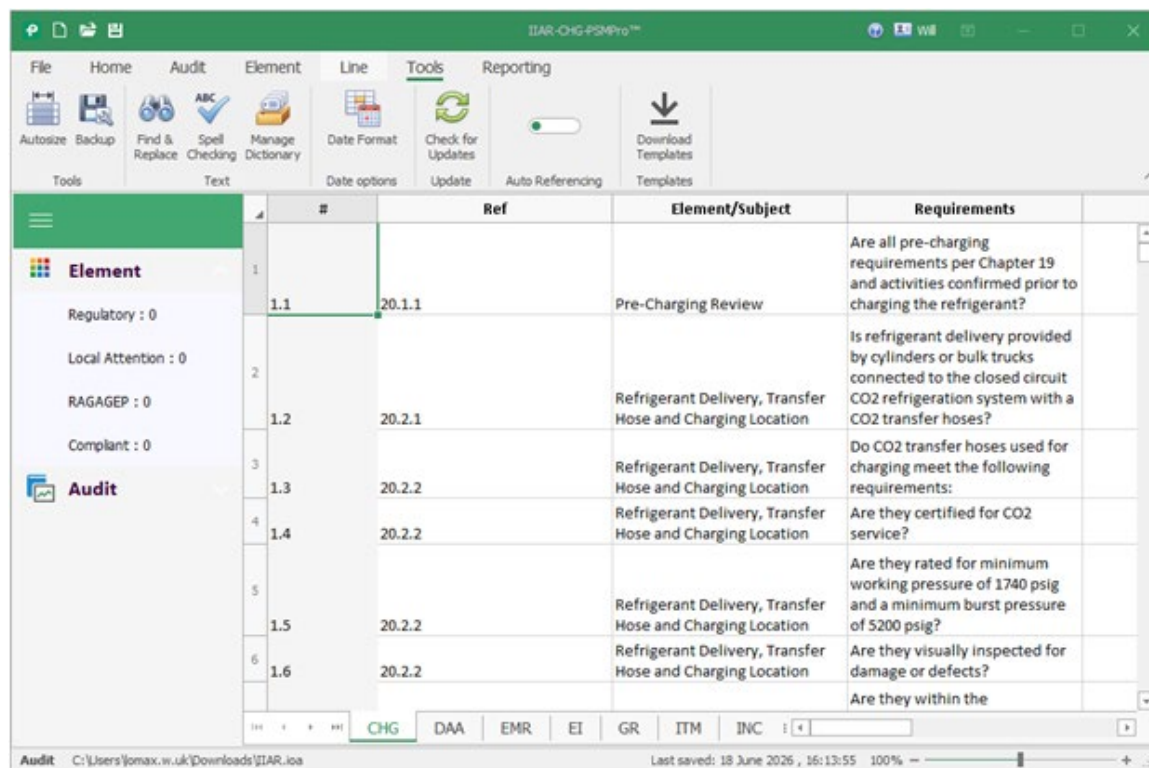


Figure 1: Process Safety Office® PSMPro®

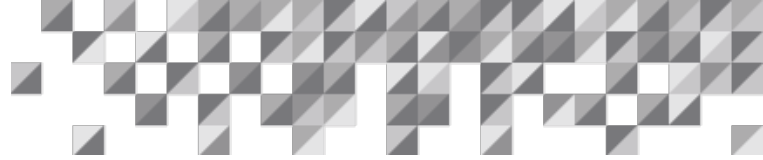


#	Ref	Element/Subject	Requirements
1.1	20.1.1	Pre-Charging Review	Are all pre-charging requirements per Chapter 19 and activities confirmed prior to charging the refrigerant?
1.2	20.2.1	Refrigerant Delivery, Transfer Hose and Charging Location	Is refrigerant delivery provided by cylinders or bulk trucks connected to the closed circuit CO2 refrigeration system with a CO2 transfer hoses?
1.3	20.2.2	Refrigerant Delivery, Transfer Hose and Charging Location	Do CO2 transfer hoses used for charging meet the following requirements:
1.4	20.2.2	Refrigerant Delivery, Transfer Hose and Charging Location	Are they certified for CO2 service?
1.5	20.2.2	Refrigerant Delivery, Transfer Hose and Charging Location	Are they rated for minimum working pressure of 1740 psig and a minimum burst pressure of 5200 psig?
1.6	20.2.2	Refrigerant Delivery, Transfer Hose and Charging Location	Are they visually inspected for damage or defects?
			Are they within the

Source: ioMosaic

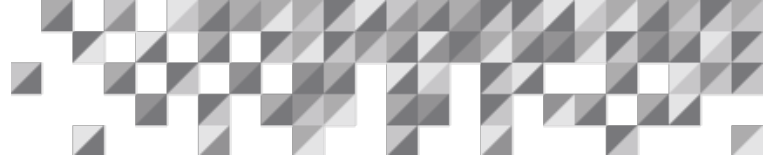
Summary

Federal enforcement in 2026 proves that EPA and OSHA inspectors are taking a rigorous, highly specialized approach to inspecting anhydrous ammonia systems. Recent citations targeting improper RAGAGEP documentation, insufficient training, missing mechanical integrity logs, and poor valve accessibility highlight that operational maintenance alone will not prevent costly penalties or serious safety incidents. To protect workers and avoid costly regulatory action, facilities must treat these systems as hazardous chemical processes and proactively validate their PSM and RMP programs through comprehensive, independent gap assessments.



Author

1. Judy A. Perry, CCPSC; perry.j.nh@iomosaic.com



References

1. (2024, June 10). National Enforcement and Compliance Initiative: Chemical Accident Risk Reduction | US EPA. epa.gov. <https://www.epa.gov/enforcement/national-enforcement-and-compliance-initiative-chemical-accident-risk-reduction>
2. US EPA. (2026, September 24). Civil enforcement case report JBS Tolleson CAFO. echo.epa.gov. https://echo.epa.gov/enforcement-case-report?activity_id=3605235611
3. Senn, J. (2026, January 15). EPA Reaches \$1.1 Million Settlement with Home Market Foods After 2022 Deadly Ammonia Release in Massachusetts | US EPA. epa.gov. <https://www.epa.gov/newsreleases/epa-reaches-11-million-settlement-home-market-foods-after-2022-deadly-ammonia-release>
4. Kittrell, J. A. (2026, January 15). EPA Acts to Protect Public from Harmful Chemical Releases in Springfield, Massachusetts | US EPA. epa.gov. <https://www.epa.gov/newsreleases/epa-acts-protect-public-harmful-chemical-releases-springfield-massachusetts>
5. OSHA. (January 21, 2026). Tyson Prepared Foods | Violation Detail. osha.gov. https://www.osha.gov/ords/imis/establishment.violation_detail?id=1839961.015&citation_id=01001
6. OSHA. (March 13, 2026). Double R Brand Foods LLC | Violation Detail. osha.gov. https://www.osha.gov/ords/imis/establishment.violation_detail?id=1860927.015&citation_id=01001
7. OSHA. (April 21, 2026). The Pictsweet Company | Violation Detail. osha.gov. https://www.osha.gov/ords/imis/establishment.inspection_detail?id=1861029.015
8. OSHA. (May 15, 2026). Taylor Farms New England, Inc. | Violation Detail. osha.gov. https://www.osha.gov/ords/imis/establishment.violation_detail?id=1860927.015&citation_id=01001