Management of hazardous substances in port areas

Series on Chemical Accidents



OECD

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The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank, Basel, Rotterdam and Stockholm Conventions and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

Foreword

On 27-28 June 2023, the OECD Working Party on Chemical Accidents organised a seminar series on the Management of Hazardous Substances at Port Areas. The first seminar provided examples from countries on the functioning of their ports with regard to the management of hazardous substances. The second was more focused on specific elements of chemical accidents management at port areas. A background report was developed for the seminar series that was developed by Lee Allford, consultant. A survey was also conducted amongst WPCA delegations, the goal of which was to collect information from countries on what are perceived as the main challenges to manage chemical accidents risks and safety at port areas and possible means for improvement.

This document builds on the background report developed for the seminar series supplemented with the conclusions from the seminars as well as the results from the survey. The report is published under the responsibility of the OECD Chemicals and Biotechnology Committee.

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1 Summary of key issues

On the 27-28 June 2023, the OECD Working Party on Chemical Accidents (WPCA) organised a seminar series on the Management of Hazardous Substances at Port Areas. The first seminar was dedicated to examples from countries on the functioning of their ports with regard to the management of hazardous substances. The second was more focused on specific elements of chemical accidents management at port areas. A background report was developed for the seminar series. A survey was also conducted amongst WPCA delegations, the goal of which was to collect information on what are perceived as the main challenges to manage chemical accidents risks and safety at port areas and possible means for improvement.

Below are the main conclusions from these activities.

Port areas are critical infrastructure of strategic importance

Ports can host a large number of different activities, from transport of goods, bulk storage, fuel bunkering, oil refining and chemical manufacture, to passenger transportation, marina operation and residential locations. There are significant economic activities for the industries using the port. They provide import and export facilities for the surrounding region and possibly to other regions and countries without maritime or river access.

Port areas can handle hazardous substances and are subject to chemical accidents

Amongst the activities that take place in ports, many can involve the manufacture, transport and storage of hazardous substances. Recent major chemical accidents at port areas have shown the huge impact that these accidents can have and the importance of sound prevention, preparedness and response measures.

Port areas are at the interface of landside, transport, ports and maritime regulations

The different types of regulations applying at port areas can create challenges in the establishment of the chain of command and in the management of safety. There are multiple levels of control and responsibilities can be difficult to establish. It is important to ensure that nothing falls outside of regulations and that all the different pieces of regulations come together so that the risk from hazardous substances is fully managed. Cooperation, coordination and communication across relevant authorities is important.

Governance and leadership

There is a need for clear leadership and accountability at the port area with assigned people who ensure overall safety and coordination. The difficulty of applying regulations for chemicals that are in transit and to establish liability was raised.

The challenge of temporary storage

Managing hazardous substances that are considered in temporary storage was highlighted as a major concern. There are challenges in communicating “real-time” information about the transit of these chemicals. They may stay in the port longer than anticipated because of a variety of reasons (e.g. shipping delays, insolvability) causing concern for management of safety for longer term storage. There is also

constant shifting of quantities and types of chemicals in temporary storage that can create, for example, particular difficulties for responders in case of an accident but also difficulties in ensuring that proper safety measures are in place at all times. The definition of temporary storage also varies between countries.

Importance of organising preparedness and response

There are particular challenges for organising preparedness and response at port areas. The variety of activities at the port, the many stakeholders present, the fact that ports are often located in densely populated areas include many of the challenges for responders in the case of an accident. Furthermore, in recent port disasters, emergency responders were among the first victims of the disaster. The events raised the importance of carefully developing emergency plans at port areas and organising regular training and exercises with key stakeholders. Also emphasised is the importance of communication on accidents prevention and response for all the port's stakeholders that are faced with risks.

Risk from new energy sources

Concerns about energy security combined with the fast development of low carbon/carbon free fuels strategies are changing the landscape of activities at port areas. Countries are importing more fuels by sea, and there are plans to increase the use of new sources of energy such as hydrogen and ammonia. It is critical to understand the range of risks that these changes will imply, including the development of realistic scenarios for risk assessment. Bunkering was raised as a particular challenge.

Risks from natural hazards

Natural hazards, such as lightning, earthquakes, floods, winds or storms, can initiate adverse events which challenge the safety and operation at port areas and can result in a chemical accident. These accidents are referred to as Natural hazard triggered technological accidents - Natech. Recent large scale chemical accidents at ports have shown the significant impacts accidents triggered by natural hazards can have on people, the environment, infrastructure and business continuity. Changes in climate may affect the intensity, frequency and location of natural hazards, and change the risk profile of a port.

Possible areas/projects as follow-up to the seminar series were mentioned as:

- The development of a mapping document on the changing nature of ports with a forecast on what the future could look like in 5, 10 and 15 years;
- The development of realistic scenarios for new risks at port areas (e.g. in the case of ammonia bunkering, and risks from natural hazards);
- The development of a list of factors that stakeholders should consider to organise regulations and risk management/oversight practices for landside/ports and maritime to reduce gaps in managing risk emphasising governance and leadership and covering the entire risk management cycle.

2 Specificities of port areas

Ports are located alongside navigable water such as oceans, rivers or lakes with facilities for the loading and unloading of cargo or passengers from ships, ferries, and other commercial vessels. Activities associated with ports include operation of vessels, cargo handling equipment, trains, trucks, vehicles, and storage and warehousing facilities related to the transportation of cargo or passengers as well as the development and maintenance of supporting infrastructure.

The term seaport is used for ports that handle ocean-going vessels, and river port is used for facilities that handle river traffic. Sometimes a port on a lake or river also has access to the ocean and is then referred to as an inland port.

Ports around the world share many similarities, as they serve as important gateways for trade and transportation. However, there are also many differences between ports, which can be attributed to a variety of factors, including their size, setting, function, and ownership.

