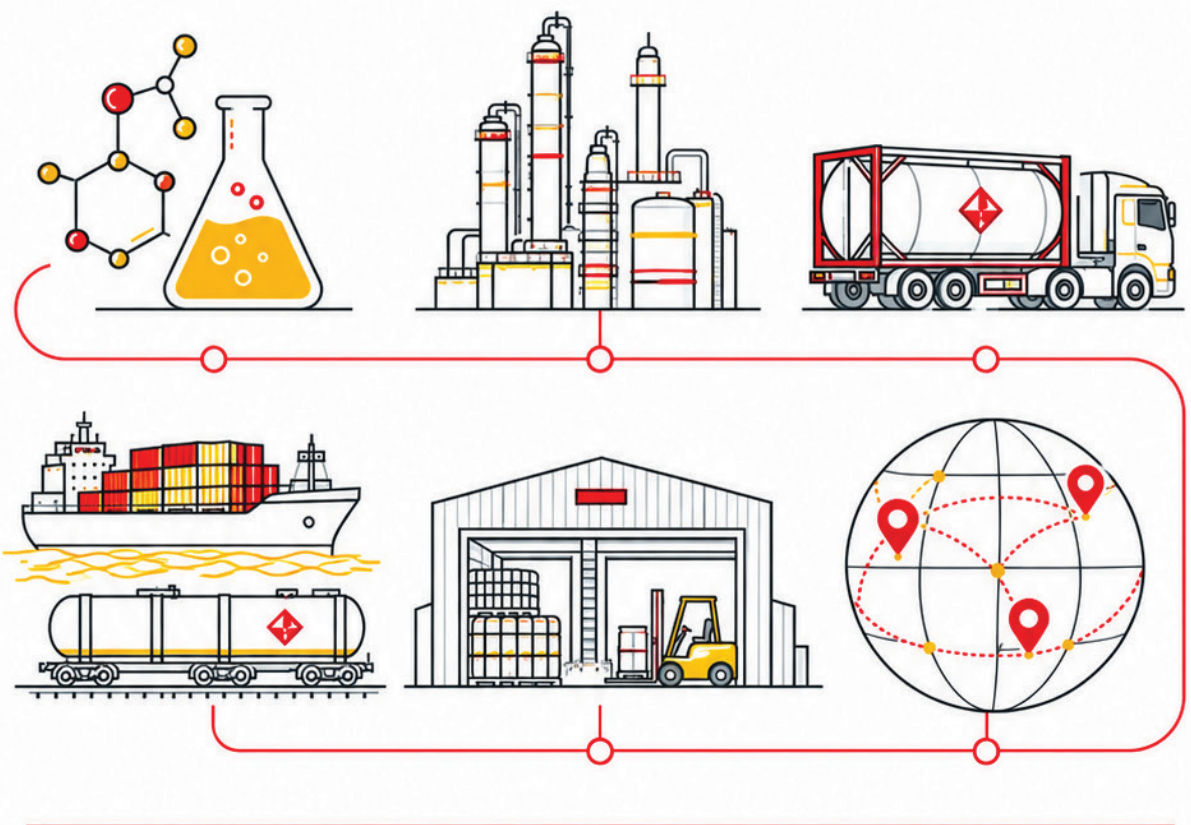


Logistics Focus[®]

From Molecules to Markets: The Future of **Chemical Logistics**

Building Safer, Smarter and More Sustainable
Chemical Supply Chains



September, 2026

Logistics Focus[®]

From Molecules to Markets: The Future of **Chemical Logistics**

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October, 2026



This publication is a part of KNIT, a knowledge dissemination initiative of TCI Group. We believe in sharing insights and knowledge with the industry, to encourage best practice replication.

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Foreword



From Molecules to Markets: The Future of Chemical Logistics

Building Safer, Smarter and More Sustainable Chemical Supply Chains

A chemical's journey begins long before it reaches a factory, farm, laboratory or household. From raw material and manufacturing to storage, transportation and delivery, every stage requires precision, coordination and care. This is the journey **from molecules to markets**.

India's chemical industry supports critical sectors including agriculture, pharmaceuticals, automotive, construction, textiles and advanced manufacturing. As the industry expands and India strengthens its position in global value chains, the need for safe, reliable and efficient chemical logistics has never been greater.

Chemical logistics is unlike conventional freight movement. Products may be flammable, corrosive, toxic, reactive or temperature-sensitive. Their transportation therefore demands specialised packaging, compliant storage, suitable equipment, trained personnel, accurate documentation and robust emergency-response systems. Safety is not an individual checkpoint; it must be embedded across the entire supply chain.

Technology is helping transform this ecosystem. Real-time tracking, telematics, geofencing, digital documentation, predictive analytics and control-tower platforms are improving visibility, strengthening compliance and enabling faster responses to potential risks and disruptions. At the

same time, sustainable logistics practices, including route optimisation, improved fleet utilisation, lower-emission transportation and efficient packaging, are becoming essential to responsible growth.

This edition of Logistics Focus, titled **"From Molecules to Markets: The Future of Chemical Logistics,"** explores the people, processes, infrastructure and technologies shaping this vital sector. It examines the opportunities and challenges associated with hazardous-material transportation, specialised warehousing, multimodal connectivity, digitalisation, sustainability and supply-chain resilience.

The future of chemical logistics will depend on collaboration among manufacturers, logistics providers, transporters, warehouse operators, regulators, technology partners and customers. Together, they can build a supply chain that is safer, smarter, more sustainable and better prepared to support India's industrial growth.

We hope this edition offers valuable insights into the opportunities and challenges shaping chemical logistics, while encouraging continued dialogue on building a more resilient and responsible chemical supply chain.