Some of the similarities between ports around the world include:

- Economic significance: Ports are important economic hubs, facilitating the movement of goods and people and driving national and regional economies including those of neighbouring and landlocked countries and those with smaller ports and harbours that are supplied by coastal shipping.
- Infrastructure: A port requires significant infrastructure e.g., terminals, jetties, wharves and pipelines, road and rail networks as well as other physical assets such as berths, piers, and cranes to accommodate ships and handle cargo.
- Regulations: Ports are subject to a variety of regulations and standards, including those related to safety, security, and environmental protection. Ports are at the interface between transportation regulation and regulations for fixed installations with the potential for regulatory overlaps and gaps. This affects not only the operations but also the classification of hazardous substances.
- Logistics: Ports are key components of global supply chains and require sophisticated logistics networks to move goods efficiently around the clock and throughout the year. Some ports will operate seasonally depending on factors such as their physical access, for example warm water ports will remain ice free and accessible throughout the year.

Some of the differences between ports around the world include:

- Size: Ports range in size from small regional facilities to large international hubs that handle millions of containers per year. The largest international ports can employ up to 100,000 workers and cover up to 3,000 km2.
- Setting: Ports can be in a variety of environments, including coastal areas, inland waterways, and urban centres.
- Function: Ports serve a variety of functions including handling, storage and transport of containers and bulk goods and passenger transportation. Ship repair plants can also have the status of ports and they may handle small quantities of hazardous substances.

- Ownership: Ports can be owned and operated by public entities, private companies, or a combination of the two, which can affect their governance and management structures.

Ports service a variety of shipping including liquid bulk (including oil and liquefied natural gas), dry bulk cargoes (such as aggregates), containerised traffic, “ro-ro” (roll on, roll off) and passenger ferry services, the cruise industry, fishing fleets and general cargo. Some ports are also bases for vessel constructing or servicing offshore energy facilities.

Ports are generally considered to be high-risk workplaces. Merchant ships can also be hazardous workplaces and port workers and seafarers work together at the intersection of ship/shore in ports. Typical accidents include slips, trips and falls and being hit by moving or falling objects. Injuries from manual handling are also common. Contributing factors to workplace accidents have been identified as inadequate risk assessment and operations management, inadequate operating procedures, lack of training and awareness, bigger and faster port equipment, bigger ships, increased port throughputs, faster ship turnarounds and more extreme weather conditions.

It is worth noting that the shore-based fixed assets and facilities undergo life cycles and have phases of construction, operation (including shutdowns and start-ups for maintenance, emergencies as well as to meet seasonal demands), decommissioning, removal and/or relocation within the same port area. From the marine perspective ships will potentially be built in shipyards and, at their end of life, broken up and recycled within the environs of an industrial port. The energy transition will quicken the pace of change as conventional shore based and marine assets are decommissioned and new fuels and technologies are introduced, resulting in a changing hazard profile for ports worldwide.

3 Chemical accidents in port areas

As far as chemical accident risks, there are several hazardous industries that are commonly found in ports or port areas, including:

- Chemical manufacturing and storage facilities: These facilities are involved in the production and storage of a variety of hazardous chemicals, including acids, bases, flammable liquids, and toxic substances.
- Oil and gas refineries: These facilities refine crude oil into gasoline, diesel fuel, and other petroleum products.
- Fertilizer manufacturing and storage facilities: These facilities produce and store fertilizers, many of which can be explosive or toxic.
- Hazardous waste storage and disposal facilities: These facilities handle and dispose of hazardous waste generated by various industries, including chemical manufacturing, oil and gas refining, and others.

The worst-case accident scenarios that can typically occur at ports depend on the specific operations and activities that take place at the port. However, some of the most severe accidents that can happen include:

- Fire or explosion: Port facilities manage bulk quantities of flammable, combustible and self-heating materials, such as fuels, chemicals, and gases. A fire or explosion can occur due to a range of factors, including equipment failure, human error, or natural disasters. Ports may also manage bulk quantities of dust-forming materials (e.g. grain) that could potentially lead to dust explosions.
- Chemical leaks and spills: Ports handle large quantities of hazardous materials, and a chemical release can occur due to equipment failure, human error, or natural hazards.
- Confined space hazards such as those found in the hold of ships as well as warehouses, silos and bins due to lack of oxygen or buildup of toxic or flammable gases.
- Container accidents: Ports handle large numbers of shipping containers, and accidents can occur due to equipment failure, human error, or mishandling of containers.
- Structural failure: Port infrastructure, such as cranes and other equipment, can fail due to structural issues or other factors, posing a risk to workers and the environment.
- Collisions: Ships and other vessels manoeuvre in and out of ports, and collisions can occur due to a range of factors, including operator error, equipment failure, and weather conditions.
- System failures: information and communication technology (ICT) and port inventory system failures, loss of key utilities such as power supply and cooling water.
- Malicious threats to the physical or cyber security of port areas have the potential to cause loss of equipment control, safety system shutdown or deletion of safety critical information such as quantity and composition of hazardous loads.

Chemical accidents at port areas are capable of causing transboundary effects when ports are sited near borders or transboundary watercourses.

There have been several recent major chemical accidents that have occurred in port areas around the world, and four are described below. The Beirut and Tianjin accidents, see details below, involved

ammonium nitrate which resulted in two of the most devastating explosions that have been recorded in peacetime and caused extensive harm, particularly amongst the emergency response services. The cargo tank styrene monomer explosion in Ulsan, Korea, below, is an example of a loss of containment which originated on ship but had consequences both on ship and in port.

Recent major accidents at port areas have triggered responses from countries to ensure appropriate measures were in place for chemical accidents prevention, preparedness and response and that these measures were properly implemented, for example:

- Inspections in ports;
- Follow-up with illegal storage of chemicals and/or suspected irregularities;
- Awareness-raising within public authorities;
- Review of laws, regulations, practices and contingency plans applicable to port areas;
- Inventories of chemicals stored and transported at port areas;
- International reviews of existing instruments/mechanisms to support countries in addressing hazards/risks in the short and long-term;
- Information and knowledge exchanges.

3.1. Port of Aqaba chlorine release

On 27 June 2022, an isotainer of liquefied chlorine gas was being loaded onto a ship by a crane in the port of Aqaba, Jordan. A lifting cable snapped, and the tank crashed onto the ship's deck and ruptured. A cloud of toxic yellow chlorine gas formed and workers evacuated the area. Thirteen people were killed and a significant number of people required hospital treatment.