Happy reading





From Feedstocks to Finished Products: Building Intelligent Chemical Supply Chains

-By Mr. Vinoo Mathew, Editor, Chemical Industry Digest magazine

Introduction

Supply Chain Management (SCM) has evolved from a support function into one of the most strategic pillars of the chemical industry. Unlike many other manufacturing sectors, the chemical industry handles thousands of substances in solid, liquid and gaseous forms, many of which may be hazardous, toxic, corrosive, flammable or environmentally sensitive. Every stage—from sourcing raw materials to production, storage, transportation and final delivery—requires meticulous planning, specialised infrastructure, regulatory compliance and technical expertise.

These challenges have become more pronounced in recent years. Geopolitical tensions, fluctuating energy prices, climate-related disruptions, port congestion, pandemics, changing environmental regulations and volatile customer demand have exposed vulnerabilities in supply chains worldwide. Chemical manufacturers are therefore under constant pressure to ensure uninterrupted supplies while improving safety, controlling costs, reducing environmental impact and meeting increasingly stringent compliance requirements.

The solution lies not only in strengthening individual supply-chain functions, but in integrating procurement, production planning, logistics, warehousing and digital technologies into a coordinated ecosystem.

Artificial Intelligence (AI), Machine Learning (ML), the Internet of Things (IoT), digital twins, predictive analytics and Generative AI are helping transform traditional supply chains into more intelligent, responsive and resilient networks.

This article examines the critical elements of chemical supply-chain management, with particular focus on strategic procurement, safe and sustainable logistics, intelligent warehousing, regulatory compliance and digital transformation.

Strategic Procurement: Planning Beyond Price

Chemical procurement is far more complex than negotiating prices with suppliers. Many chemical feedstocks are derived from petroleum, natural gas, minerals and agricultural products, making their prices sensitive to global economic and political developments. Crude oil prices, currency movements, energy costs, trade policies and environmental regulations can rapidly influence raw-material availability and production economics.

Procurement teams must therefore move beyond reactive purchasing and adopt predictive market intelligence. Continuous monitoring of commodity markets, geopolitical developments, supplier capacity



and regulatory changes can help companies secure supplies more effectively and reduce exposure to sudden disruptions. Advanced forecasting models, scenario planning and early-warning systems are becoming increasingly important tools for procurement professionals.

Supplier Diversification

The COVID-19 pandemic, geopolitical conflicts and disruptions along global shipping routes have demonstrated the risks associated with dependence on a single supplier or sourcing region. Chemical companies are consequently adopting diversified sourcing strategies involving multiple qualified suppliers across different geographies.

Long-term partnerships with key vendors can improve supply assurance, while robust supplier-qualification programmes help ensure consistent product quality, safety and regulatory compliance. Diversification also strengthens business continuity and provides greater flexibility during periods of market volatility.

Risk-Based Procurement Planning

Risk assessment is now a core component of procurement strategy. In addition to price, companies are evaluating suppliers on political stability, economic conditions, climate exposure, transportation infrastructure, financial health, operational capability and evolving regulatory requirements.

Digital risk-assessment platforms can continuously monitor these parameters and alert procurement teams to emerging threats. This proactive approach enables companies to prepare alternative sourcing, inventory and logistics plans before disruptions affect production, thereby reducing operational and financial risk.

Inventory Optimisation

Maintaining the right inventory balance remains one of the most challenging aspects of chemical supply-chain management. Excess inventory increases storage costs, ties up working capital and may create additional safety or shelf-life concerns. Insufficient inventory, on the other hand, can interrupt production and affect customer deliveries.

AI-enabled planning tools can analyse historical consumption, seasonal demand, supplier performance, lead-time variability and market conditions to recommend appropriate inventory levels. Data-driven inventory management improves supply reliability while reducing unnecessary stockholding.

Chemical Logistics: Safety Across Every Movement

Transportation is one of the most critical phases of the chemical supply chain. Every movement of a hazardous material carries potential risks to people, the environment and public safety. Chemical logistics must therefore combine operational efficiency with stringent safety controls.

The choice of transportation mode depends on the chemical's physical properties, hazard classification, volume, transportation distance, required delivery time and cost. Road transport offers flexibility and is particularly suitable for regional distribution and last-mile delivery. Rail is often preferred for bulk commodities over long distances because it can offer cost and environmental advantages. Maritime transport remains essential for international chemical trade, supported by specialised tankers and ISO tank containers. Where production sites and customers are connected by fixed infrastructure, pipelines can provide



a safe, economical and efficient option for continuous movement.

Increasingly, companies are adopting multimodal logistics solutions to balance safety, service requirements, cost and sustainability. Effective multimodal planning requires smooth coordination among manufacturers, transporters, terminals, ports, warehouses and customers.

Hazardous Chemical Transportation

The transportation of hazardous chemicals involves much more than moving products from one point to another. Shipments must comply with applicable requirements for classification, packaging, labelling, documentation and emergency response. Correct hazard classification and compatible packaging are essential for safe handling throughout the journey.

Driver competency, vehicle suitability, route planning, loading procedures, emergency communication and spill-containment capabilities are equally important. Safety performance also depends on regular training, preventive maintenance and clear accountability across every handover.

GPS tracking, IoT sensors and telematics are strengthening transportation safety by providing real-time visibility into vehicle location, container conditions and route deviations. When abnormal conditions are detected, timely alerts can enable intervention before a minor deviation becomes a serious incident.

Sustainability in Chemical Logistics

Environmental sustainability has become an important performance measure for chemical logistics. Companies are expected to reduce greenhouse-gas emissions while maintaining reliable and safe supply chains.

Route-optimisation tools can reduce fuel consumption and empty return trips, while load consolidation improves vehicle utilisation. Rail and other lower-emission modes can be considered wherever operationally feasible. Companies are also evaluating electric vehicles, alternative fuels and more energy-efficient fleets for suitable routes and cargo profiles.

Warehouses powered by renewable energy and reusable packaging systems, including returnable Intermediate Bulk Containers (IBCs), can further reduce the environmental footprint of chemical distribution. These measures support sustainability objectives while also creating opportunities for long-term operating efficiencies.

Chemical Warehouse Design: Safety by Design

Chemical warehouses differ fundamentally from conventional storage facilities. Their design must be based on chemical compatibility, hazard characteristics, storage conditions and emergency requirements—not simply on maximising capacity.

Incompatible substances, such as acids and alkalis or oxidisers and combustible materials, must be physically segregated to prevent accidental reactions. Storage layouts should also account for temperature sensitivity, ventilation, access control, inventory rotation and safe handling procedures.

Fire-protection systems may include sprinklers, foam-suppression equipment, explosion-proof electrical installations and gas-detection systems, depending on the materials stored and applicable standards. Spill-control measures, including bund walls and secondary containment, help prevent accidental releases from spreading and contaminating surrounding areas.



These engineering controls, supported by clear operating procedures and trained personnel, provide multiple layers of protection and strengthen compliance with safety and environmental requirements.

Warehouse Automation

Warehouse operations are increasingly becoming automated as companies seek to improve safety, efficiency and inventory accuracy. Warehouse Management Systems (WMS) integrate barcode scanning, RFID identification and real-time inventory tracking to provide end-to-end material traceability.

Advanced technologies such as Automated Storage and Retrieval Systems (ASRS), Automated Guided Vehicles (AGVs) and robotic pallet-handling systems can reduce manual intervention and improve productivity. Automation can also reduce human error and limit worker exposure to hazardous substances. Its successful adoption, however, requires appropriate facility design, system integration, maintenance capability and workforce training.

Responsible Care and Regulatory Compliance

Compliance in the chemical industry extends beyond fulfilling legal obligations. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) provides a common framework for classifying and communicating chemical hazards through standardised labels and Safety Data Sheets. This supports safer handling across national and international supply chains.

Voluntary initiatives such as Responsible Care encourage companies to continuously improve environmental stewardship, product safety, transportation practices, emergency

preparedness and community engagement. These programmes can strengthen operational discipline, stakeholder confidence and corporate reputation when supported by measurable performance and transparent reporting.

Regulatory compliance is most effective when it is integrated into procurement, warehouse, transport and customer-delivery processes rather than treated as a separate administrative activity.

Digital Transformation: Building Connected Supply Chains

One of the most significant changes in chemical supply-chain management is the move towards integrated digital ecosystems. Traditionally, procurement, logistics and warehousing often operated as separate functions, with limited information sharing. Today, companies are using integrated Enterprise Resource Planning (ERP), Warehouse Management System (WMS), Transportation Management System (TMS) and supply-chain planning platforms to connect these activities.

AI and Digital Technologies

AI and ML can support demand forecasting, inventory planning, supplier evaluation and transportation optimisation by analysing large and diverse datasets. IoT devices can monitor warehouse conditions, storage tanks, production equipment and transport assets, providing real-time operational visibility.

Digital twins enable organisations to simulate supply-chain scenarios before making physical changes. They can help assess alternative sourcing strategies, warehouse configurations, transport routes and disruption-response plans.



Generative AI is also beginning to support documentation, regulatory research, standard operating procedures and knowledge management. These tools are not a substitute for technical expertise or managerial judgement. Rather, they can improve decision quality, accelerate routine work and allow professionals to focus on higher-value activities.

Integrated Planning and Collaboration

Integrated digital platforms enable procurement, production, warehousing, logistics and customer-service teams to work with shared information. This improves forecasting, inventory planning, transport scheduling and delivery performance while reducing avoidable costs.

Collaboration networks can extend this visibility beyond the organisation by connecting suppliers, logistics partners, terminals and customers. Such multiparty coordination is particularly valuable in chemical supply chains, where accurate information about product characteristics, handling requirements, shipment status and delivery conditions is essential.

Building Resilience for the Future

Supply-chain resilience has become as important as operational efficiency. Chemical companies are investing in diversified supplier networks, digital-visibility platforms, predictive analytics, scenario planning and strategic inventories to prepare for future disruptions.

Resilience does not mean eliminating every risk. It means developing the visibility, flexibility and response capability required to anticipate disruptions, absorb their impact and recover quickly. This includes identifying critical suppliers, mapping dependencies, planning alternative routes, maintaining appropriate buffers and regularly testing business-continuity plans.

Climate change, evolving environmental regulations, geopolitical uncertainty and changing customer expectations will continue to reshape chemical supply chains. Organisations that combine safety, sustainability, digitalisation and integrated planning will be better positioned to compete in this complex environment.

Key Technologies Driving Transformation

The following technologies are contributing to the transformation of chemical supply chains:

1. Supply-chain visibility solutions: Provide real-time insights into inventory, shipment status, capacity constraints and emerging bottlenecks.
2. Intelligent category-management tools: Analyse market, supplier and spend data to support sourcing decisions, cost management and supplier relationships.
3. Unified procurement platforms: Integrate direct and indirect sourcing processes and improve coordination across business functions.
4. Collaboration networks: Enable communication and shared processes across suppliers, logistics partners, customers and other stakeholders.
5. ESG tracking and reporting tools: Support the measurement, management and reporting of environmental, social and governance performance.
6. Flexible planning and workflow tools: Support demand forecasting, resource planning, capacity management and workforce deployment as operating conditions change.
7. Data-management and reporting solutions: Centralise information, improve data quality and support faster, evidence-based decision-making.

Conclusion



Supply Chain Management in the chemical industry is no longer confined to moving materials from one location to another. It has become a strategic discipline that integrates procurement, production, logistics, warehousing, compliance and digital technologies across a unified value chain.