The tank's weight was greater than the load capacity of the lifting cable and the required safety measures for dealing with such hazardous material were not in place. No qualified person was on the deck at the time to check the lifting equipment and procedures. Several of the workers involved in the loading stated that they were not aware of the weight nor the content of the containers.

Other contributing factors identified included:

- deficiency and noncompliance with procedures concerning the handling of hazardous chemicals,
- poor and informal hazard communication practices,
- lack of training and competencies amongst the work team,
- improper follow-up of daily operations and maintenance reports,
- poor leadership and unclear responsibilities.

The accident could have harmed far more workers who had just finished their shift and had left the site shortly before the leak. Winds also blew the toxic gas away from populated areas in the port city to the outlying desert. Nevertheless, questions remain whether it was essential for several workers to be in the vicinity of the loading operation at the time of the release.

For more information, see the report from the Jordanian Chemical Process Safety Engineers Society: https://www.linkedin.com/posts/jordanian-chemical-process-safety-engineers-society_aqabaabrport-accident-incident-activity-6950927450033827840-eoDB?utm_source=linkedin_share&utm_medium=member_desktop_web and the dedicated webpage of the International Cargo Handling Coordination Association: https://ichca.com/preliminary-findings-into-chlorine-tank-incident-at-the-port-of-aqaba#:~:text=A%20number%20of%20tanks%20containing,of%20more%20than%20250%20people

3.2. Beirut Port Explosion

On 4 August 2020, a massive explosion occurred at the port of Beirut in Lebanon, killing over 200 people and injuring thousands more. The explosion was caused by the detonation of a substantial quantity of ammonium nitrate that had been unsafely stored in a warehouse for several years.

The impact of the explosion was catastrophic, with at least two hundred fatalities and thousands injured. The explosion also caused widespread damage to homes and businesses in the surrounding areas, leaving many residents homeless. It also led to political unrest and protests in Lebanon, as people demanded accountability for the tragedy.

The disaster was several years in the making. The ammonium nitrate in question had been confiscated in 2013 from a vessel that had suffered technical problems and had entered the Port of Beirut in November 2013. Upon inspection, the vessel was prohibited from sailing, and shortly afterwards the ship was abandoned by the owner. Owing to the risks associated with the cargo, the ammonium nitrate was warehoused at the port but without proper safety measures.

The Beirut port explosion prompted many governments to take actions within their countries, including heightened site inspections to ensure compliance with laws and regulations, reviews of laws and regulations, and awareness raising through media and expert dialogues.

For more information, see for example https://www.icheme.org/media/18192/lpb284_pg02.pdf. Please also see the information collected and conclusions and recommendations generated from the *UN/OECD seminar in follow-up to the 2020 Beirut port explosion: Lessons learned, experiences and good practices in managing risks of ammonium nitrate storage, handling and transport in port areas, preventing accidents and mitigating their consequences* (online, 14 December 2021), co-organized by the United Nations Economic Commission for Europe's Secretariat of the Industrial Accidents Convention (lead), International Labour Organization (ILO), International Maritime Organization (IMO), United Nations Environment Programme/Office for the Coordination of Humanitarian Affairs Joint Environment Unit (UNEP/OCHA JEU), United Nations Office for Disaster Risk Reduction (UNDRR) Regional Office for Arab States and Organisation for Economic Co-operation and Development (OECD): https://unece.org/info/Environmental-Policy/Industrial-Accidents/events/358445.

3.3. Cargo tank styrene monomer explosion

On 28 September 2019, a cargo tank containing styrene monomer ruptured, causing an explosion and fire. The tanker was moored alongside another cargo chemical tanker in a general cargo berth located in Ulsan, Korea. The ignition of the styrene monomer vapour resulted in a fireball, which reached the road bridge above. Both vessels were damaged, and two crew members suffered minor injuries. Fifteen emergency responders were injured during the firefighting, which lasted for over 6 hours.

The rupture of the styrene monomer tank resulted from a runaway polymerisation reaction that was initiated by elevated temperatures caused by heat transfer from other chemical cargoes. The elevated temperatures caused the inhibitor, added to prevent the chemical's polymerisation during the voyage, to deplete more rapidly than expected. Although the styrene monomer had not been stowed directly adjacent to heated cargo, the potential for heat transfer through intermediate tanks was not fully appreciated or assessed. Critical temperature limits had been reached before the vessel berthed under the road bridge in Ulsan. The tanker's crew did not monitor the temperature of the styrene monomer during the voyage, and therefore were not aware of the increasingly dangerous situation.

Following the accident, the Ministry of Oceans and Fisheries, Korea, prohibited ship-to-ship transfer operations for dangerous cargo on general cargo berths in Ulsan. The company owning the ship took immediate action to ensure that the temperatures of all cargoes carried on board its ships were monitored

and reported to its shore management. It also took steps to enhance crew awareness on the hazards of inhibited and heat sensitive cargoes. The company is developing technological and administrative initiatives to assist with the safe stowage and monitoring of heat sensitive cargoes.

For more information, see https://assets.publishing.service.gov.uk/media/60f93e2cd3bf7f044c51590b/2021-09-StoltGroenland-Report.pdf

3.4. Tianjin Port Explosion

On 12 August 2015, explosions occurred at the Port of Tianjin in China. The accident involved a series of explosions at a warehouse in the port area that stored hazardous chemicals, including sodium cyanide and ammonium nitrate. The impact of the explosions was devastating, with about two hundred people killed, hundreds injured, and thousands of homes and buildings damaged. The explosions also caused widespread environmental damage, with toxic chemicals contaminating the air, soil, and water in the surrounding areas.

In February 2016 an investigation concluded that an overheated container of dry nitrocellulose resulted in the initial explosion which then triggered larger explosions. Contributory factors included the improper storage of hazardous chemicals (significantly over the prescribed legal limit), inadequate safety measures, and a failure to properly regulate and enforce safety standards (a violation of safety regulations stating that hazardous operations be located at least one kilometre away from public buildings).