Safe handling of hazardous materials, sustainable transportation, scientifically designed warehouses, rigorous compliance and intelligent planning are essential to operational excellence. As digital technologies mature, chemical companies have an opportunity to transform fragmented operations into connected, data-driven ecosystems.

Organisations that adopt integrated planning, advanced analytics, automation and responsible AI can improve efficiency and reduce costs while also strengthening safety, resilience and sustainability. In an era of global uncertainty, the most successful chemical manufacturers will be those that view supply-chain management not merely as an operational necessity, but as a strategic competitive advantage.



Company Profile

Chemical Industry Digest

Published by Blockdale Media LLP



Chemical Industry Digest is a specialised industry publication providing comprehensive coverage of India's chemical sector and its allied industries. Published by Blockdale Media LLP, the magazine serves as a platform for informed discussion, industry analysis and knowledge exchange among chemical manufacturers, technology providers, logistics companies, policymakers, researchers and other stakeholders.

The publication covers a wide range of subjects, including chemical manufacturing, process technology, plant operations, safety, sustainability, regulatory developments, supply-chain management, logistics, automation and digital transformation. Through expert articles, industry insights, interviews, case studies and analysis, it examines the trends and developments shaping the chemical industry.

With its focus on practical knowledge and sector-specific perspectives, Chemical Industry Digest connects industry experience with emerging technologies, business priorities and evolving regulatory expectations. Its content is intended to support informed decision-making and encourage the adoption of safer, more efficient, sustainable and innovative practices across the chemical value chain.

As the chemical industry responds to changing markets, technological advances and the growing importance of resilience and responsible growth, Chemical Industry Digest continues to provide relevant and credible content for professionals and decision-makers across the sector.

Author Profile



-By Mr. Vinoo Mathews
Editor, Chemical Industry
Digest magazine

Vinoo Mathews is the Publisher and Editor of Chemical Industry Digest, published by Blockdale Media LLP, which also publishes a medical monthly, The Indian Practitioner.

He is in the field of Industrial communications, advertising and marketing since the last 45 years. He has written several articles, edited articles on a variety of topics related to chemical and allied industries, in the healthcare field and also on general political and social interest areas. He had an overseas stint in Advertising working with the largest Advertising Agency in the Middle East before he started his entrepreneurial venture of Blockdale Media. He has an educational background in chemistry. He is well read and has also widely travelled overseas.

Blockdale Media LLP now into the 40th year, is a company he started, which is specialised in publishing niche industrial journals and also in organising many workshops and conferences in the chemical field.





Powering Solar Manufacturing: Why Safe, Just-in-Time Chemical Logistics Matters

-By Mr. Bharat Bhatnagar, Managing Director - Kredence Electronics Materials

India's solar-manufacturing industry is entering a defining phase. Supported by policy initiatives, significant investment and the growing need to strengthen domestic manufacturing capabilities, India is emerging as an important global destination for solar-cell and module production.

As manufacturing capacity expands, attention is naturally focused on technology, efficiency, quality and cost competitiveness. Yet, behind every successful manufacturing operation lies an equally important enabler: a dependable supply chain.

For a hazardous-chemical-intensive industry such as solar manufacturing, logistics is not simply about moving materials from one location to another. It is an integral part of the manufacturing process. The timely availability of high-purity and electronic-grade chemicals can directly influence production continuity, plant utilisation, product quality and customer commitments.

A reliable hazardous-chemicals supply chain has therefore become essential to India's solar-manufacturing ambitions.

The Supply Chain Behind Solar Manufacturing

Solar-cell and module production requires a consistent supply of specialised materials

and chemicals. Many of these substances are hazardous, sensitive or subject to strict handling and storage requirements. Their movement must be carefully planned across multiple stages, including manufacturing, packaging, warehousing, transportation, delivery and, in some cases, return or replenishment cycles.

Any disruption in this chain can affect more than a single shipment. A delayed delivery may interrupt production schedules, reduce plant utilisation, exhaust inventory buffers and affect commitments to downstream customers.

This makes chemical logistics a strategic component of manufacturing continuity. The objective is not merely to deliver materials safely, but to ensure that they are available when required, in the right quantity, at the right quality and under the right conditions.

Just-in-Time Manufacturing Needs Just-in-Time Logistics

Kredence Electronics Materials India Private Limited has developed its supply-chain model around Just-in-Time (JIT) inventory, particularly for critical hazardous chemicals used by customers in advanced manufacturing applications.

The principle is straightforward: the right material must reach the customer at the right time and in the right quantity, without



requiring the customer to maintain excessive inventory. In practice, however, a successful JIT model requires much more than maintaining stock at a warehouse.

It depends on an integrated ecosystem involving:

- Accurate demand forecasting.
- Inventory planning and replenishment.
- Strategically positioned stocks.
- Compliant storage facilities.
- Safe and timely transportation.
- Customer production schedules.
- Real-time communication.
- Contingency planning for disruptions

The closer a manufacturing operation moves towards JIT inventory, the more important supply-chain reliability becomes. With limited inventory buffers, there is little room for delays, inaccurate forecasts or poor coordination.

A robust JIT model must therefore balance efficiency with resilience. Inventory should be lean, but not fragile. Transportation should be planned, but also flexible enough to respond to urgent requirements. This balance requires close coordination between the materials supplier, logistics providers and customers.

Logistics as Manufacturing Infrastructure

In conventional thinking, logistics is often viewed as an activity that begins after production is complete. In solar manufacturing, this approach is inadequate. The logistics network is part of the manufacturing infrastructure itself.

The availability of suitable vehicles, trained personnel, compliant storage, route visibility and emergency-response capability can directly influence the customer's ability to maintain production. In this context, logistics

performance must be measured not only by delivery time, but also by safety, consistency, predictability and responsiveness.

A dependable logistics ecosystem should be capable of:

- Planning vehicle capacity in line with customer demand.
- Coordinating loading and unloading windows.
- Managing documentation and compliance requirements.
- Monitoring shipments throughout transit.
- Responding quickly to route deviations or delays.
- Maintaining communication during every stage of the journey.
- Activating contingency arrangements when required.

Such capabilities become especially important when materials are transported over long distances across diverse regions, road conditions and operating environments.

Safety by Design

As the movement of hazardous chemicals increases with the growth of solar manufacturing, safety must remain non-negotiable.

The transportation of hazardous chemicals by road tanker requires appropriate vehicle selection, regular inspection and maintenance, proper documentation, suitable safety equipment and clearly defined emergency procedures. Loading, unloading and transfer operations must be performed in accordance with established protocols and the characteristics of the material being handled.

Similar care is required when hazardous chemicals are transported in Intermediate Bulk Containers (IBCs). Trucks carrying IBCs must be suitable for the cargo, and the containers must



be properly positioned and secured to prevent movement or damage during transit. Pre-dispatch inspections, safe loading practices and adherence to handling procedures are essential to reducing operational risks.

Safety should not be viewed as a final verification step or a regulatory formality. It must be built into the entire supply-chain design—from packaging and storage to vehicle selection, route planning, delivery and emergency response.

The Driver's Role

Among the many elements that contribute to safe hazardous-chemical transportation, the driver remains central.

Drivers handling hazardous cargo require specialised knowledge and practical training. Regular and refresher programmes should cover defensive driving, cargo characteristics, loading and unloading procedures, personal protective equipment, emergency communication, spill management and the actions to be taken in the event of an accident, breakdown or route disruption.

Periodic medical-fitness examinations, competency assessments and safety briefings can further strengthen operational discipline. Drivers transporting hazardous chemicals over long distances also face changing road conditions, traffic patterns, terrain and weather. Their ability to recognise risks and respond appropriately is critical to safe delivery.

Technology can improve visibility, but it cannot replace human judgement. A resilient logistics system therefore depends on a combination of suitable equipment, digital tools, robust procedures and competent people.

Visibility Through Technology

Technology will play an increasingly important role in strengthening hazardous-chemical logistics and supporting JIT inventory models.

GPS-enabled vehicle tracking can provide real-time location information, while telematics can support monitoring of vehicle performance, driving behaviour and route adherence. Digital documentation and electronic proof of delivery can improve accuracy and reduce administrative delays. Route-optimisation tools can help identify efficient and safer routes, while predictive maintenance can reduce the likelihood of vehicle-related disruptions.

For a JIT supply chain, knowing where a vehicle is and when it is expected to arrive provides valuable decision-making time. If a delay is detected, supply-chain teams can assess inventory levels, communicate with the customer, adjust production plans or arrange an alternative response.

The next stage of development will involve deeper digital integration among manufacturers, logistics providers and customers. Shared visibility of forecasts, inventory positions, dispatch schedules, vehicle availability and delivery status can create a more predictive supply chain.

Instead of reacting to shortages after they occur, stakeholders can identify emerging requirements early and position inventory and transportation capacity in advance.

Building Resilience into JIT

JIT logistics is often associated with lean inventory, but lean does not have to mean vulnerable. Resilience can be built into the model through carefully designed safeguards.



These may include:

- Multiple qualified logistics partners.
- Alternative routes and transportation plans.
- Strategically positioned inventory.
- Pre-approved vehicles and backup capacity.
- Emergency-response procedures.
- Clear escalation protocols.
- Real-time shipment visibility.
- Periodic testing of contingency plans.

The objective is to minimise unnecessary inventory while retaining the ability to respond when market, weather, infrastructure or operational conditions change. This is particularly important for hazardous chemicals, where finding a replacement vehicle or route at short notice may involve additional compliance and safety checks.

Supporting the Next Phase of Solar Growth

India's solar-manufacturing journey is still at an early but highly promising stage. As new solar-cell and module-manufacturing capacities become operational, the scale and complexity of the hazardous-chemicals supply chain will increase.

Companies that have developed JIT inventory and supply capabilities will play an important

role in ensuring the reliable availability of critical electronic-grade and high-purity chemicals. However, the success of this model will depend equally on the logistics infrastructure supporting it.

The next generation of chemical logistics will require more than transportation capacity. It will require:

- Strong safety systems.
- Specialised vehicles and equipment.
- Trained and competent personnel.
- Compliant storage and handling.
- Real-time visibility.
- Predictive planning.
- Reliable communication.
- The ability to respond to urgent and unexpected requirements.

Manufacturers, chemical-material suppliers, logistics providers and customers will need to work as an integrated network. Their shared objective must be to maintain production continuity while protecting people, communities and the environment.

India's solar ambitions will be built on manufacturing capacity, technology and innovation—but they will be delivered through supply chains. At the heart of those supply chains will be chemical logistics that is safe, reliable, visible and truly just in time.



Company Profile

Kredence Materials



Kredence Materials is a specialised provider of advanced materials and chemical solutions for high-technology manufacturing industries. The company supports customers whose operations require high-purity, electronic-grade and specialised materials, with a strong focus on quality, reliability, safety and supply continuity.

Its capabilities extend beyond the supply of materials. Through structured inventory planning, strategically positioned stocks and responsive supply-chain coordination, Kredence Materials helps customers manage critical material requirements and support uninterrupted manufacturing operations. Its Just-in-Time approach is designed to deliver the right material, in the right quantity and at the right time, while helping customers optimise inventory levels.