Immediately after the explosion, dangerous cargo operations were temporarily banned. Vessels were temporarily allowed to leave but not to enter, and stringent checks of movements in and out of the port were imposed. The overall port planning was also revised, and unaffected sections of the port continued operations.

Given the size and importance of the port of Tianjin, the impact of the disruption was severe for both regional and global supply chains. The port and its hinterland were congested for months after the explosion, with the main road accessing the port being temporarily unavailable. Several key port buildings were either destroyed or damaged, public transportation facilities stopped functioning order, and most administrative functions, such as customs and inspection offices, were interrupted. The oil and gas industries, liquefied natural gas (LNG) imports and steel and iron ore trades were particularly affected.

For more information see, https://www.icheme.org/media/18714/lpb286_pg17.pdf.

3.5. A selection of historical port related accidents

The following table (Table 1) provides a summary description of a selection of port-related accidents that occurred since 2000 and resulted in fatalities. The selected accidents primarily originated onshore in pipeline, warehousing and container operations with two occurring at the interface between ship and shore in loading/unloading operations. This is not an exhaustive list, and it is worth noting that reports in accident databases do not always identify accidents as occurring within port areas and that accurately locating incidents requires further research.

Table 1. Examples of port-related accidents that occurred since 2000.

Year	Location	Description	Operation	Killed	Injured	Substances
2022	**Bangladesh**; Sitakunda; Chittagong	A fire followed by several explosions occurred at a harbour container depot which stored hazardous substances including hydrogen peroxide	Storage	>50	>450	Hydrogen peroxide
2020	**USA**; Port of Corpus Christi, Texas	A propane pipeline explosion sank a dredging vessel	---	5	5	Propane
2016	**Germany**; Ludwigshafen	Explosion and fire occurred among the pipelines that connect a chemical complex to its harbour on the Rhine River	Maintenance	5	45	Ethylene, propylene
2013	**China**; port city of Qingdao; Qingdao	A pipeline exploded while a leakage was repaired	Maintenance	62	---	Oil
2012	**Egypt**; Port Said	Two containers leaked toxic fumigant phosphine in the port		6	>100	Phosphine
2010	**China**; Xingang Harbour; Dalian; Liaoning Province	Explosion of two crude oil pipelines and fire at the port. Between 60,000 to 90,000 tons were spilled into the sea	Process	1	0	Oil
2009	**Italy**; port of Genova; Genova	Fire and explosion at a chemical warehouse in the port	Storage	6	---	---
2008	**USA**; Port Wentworth; Georgia,	Dust explosion and fire in silos	Storage	14	36	Grain
2004	**Algeria**; Skikda	Explosion and fires following a leaking pipeline. A large part of the port was destroyed. Three LNG trains were damaged which represented approximately 2% of the world's liquefaction capacity.	Gas liquefaction plant	30	>70	LNG

Source: From CAPRI database, https://minerva.jrc.ec.europa.eu/en/shorturl/capri/caprihome

4 Key risk management elements at port areas

This section provides a brief overview of some elements to consider that are specific to the management of hazardous substances at ports.

4.1. Governance of the port

Several authorities have responsibility for ensuring the safe handling, storage, and transportation of hazardous goods in port areas worldwide. There are multiple levels of control and responsibilities, and different regulations are at play (e.g. landside, transport, and maritime regulations) with possible gaps, repetitions or contradictions.

The seminar series highlighted the importance of communication and cooperation amongst the different stakeholders that are part of the chain of command and operators to ensure sound prevention, preparedness and response to chemical accidents at port areas, as well as the need for clarity on responsibilities.

Stakeholders involved in governance include:

- *Port authorities*: Port authorities are responsible for overseeing and managing port operations, including the handling of hazardous goods. They establish regulations, guidelines, and protocols to ensure the safe handling, storage, and transportation of hazardous materials within the port area. Port authorities often have dedicated departments or units responsible for safety and environmental management.
- *Maritime authorities*: Maritime authorities, such as coast guards or maritime administrations, regulate and enforce safety and security standards for vessels operating in port areas. They ensure compliance with international maritime conventions and regulations related to the handling and transport of hazardous goods. Maritime authorities also conduct inspections, audits, and investigations to ensure adherence to safety protocols.
- *Regulatory agencies*: Regulatory agencies at the national or regional level establish and enforce rules and regulations pertaining to hazardous goods handling and transportation. These agencies often develop and implement frameworks based on international standards, such as the International Maritime Organization (IMO) International Maritime Dangerous Goods (IMDG) Code.
- *Emergency response and fire departments*: Emergency response agencies, such as fire departments and hazardous materials response teams, play a critical role in mitigating incidents involving hazardous goods. They are trained to respond to accidents, spills, leaks, fires, and other emergencies promptly. These agencies work closely with port authorities and other entities to develop emergency response plans and conduct drills.
- *Terminal operators and stevedores*: Terminal operators and stevedoring companies are responsible for the day-to-day handling and operations of cargo in the port. They implement safety protocols and ensure that hazardous goods are handled and stored appropriately. Terminal

operators often have dedicated safety and security teams responsible for overseeing the safe movement of hazardous cargo.

- *Shipping companies and freight forwarders*: Shipping companies and freight forwarders have responsibilities in ensuring the safe transport of hazardous goods from origin to destination. They must comply with regulations regarding the proper documentation, packaging, and labelling of hazardous goods. These entities work closely with port authorities, regulatory agencies, and other stakeholders to ensure compliance.

4.2 Land-use planning

The accidents previously described illustrate the value of designated land-use planning within port areas. In the case of Tianjin and Beirut separation distances between hazardous material storage were not observed leading to extensive harm amongst the local population.