The company serves the evolving needs of advanced manufacturing applications, including India's expanding solar-cell and module-manufacturing ecosystem. Its product and service capabilities are supported by disciplined handling, compliant storage, specialised transportation and close coordination with customers and logistics partners.

Kredence Materials places strong emphasis on the safe and responsible management of hazardous and high-purity materials. Its operations are guided by robust processes covering quality assurance, inventory management, packaging, transportation, delivery coordination and supply-chain visibility.

As India strengthens its domestic manufacturing capabilities and expands its role in global technology-driven industries, Kredence Materials is focused on enabling reliable, efficient and responsible material supply chains. By combining technical understanding with responsive service and supply-chain expertise, the company aims to be a dependable partner to customers operating in demanding manufacturing environments.

Author Profile



-By Mr. Bharat Bhatnagar
Managing Director- Kredence
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Mr Bharat Bhatnagar, Managing Director- Kredence Electronics Materials

He has over 30 years of industry experience, including more than 11 years in the solar sector. He founded Kredence after 17 years of professional experience and has since built it into a prominent name in India's solar-cell industry, focusing strongly on high-purity chemicals, Make in India, and Just-in-Time Inventory.





Beyond Compliance: Building a Safety-First Culture in Cryogenic Logistics

-By Mr. Subhrangsu Mukherjee - Sr. General Manager - Operation, Bulk Distribution, SHEQ, CSG, Air Water India Private Limited

Safety as a Shared Value

In cryogenic logistics, risk is inherent and operational margins are narrow. The handling, storage and transportation of liquefied gases such as oxygen, nitrogen, argon and helium require disciplined processes, specialised equipment, trained personnel and continuous vigilance.

In this environment, safety cannot be treated merely as a regulatory requirement. It is a commitment to protecting lives, safeguarding the environment and ensuring the continuity of operations.

Cryogenic logistics involves hazardous materials, complex supply chains and stringent operating requirements. A failure at any stage—whether during loading, transportation, unloading, storage or emergency response—can have serious consequences. A strong safety culture helps reduce these risks while improving operational reliability, workforce confidence and customer trust.

Safety culture refers to the shared values, behaviours and practices that determine how safety is prioritised within an organisation. It begins with leadership and must extend through every level of the business, from managers and supervisors to drivers, loading teams, contractors and support functions.

A mature safety culture goes beyond checklists and audits. It encourages people to identify hazards, report near misses, stop unsafe work

and participate in improving processes. It also uses reliable data, operational experience and employee feedback to anticipate risks before they become incidents.

A strong safety culture can help organisations:

- Reduce incidents, delays and operational costs.
- Identify emerging risks earlier.
- Improve productivity and operational discipline.
- Strengthen communication and collaboration.
- Support data-based decision-making.
- Build employee confidence and customer trust.
- Create opportunities for continuous improvement.

Leadership Must Set the Standard

The journey towards safety excellence begins at the leadership level. Leaders must allocate appropriate resources, establish clear expectations and demonstrate through their actions that safety takes precedence over operational pressure.

Visible leadership participation is essential. Leaders and managers should take part in safety meetings, drills, site visits, audits and review discussions. Their behaviour sends a clear message about the organisation's priorities. When leaders consistently follow safety procedures, engage with frontline teams and recognise safe practices, employees are



more likely to adopt the same standards.

Leadership responsibility includes:

- Designing clear safety policies and procedures.
- Providing appropriate resources and equipment.
- Ensuring that employees are trained and competent.
- Reviewing safety performance regularly.
- Encouraging open reporting without fear of blame.
- Holding people accountable for unsafe practices.
- Demonstrating that production targets cannot override safety.

Safety must be understood as a shared organisational responsibility. It applies equally to ground-level employees, office personnel, contractors, suppliers and transport partners.

Empowering Employees and Drivers

Employees are the backbone of any safety programme. They should be encouraged to report unsafe conditions, participate in safety audits and contribute to continuous improvement.

Open dialogue and regular feedback are particularly important. Employees need to know that their concerns will be heard, investigated and addressed. A reporting system that produces no visible action will eventually discourage participation.

The same principle applies to drivers, who are central to the safe distribution of cryogenic products. Driver selection and engagement should consider:

- Valid licences and appropriate driving skills.
- Knowledge of hazardous products.
- Understanding of traffic rules.

- Vehicle knowledge and defensive-driving ability.
- Loading and unloading procedures.
- Firefighting, spill control and first-aid awareness.
- Route compliance.
- Physical fitness and temperament.
- Ability to communicate during an emergency.

Driver empowerment moves safety from a purely supervisory model towards active participation. Drivers should be equipped with the information, training and tools necessary to recognise risks and make safe decisions.

Using Technology to Support Drivers

Technology can help identify risky driving behaviour, but it should be used to support drivers—not merely to monitor or penalise them.

AI-enabled video telematics and other systems can identify fatigue, distraction, mobile-phone use, seat-belt non-compliance, speeding, harsh braking and other warning signs. Real-time alerts can help drivers and managers intervene before a risky behaviour results in an incident.

Fatigue requires particular attention. Even a brief microsleep at highway speed can cause a vehicle to travel a considerable distance without conscious control. Fatigue-management systems should therefore include adequate rest, journey planning, suitable breaks, safe parking and clear escalation procedures.

A human-centred approach is equally important. Stress, isolation, family concerns, financial pressure and long working hours can affect a driver's concentration and decision-making. Constructive conversations between managers and drivers can help identify these pressures and enable timely support.



Recorded driving events can also be used for self-review and coaching. When drivers are able to examine their own behaviour and understand why a particular action was risky, technology becomes a tool for learning and self-correction.

Driver buy-in is essential. Employees should be informed in advance about what technology will capture, why it is being introduced and how the data will be used. When drivers understand that the objective is to protect them and improve safety, rather than simply find fault, participation and effectiveness improve.