There are different elements that can contribute to a reduction of the risks of accidents at ports that are associated to an active engagement in the land-use planning process within and close to port areas, for example:

- *Zoning and separation*: Ports can work with local planning authorities to establish appropriate zoning regulations.
- *Risk assessment and buffer zones*: Ports can conduct comprehensive risk assessments to identify and evaluate potential hazards associated with the storage and transportation of hazardous goods. Based on the findings, they can collaborate with land-use planners to establish buffer zones or setbacks to provide an additional level of protection around hazardous materials facilities.
- *Infrastructure planning*: Engaging in the land-use planning process allows ports to consider infrastructure needs and develop adequate facilities for the safe handling, storage, and transport of hazardous goods. This includes designing appropriate road networks, access routes, storage areas, and emergency response infrastructure to minimise the risks.
- *Emergency response planning*: Collaboration with land-use planners enables ports to integrate emergency response planning into the overall land-use strategy. This includes identifying evacuation routes, establishing emergency staging areas, and coordinating with local emergency services to ensure prompt and effective response in case of accidents involving hazardous materials.
- *Environmental protection*: Engaging in land-use planning allows ports to consider environmental protection measures and ensure the safe management of hazardous goods. This can involve implementing pollution control technologies, establishing containment measures for spills and leaks, and preserving sensitive ecosystems through proper land-use design.
- *Stakeholder engagement*: Ports can actively involve relevant stakeholders, including local communities, environmental organisations, and regulatory agencies, in the land-use planning process. This engagement fosters transparency, it promotes understanding of risks associated with hazardous goods, and allows for collaborative decision-making to address concerns and enhance safety measures.
- *Public awareness and education*: Ports can contribute to public awareness and education programmes through the land-use planning process. This can include disseminating information on the types of hazardous materials handled, safety protocols, and emergency response procedures to raise awareness and enhance understanding among nearby communities. This should extend to the public in neighbouring and riparian countries that could be affected by accidents capable of causing transboundary effects from port areas.

By engaging with the land-use planning process, ports integrate safety considerations, risk assessments, and emergency response planning into the overall development and operation of port areas. This collaborative approach helps reduce the risks of accidents involving hazardous goods and ensures the protection of nearby communities and the environment.

4.2. Emergency preparedness and response

Throughout the seminar series, the challenges of organising response to chemical accident at port areas were raised. Issues highlighted include:

- The need for sound emergency planning with engagement of competent authorities and responders and that is based on the entire set of activities taking place in the port as well as its proximity to residential areas;
- The difficulty of always having information on hazardous chemicals present in the port, in particular in the case of temporary storage. This can challenge emergency response in the case of an accident;
- Notification systems and lack of clarity in the chain of command and responsibilities;

There are several elements that can be considered by operating companies, operators of individual enterprises and both port and local authority and emergency responders within the port area, both individually and jointly when preparing and responding to a chemical accident:

- Identification of chemicals and hazards: inventory of chemicals stored or transported through the port, along with their associated hazards, risks, and safety protocols. It is essential to have this information readily available to emergency responders in case of an incident.
- Strengthening coordination and cooperation between the competent authorities and the stakeholders involved in the management of related emergencies;
- The development of emergency plans: emergency plans that outline procedures for responding to chemical emergencies. These plans should identify potential emergency scenarios, define roles and responsibilities of staff, outline communication protocols, and provide instructions for evacuation, sheltering-in-place, and medical treatment.
- Training of staff: regular training of relevant personnel at the port on the emergency plan, for example how to recognize signs of a chemical emergency, how to use protective equipment, and how to respond to different scenarios.
- Conducting drills: ensure that all staff members understand their roles and responsibilities in an emergency. These drills can help identify gaps in the emergency plan and provide opportunities for improvement.
- Maintaining equipment: all safety equipment, such as personal protective gear, spill response equipment, and fire suppression systems.
- Coordinating with local authorities: establish relationships with local emergency response agencies and coordinate with them on emergency planning and response efforts. This coordination can help ensure that resources are efficiently allocated and that response efforts are effective.
- Coordination of on-site plans and response activities between enterprises collocated in port areas: ensure the plans are consistent, establish systems for mutual aid when needed, and help avoid domino effects.
- Monitor and report incidents: monitoring system in place to detect chemical releases or other incidents.
- Transboundary cooperation: for ports near national borders or transboundary watercourses, authorities should ensure that emergency plans are prepared jointly with or are compatible with

emergency plans of neighbouring or riparian countries in order to address the possible transboundary effects of chemical and industrial accidents. Authorities should also use industrial accident notification systems to notify other countries in case of an (imminent) chemical accident that is capable of causing transboundary effects and to promptly request mutual assistance.

4.3. Awareness and communication between operators

In port areas, good practice in awareness and communication between various companies and operators involves establishing effective communication channels and promoting a culture of collaboration and shared responsibility for safety and environmental protection. Several key elements in awareness and communication in port areas are:

- Establishing a communication protocol: a clear and well-defined communication protocol between all companies and operators in the port area to ensure that information is shared in a timely and effective manner. This may include regular meetings, email updates, or other forms of communication.
- Developing a shared safety culture: commitment from all companies and operators in the port area to promoting a culture of safety and environmental protection. This may involve developing a shared set of values, principles, and goals related to safety and sustainability.
- Encouraging reporting of incidents and hazards: encourage reporting of incidents and hazards and establish a reporting mechanism. This helps to identify potential risks and hazards and allows for prompt action to be taken to prevent accidents.
- Providing training and education: training and education by companies and operators to their employees on safety and environmental protection and ensure that all employees are aware of the communication protocol and reporting mechanisms.
- Engaging with stakeholders: such as local communities, NGOs, and regulatory bodies to ensure that they are aware of the risks and concerns associated with port activities, and that their concerns are addressed.

Overall, good practice in awareness and communication between various companies and operators in port areas involves establishing effective communication channels, promoting a culture of collaboration and shared responsibility, and engaging with stakeholders to ensure that safety and environmental protection are a top priority.

4.4. Natural hazards (Natech risks and challenges)

Owing to their low-lying nature, ports are exposed to natural hazards such as storms, lightning, floods, cyclones and hurricanes, earthquakes and tsunamis. These natural hazards can cause significant damage to port infrastructure, disrupt port operations, and pose a threat to the safety of workers and the public. Recent examples are the major Natech accidents at the port of Iskenderun in Türkiye that happened in February 2023 following an earthquake of magnitude 7.8 and the accident in Cuba at a supertanker port in August 2022 caused by lightning.

Rising sea levels and more frequent extreme weather events, driven by climate change, are also increasing the risk of natural hazards at ports such as tidal flooding and coastal erosion.