Learning from Driver Feedback

Drivers experience road conditions, traffic behaviour and operational challenges directly. Their observations can reveal risks that may not be visible through technology or management reports.

A structured post-journey feedback system can capture information about:

- Unsafe behaviour by other road users.
- Traffic congestion and route bottlenecks.
- Road damage and construction activity.
- Difficult loading or delivery locations.
- Unsafe parking areas.
- Weather and visibility conditions.
- Near misses and route-specific hazards.

Sharing this information with other drivers and logistics teams helps convert individual experience into collective learning. It also encourages drivers to remain observant and actively assess risks throughout the journey.

Route and Site Surveys

Route and site surveys are essential components of cryogenic logistics planning.

A route survey should identify the physical

and operational characteristics of the journey, including road condition, congestion zones, accident-prone areas, sharp turns, steep gradients, restricted sections, hospitals, fire stations, police posts and authorised parking locations.

The assessment should also consider seasonal changes, road construction, festivals, weather conditions and other factors that may alter the risk profile.

A site survey focuses on the delivery location. It should confirm:

- Access for the vehicle and emergency services.
- Suitability of the delivery point.
- Safe positioning of the vehicle.
- Loading and unloading arrangements.
- Statutory and site-specific requirements.
- Emergency equipment and communication systems.
- Spill-prevention and evacuation arrangements.
- Customer awareness of product hazards.

No delivery should be treated as routine merely because the location has been used previously. Conditions can change, and route and site information should be reviewed periodically.

Journey Planning and Fatigue Management

Fatigue is a major risk in logistics operations. Drivers should have adequate rest before beginning a journey, and work schedules should avoid unnecessary exposure to high-risk driving hours wherever possible.

Journey planning should consider:

- Driver fitness and rest.
- Road and weather conditions.
- Traffic patterns.



- Delivery windows.
- Safe parking locations.
- Emergency facilities.
- Curfew or restricted-driving periods.
- Availability of alternate routes.

Regular breaks are essential during long journeys. A short break at suitable intervals helps reduce fatigue, restore concentration and prevent highway hypnosis. Parking locations should ideally provide safe resting, food, sanitation and accommodation facilities.

Late-night and early-morning driving can involve reduced visibility, lower alertness and a higher risk of fatigue-related incidents. Organisations should assess whether such journeys can be rescheduled or managed through additional controls, including driver rotation and enhanced monitoring.

Daily Operational Controls

Several simple but important controls can significantly improve safety performance.

Pre-trip vehicle inspection

Vehicles should be inspected before loading. The inspection should cover the vehicle, tank, tyres, brakes, lights, safety equipment, documentation and required permits. Any defect affecting safety or regulatory compliance must be addressed before departure.

Pre-trip dialogue

A structured pre-trip discussion should confirm the driver's fitness, route, product hazards, delivery requirements, weather conditions, emergency contacts and communication protocols. This ensures that all participants share the same understanding before the journey begins.

Toolbox talks

Toolbox talks provide short, practical reminders about product hazards, loading and unloading, personal protective equipment, emergency response and specific route conditions. They are particularly useful before transporting products such as liquid nitrogen, oxygen or argon.

Communication

Clear communication between the driver, control room, customer and logistics team is vital. Relevant information about route conditions, delays, product requirements and emergencies must be communicated promptly and accurately.

Post-trip review

After delivery, the vehicle and tank should be inspected, and driver feedback should be recorded. Any defect, deviation, near miss or operational concern should be addressed before the next journey.

Labelling and Product Information

Clear labelling is essential for the correct identification and handling of hazardous products. Hazard classifications, warning labels, pictograms and relevant codes should be accurate, visible and consistent.

Safety Data Sheets must be current, accessible and understood by all personnel who handle or transport the product. Consistent product naming and documentation reduce the possibility of confusion, particularly during loading, unloading, transfer and emergency response.



Emergency Preparedness and Mock Drills

Emergency preparedness converts written procedures into coordinated action. Mock drills help employees develop decision-making, communication, coordination and problem-solving skills under pressure.

In cryogenic logistics, drills should test the organisation's ability to manage incidents both within the facility and on public roads. They should involve, where appropriate, local authorities, emergency services, community responders and district disaster-management agencies.

A Transport Emergency Response Plan (TERP) should define:

- Roles and responsibilities.
- Emergency contacts.
- Communication and escalation procedures.
- Initial actions for drivers.
- Spill, leak, fire and exposure response.
- Coordination with authorities.
- Community-protection measures.
- Post-incident reporting and review.

Drivers transporting hazardous products should be trained to take immediate, safe and appropriate action during an off-site emergency. Their role may include securing the area, raising the alarm, sharing product information, preventing escalation and supporting emergency responders without placing themselves at further risk.

Audits, Inspections and Training

Audits and inspections serve different but complementary purposes. Inspections examine physical conditions, equipment and work practices. Audits assess systems, procedures, records, training, legal compliance

and the effectiveness of controls.

Findings must be assigned to responsible persons, given clear timelines and tracked to closure. Repeated findings should trigger a review of the underlying process rather than merely a correction of the immediate issue.

Training should cover defensive driving, hazard identification, emergency response, product handling and the correct use of personal protective equipment. Interactive sessions, simulations, refresher programmes and real-life case studies can improve retention.

Simulator-based training, rollover-prevention exercises and virtual training platforms can provide additional practice in managing high-risk situations without exposing employees to actual danger.

Recognition, Well-Being and Mental Health

Positive reinforcement can strengthen safety culture. Recognition of safe driving, effective hazard reporting, good housekeeping, responsible vehicle handling and constructive participation in safety initiatives reinforces the behaviours the organisation wants to encourage.