There are a number of measures that ports can consider:

- Developing and implementing disaster preparedness plans that outline emergency response procedures and identify critical infrastructure and equipment.
- Investing in resilient infrastructure and equipment that can withstand natural hazards such as reinforced port buildings and barriers.
- Conducting regular risk assessments to identify potential hazards and vulnerabilities and taking steps to mitigate risks.
- Conducting inspections after natural hazard impact and before restarting activities to guarantee safety.
- Developing and implementing safety and environmental management plans that address the impacts of climate change on port operations and infrastructure.
- Collaborating with other ports, local authorities, and emergency response agencies to develop coordinated disaster response plans and share best practices.

5 Items of special concern to port areas

5.1. Management of warehouses

Warehouses are a key element of the supply chain management for industry, in particular at ports. They often store large quantities of hazardous substances and are prone to escalation of initiating events and domino effects. In June 2022, a fire and explosions at a chemical depot in the port of Sitakunda, Bangladesh killed at least 49 people and injured 350.

The European Commission Joint Research Center published its 16th Lessons Learnt Bulletin on industrial incidents that took place in warehouses that was presented during the seminar series.[1] Based on the analysis of 38 cases of accidents at warehouses, the document raises the following key points for operators and inspectors. The importance of:

- Risk assessment (permittable substances and quantities);
- Inventory control and safe interim storage;
- Labelling and marking of containers;
- Integral site planning and structural integrity;
- Land use planning;
- Firefighting and firewater containment;
- Training with external emergency services.

The management of warehouses in port areas presents additional challenges compared to inland warehouses in terms of managing chemical risks due to the following factors:

- Location: By their very nature warehouses in port areas are located near water bodies, transportation infrastructure, and other industrial facilities. This proximity increases the risk of chemical accidents due to potential exposure to external hazards, such as severe weather, transportation accidents, or incidents at neighbouring facilities.
- Transportation: Warehouses in port areas are often involved in the transportation of chemicals to and from the port, increasing the risk of accidents during transportation. This requires additional safety measures, such as proper loading and unloading procedures, specialised equipment, and coordination with transportation providers.
- International Trade: Port areas are often involved in international trade, which introduces additional challenges related to the transportation, storage, and handling of chemicals. This may require compliance with international regulations, language barriers, and cultural differences in safety practices.

1 See, https://minerva.jrc.ec.europa.eu/en/shorturl/minerva/mahb_bulletin_16_on_warehousespdf

- Emergency Response: In the event of a chemical accident or spill, emergency response efforts in port areas can be more complex due to the potential for multiple agencies to be involved, including port authorities, local emergency responders, and national agencies. This requires coordinated emergency response planning and training.

5.2. Type of hazardous substances

Port areas handle a wide range of hazardous substances and dangerous goods that are transported and stored in large quantities. The specific types of hazardous substances and dangerous goods may vary depending on the location and type of port, but some common examples include:

- Chemicals: Various chemicals are transported through ports, including corrosives, flammable liquids, toxic substances, and oxidizing agents. Some chemicals commonly transported through ports include ammonia, chlorine, and sulphuric acid.
- Petroleum products: Products such as crude oil, gasoline, diesel fuel, liquefied petroleum gas (LPG) and LNG are often transported through ports for distribution.
- Explosives: Explosive materials like fireworks, ammunition, and blasting agents are often transported through ports.
- Hazardous waste: Hazardous waste materials generated by industries and municipalities are often transported through ports for disposal or treatment.

Key elements for consideration when managing hazardous substances include:

- notification requirements for dangerous cargo shipments;
- general requirements and procedures for the safe handling of dangerous cargoes;
- storage requirements;
- segregating incompatible products;
- time constraints for products kept on the wharf (not in covered storage)
- emergency response procedures; and
- management systems to cover aspects such as training and communication.

5.3. Tank storage

Bulk storage/tank farm operators need to consider the hazards presented by tank storage in port areas.

Some of these considerations include:

- Tank design and construction: the design and construction of tanks is very important to meet safety standards and regulations to prevent leaks, ruptures, and explosions. Proper materials, thickness, and welding techniques must be used to ensure tank integrity.
- Tank location and foundation: The tanks should be located on stable ground with appropriate foundation and support structures. Tank farms must be properly separated from other plant and within the same tank farm between individual tanks. The location must also allow easy access for emergency responders in case of an incident.
- Tank operation; overfill protection and procedures/ practices.
- Tank maintenance: Regular maintenance of tanks is crucial to prevent leaks and ensure the safety of stored substances. This includes inspecting and testing tanks for signs of corrosion, damage, or wear, which may involve physical entry into confined spaces and exposure to asphyxiation risks in

oxygen depleted environments. Tanks vents should be kept clear to prevent collapse during tank emptying. Damage of the tanks can be minimised by using weak seam roofs.

- Spill prevention and control: Spill prevention and control measures must be in place to minimise the impact of accidental spills. This includes the use of secondary containment systems, spill response kits, and emergency shutdown procedures.
- Fire prevention and protection: Tanks are highly susceptible to fire hazards, so fire prevention and protection measures must be in place. This includes fire suppression systems, fire alarms, and emergency response plans.

5.4. Pipelines

In port areas, pipelines can present several hazards, including:

- Chemical hazards: Pipelines can transport hazardous chemicals, such as flammable or toxic gases and liquids, which can pose a risk to life safety, human health and the environment in the case of leakage or spills.
- Physical hazards: Pipelines can be damaged by physical hazards, such as excavation or construction activities, which can lead to rupture or leakage of the pipeline. Pipeline damage can also occur due to natural disasters, such as earthquakes or hurricanes.
- Corrosion hazards: Pipelines made of metal are vulnerable to corrosion due to exposure to saltwater and other corrosive substances in the port environment. Corrosion can weaken the pipeline and cause leakage or failure.
- Environmental hazards: Pipeline leaks and spills can cause significant harm to the environment, including damage to marine life, habitats, and water quality.

5.5. Transport (loading and unloading)

The loading and unloading of ships in port present several major accident risks. Here are some of the key risks associated with these activities:

- Cargo handling accidents: The movement of heavy cargo using cranes, forklifts, and other equipment poses risks of accidents such as equipment failures, dropped loads, and collisions. Improper securing or stowage of cargo can lead to shifting loads, which may result in capsizing or damage to the vessel or port infrastructure.
- Crane and machinery accidents: The operation of cranes, gantries, and other machinery used for cargo handling poses risks of accidents due to mechanical failures, operator error, or improper maintenance. Collisions between cranes, swinging loads, or accidents caused by improper use of lifting equipment can lead to injuries and damage.
- Fires and explosions: Cargo, especially hazardous materials, may pose a risk of fires and explosions during loading and unloading. Chemical reactions, improper handling of flammable substances, or ignition sources can result in accidents, endangering workers, vessels, and port facilities.
- Structural failures: During the loading or unloading process, structural failures of the vessel, such as hull breaches or collapse of ramps, can occur, potentially causing accidents, injuries, or cargo spills. Ageing infrastructure, poor maintenance, or inadequate safety measures increase the risk of such incidents.

- Fatigue and human error: Long working hours, shift work, and demanding schedules can lead to fatigue among workers involved in cargo operations. Fatigue can impair judgment, concentration, and reaction times, increasing the risk of human error.

5.6. Temporary (intermediate) storage

Temporary or intermediate storage is a special concern in port areas when it comes to the storage of dangerous goods for several reasons:

- Proximity to other activities: Ports are typically busy areas with many different activities taking place close to one another. This can increase the risk of accidents or incidents involving dangerous goods, especially if they are being stored temporarily or in an intermediate location before being transported or further processed.
- Limited storage space: Port areas often have limited space for storage, which can lead to dangerous goods being stored in areas that are not specifically designed or equipped for their safe storage. This can increase the risk of spills, leaks, or other incidents that could have serious consequences.
- Environmental impact: By their nature ports are located near waterways or other sensitive environments, which can be adversely affected by spills or leaks of dangerous goods. Even temporary storage of these materials can increase the risk of environmental damage if proper precautions are not taken.
- Security concerns: Dangerous goods are attractive targets for theft or sabotage, and port areas can be vulnerable to these types of threats. Temporary or intermediate storage can increase the risk of these incidents occurring if appropriate security measures are not in place.

The definition of temporary or intermediate storage can vary between countries. The status of temporary storage requires regular review by managers who have sufficient authority to intervene when safety standards are or have the potential to be violated. Problems arise when unforeseen circumstances mean that temporary becomes extended storage: e.g., strikes, legal action such as confiscation, sanctions, insolvency, etc.

5.7. Management of non-routine issues

The confiscation or seizure of dangerous goods in port areas presents an elevated chemical accident risk for several reasons:

- Dangerous goods can react violently if not handled properly: When dangerous goods are confiscated or seized, they may have already been mishandled or stored improperly, which can increase the risk of unpredictable and dangerous reactions.
- Lack of information: Confiscated or seized dangerous goods may not come with complete information about their composition or potential hazards. This can make it difficult to properly handle and dispose of these materials in a way that minimises the risk of harm to people or the environment. Re-packaged substances with incomplete or incorrect labelling will add to the chemical accident risk. It is conceivable that such loads may be incorrectly described (unintentionally or purposely) or contain undeclared materials.
- Limited time for response: Confiscated or seized dangerous goods often need to be moved quickly to minimise the risk of harm. This can limit the time available to properly assess the risks and develop a safe plan for handling, storage and transportation of the materials.

- Human error: Confiscation or seizure of dangerous goods can involve a complex chain of custody, with multiple parties involved in the handling and transport of the materials. This can increase the risk of human error, such as a lack of segregation with other incompatible goods, which can have serious consequences.

6 Emerging risks

Emerging risks that can impact major accident safety in ports worldwide include:

- Increased containerisation: The growth of containerisation has led to larger ships and higher volumes of containers being handled at ports. This poses challenges in terms of handling and storing hazardous materials, as well as managing the potential risks associated with container fires, explosions, and leaks.
- Automation and robotics: The adoption of automation and robotics in port operations introduces new safety considerations. While these technologies can improve efficiency and safety, they also raise concerns about the potential for equipment malfunctions, collisions, and accidents involving autonomous vehicles or unmanned aerial vehicles (drones).
- Energy Storage Systems (ESS): The use of energy storage systems, such as lithium-ion batteries, for electric vehicles and renewable energy storage, is increasing in ports. ESS installations carry inherent risks, including the potential for thermal runaway, fires, and explosions if not managed properly.
- LNG fuelling infrastructure and risks for new energy sources: Ports are increasingly providing liquefied natural gas (LNG) as a fuel source. However, the handling, storage, and bunkering of LNG present safety challenges due to the potential for leaks, cryogenic hazards, and the need for specialist infrastructure and training. Current plans to increase the use of new fuels such as hydrogen and ammonia also raise consideration of new safety risk.
- Climate change impacts: Climate change can impact port safety. Rising sea levels, increased storm intensity, and changing weather patterns can heighten the risks of accidents, such as vessel collisions, grounding, and structural failures.
- Novel cargo and hazardous materials: The transportation of new or unconventional cargoes, including hazardous chemicals or substances, can introduce unique risks. Ports need to assess and manage the potential hazards associated with these materials, including storage requirements, compatibility issues, and emergency response capabilities.
- Break-down in regulatory compliance: The interaction between humans and increasingly complex automated systems can lead to new safety challenges. It is important to ensure that operators have the necessary training and skills to work effectively and safely with advanced technologies.

To address these emerging risks, port authorities, industry stakeholders, and regulatory bodies need to regularly assess and update safety protocols, implement appropriate training programs, conduct risk assessments, and enhance emergency response capabilities. Collaboration and information sharing among ports can also help identify best practices and lessons learned to improve major accident safety in the industry.

7 Survey on Challenges to Managing Chemical Accident Risk at Port Areas

In preparation for the OECD seminar series on the *Management of hazardous substances at port areas*, a short survey was circulated to delegations of the WPCA. The goal of this survey was to collect information from countries on what are perceived as the main challenges to manage chemical accidents risks and safety at port areas and possible means for improvement.