Safety performance is also closely connected with physical and mental well-being. Fatigue, poor sleep, stress, isolation, inadequate nutrition and long periods away from home can affect concentration and decision-making.

Driver-wellness programmes should include fatigue awareness, health checks, access to support, appropriate rest arrangements and opportunities for constructive engagement. Mentorship programmes, in which experienced drivers guide newer colleagues, can strengthen both technical competence and peer support.



Data-Driven Safety Improvement

Reliable data helps organisations move from reactive incident management to proactive risk prevention. Safety dashboards can bring together information on:

- Near misses and incidents.
- Unsafe driving behaviour.
- Speeding and harsh braking.
- Unsafe parking.
- Improper loading and unloading.
- Vehicle defects.
- Route deviations.
- Fatigue-related alerts.
- Inspection and audit findings.
- Corrective-action closure.

The quality of the data is as important as the technology used to analyse it. Incomplete, inaccurate or inconsistent information can produce misleading conclusions. Organisations should therefore define what data is required, how frequently it should be collected, who is responsible for validation and how the findings will be acted upon.

AI and Machine Learning can help identify patterns across large volumes of operational data. Predictive analytics may reveal relationships between driving behaviour, route conditions, time of day, vehicle performance and near-miss events.

Real-time dashboards can support immediate intervention, while periodic reviews can help management identify systemic issues and revise procedures. Every incident, near miss and significant route disturbance should be reported promptly, investigated and used for learning.

Technology and Safer Operations

Technology is changing the way safety is managed in cryogenic logistics. Vehicle-

tracking systems can monitor location, speed, acceleration, deceleration, route adherence and driving behaviour. AI-enabled cameras can identify fatigue, distraction, lane changes, speed violations and route deviations.

Telemetry can support automated tank-level monitoring and more accurate delivery planning. Automated alerts can notify drivers and control rooms when operating parameters move outside defined limits.

Advanced vehicle-safety systems, including Anti-lock Braking Systems (ABS), Advanced Driver Assistance Systems (ADAS), electronic stability controls and rollover-prevention technologies, can further reduce risk when properly selected, maintained and used.

Technology should not be viewed as a substitute for training, supervision or judgement. Its greatest value lies in combining real-time information with competent people and well-defined response procedures.

Collaboration Across the Ecosystem

Safety in cryogenic logistics cannot be achieved by one organisation acting alone. Manufacturers, customers, logistics providers, transporters, suppliers, contractors and regulators must work towards aligned standards and shared objectives.

Transporters are a vital link between production and consumption. Their safety culture directly affects the secure and timely delivery of industrial gases and other hazardous products. Customers also have responsibilities, including providing safe access, maintaining suitable delivery facilities, communicating product hazards and ensuring emergency readiness.

Collaborative safety platforms can support the sharing of data, lessons learned, route information, incident alerts and corrective actions. Such cooperation helps ensure that



risks identified in one part of the supply chain are not repeated elsewhere.

Overcoming Resistance to Change

The introduction of new safety processes may encounter resistance, particularly when employees are accustomed to established routines or fear that monitoring systems will be used for punishment.

Change management must therefore be based on clear communication, employee

involvement and visible leadership support. Near misses and unsafe observations should be treated as opportunities for learning and improvement, not as automatic grounds for blame.

A fair and transparent approach encourages reporting and helps organisations address underlying causes. The objective should be to understand what happened, why it happened and how the system can be improved.

Conclusion: Safety as a Continuous Journey



Developing a proactive safety culture in cryogenic logistics is not a one-time initiative. It is a continuous journey built on leadership commitment, employee engagement, driver empowerment, effective training, reliable data and collaboration across the supply chain.

The transition from compliance to safety excellence requires organisations to anticipate hazards, learn from experience and continuously improve their systems. Route surveys, vehicle inspections, toolbox talks, fatigue management, emergency drills, audits, feedback systems and technology-enabled monitoring all contribute to this objective.

Data analytics and AI can help identify emerging risks, but technology is effective only when supported by accurate information, trained people and timely action. Equally important is the creation of an environment where employees feel confident to report concerns, stop unsafe work and participate in improvement.

A resilient safety culture protects employees, customers, communities and the environment. It also supports operational continuity, strengthens trust and improves business performance.

Ultimately, safety in cryogenic logistics is the responsibility of everyone—leadership, employees, drivers, contractors, suppliers and customers. When every individual understands that safety is a shared value rather than a checklist requirement, every journey, delivery and operation becomes safer.

Beyond compliance, the goal is simple: every person should return home safely after every shift and every journey.



Company Profile

Air Water India Private Limited

Air Water India Private Limited (AWIPL) is a wholly owned subsidiary of **Air Water Inc., Japan**, a diversified organisation headquartered in Osaka with interests spanning industrial gases, medical products, chemicals, agricultural products and other businesses.



AWIPL entered the Indian industrial-gases sector following Air Water Inc.'s acquisition of the East Region divestment business of Praxair India Private Limited in 2019. This was followed by the acquisition of the South Region divestment business of Linde India Limited, further strengthening Air Water India's presence and capabilities in the domestic market.

The company is engaged in the manufacturing, storage, distribution, transportation, trading, sale, purchase and leasing of industrial gases, including oxygen, nitrogen, argon and helium. It owns and operates two large air-separation units and multiple filling stations across eastern and southern India.

With capabilities extending across the industrial-gas value chain, Air Water India serves customers that depend on reliable, safe and consistent gas supplies for their operations. Its activities encompass production, storage, transportation and delivery, supported by a strong focus on quality, operational discipline and customer service.

The company is committed to contributing to India's industrial growth by delivering dependable products and solutions and by building long-term relationships with customers across the regions it serves. Through its technical capabilities, infrastructure and service orientation, Air Water India continues to strengthen its role in the country's industrial-gases ecosystem..

Author Profile



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