Seven responses were received from Bulgaria, Estonia, Finland, Germany, Poland, Sweden and New Zealand.

Most of the respondents indicated that they did not have recent major chemical accidents at their ports. One respondent indicated an accident at a warehouse (non-Seveso establishment) with fire at oil barrels and with also the presence of titanium powder/dust. The accident involved a large number of responders and a perimeter set of 800 metres around the zone of the accident. There were no injuries and only damage to property. The warehouse was moving its content to another place when the accident occurred. A “near miss” was also reported by the same respondent with an accident at a Seveso upper-tier establishment in a port area. There was an ammonia leakage from a railway tanker during the unloading process (the railway tanker contained 40 tons of ammonia). At the time of the incident, the wind was in direction of the gulf. The effects were local. With the help of firefighters, the valves were closed.

The survey asked countries to indicate their primary concerns regarding safety in ports. The following points were mentioned:

- Most of the respondents raised the challenges of organising response in the case of a chemical accident. They highlighted the importance of a comprehensive risk analysis and the development of sound emergency plans at port areas. Some respondents also pointed out the challenges of rescue teams arriving at different times on the site of the accident and the difficulties to lead rescue teams to the scene.
- Most respondents raised as a major concern the issue of temporary storage at port areas. Responses highlighted:
  - a lack of internationally agreed definition of “temporary/intermediate” storage. Definitions of temporary storage can vary across countries;
  - challenges in establishing systems for communicating “real-time” information to port authorities on the hazardous chemicals that are temporarily stored in a port and their ins and outs;
  - challenges of temporary storage being at the interface of fixed-installations and transport regulations. It was pointed out that long term storage and temporary storage can be managed by different authorities for example and the lack of information makes it difficult for the right authority to take charge of the hazardous chemicals stored;

  - hazardous substances that stay in the port longer than anticipated because of unforeseen circumstances (e.g. Covid crisis, shipping delays, etc.). Some hazardous substances if they are stored for a longer period of time need special safety equipment for safe storage;
- Some respondents raised the concern of availability of fire water protection at port areas;
- The difficulty of establishing cooperation and exchange of information between companies in a port (e.g., joint exercises, information about domino effects, etc.) was also raised as a concern by some respondents as well as the system of notification in case of an accident;
- Some respondents highlighted the difficulty for port operators to have a clear overview of all the activities in a port;
- Some respondents raised the risks linked to presence in port areas of new energy sources and the management of their risks. For example, a respondent highlighted the difficulty of responding to fire from lithium-ion batteries.

The survey also asked for the main areas for improvements of safety at port areas. Respondents highlighted the following:

- Port authorities should have a clear overview of all activities in a port, in particular when they involve hazardous substances. There should be systems established for port authorities to receive “real-time” information on the chemicals stored in port areas, in particular those considered as in temporary storage (their type, risk, means of storage, etc);
- Regular exercises for emergency response are critical;
- The systematic development of a comprehensive risks analysis and emergency and response plans considering the whole port area;
- Ensure consistency in the different regulations that will affect the management of hazardous substances at port areas (in land, loading and unloading, transport and maritime);
- Bring clarity on the authorities in charge – who is taking responsibility;
- Ensure a continuous communication and cooperation between operators;
- Increase the sharing of good practices across countries for continuous improvement of port operations.
- The promotion of a mature safety culture at port areas with improving incident reporting, notifications, and implementation of lessons learnt.

8 Key guidance and international frameworks

The key guidance and international frameworks relevant to the management of hazardous materials in port areas are:

- Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), https://unece.org/about-adr
- UN Globally Harmonised System of Classification and Labelling of Chemicals (GHS), https://unece.org/about-ghs
- UN Recommendations on the Transport of Dangerous Goods, Model Regulations, https://unece.org/transport/dangerous-goods/un-model-regulations-rev-23
- UNECE Convention on the Transboundary Effects of Industrial Accidents, https://unece.org/environment-policy/industrial-accidents
- ILO Prevention of Major Industrial Accidents Convention (No. 174), https://normlex.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:55:0::NO::P55_TYPE,P55_LANG,P55_DOCUMENT,P55_NODE:CON,en,C174,/Document
- ILO Chemicals Convention (No. 170), https://normlex.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:55:0::NO::P55_TYPE,P55_LANG,P55_DOCUMENT,P55_NODE:CON,en,C170,/Document
- IMO International Maritime Dangerous Goods (IMDG) Code, https://www.imo.org/en/OurWork/Safety/Pages/DangerousGoods-default.aspx
- IMO International Maritime Solid Bulk Cargoes (IMSBC) Code, https://www.imo.org/en/OurWork/Safety/Pages/CargoesInBulk-default.aspx
- IMO Recommendations on the Safe Transport of Dangerous Cargoes and Related activities in Port Areas, https://www.imo.org/en/OurWork/Safety/Pages/Cargoes.aspx
- IMO International Ship and Port Facility Security Code (ISPS) Code, https://www.imo.org/en/OurWork/Security/Pages/SOLAS-XI-2%20ISPS%20Code.aspx
- OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response, https://www.oecd-ilibrary.org/environment/oecd-guiding-principles-for-chemical-accident-prevention-preparedness-and-response_9789264101821-en
- APELL for Port Areas: Preparedness and Response to Chemical Accidents in Ports, https://wedocs.unep.org/handle/20.500.11822/9189?show=full
- TransAPELL: Guidance for Dangerous Goods Transport Emergency Planning in a Local Community, https://digitallibrary.un.org/record/436234?ln=fr

Management of hazardous substances in port areas

Series on Chemical Accidents

In June 2023, the OECD organised a seminar series on the Management of Hazardous Substances at Port Areas. The first seminar presented examples from countries on the functioning of their ports with regard to the management of hazardous substances. The second focused on elements of chemical accidents management at port areas. A background report was developed for the seminar series and a survey was conducted amongst WPCA delegations, the goal of which was to collect information on what are perceived as the main challenges to manage chemical accidents risks and safety at port areas and possible means for improvement. This document builds on the background report developed for the seminar series supplemented with the conclusions from the seminars as well as the results from the survey.