FRENSH MINISTRY FOR SUSTAINABLE DEVELOPMENT - SRT / BARPI

ACCIDENTS IN CONFINED SPACES

ARIA 33637 /Source CSB (USA)

ARIA
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INTRODUCTION

Many industrial accidents involve work conducted within confined areas, where the primary risk has been generated by the latent or accidental presence of an either flammable, toxic or simply oxygen-deficient atmosphere [1]. Some persons have died after entering such spaces due to underestimating the risks, while others have succumbed by attempting to rescue those already incapacitated.

Given the lack of awareness relative to these phenomena, a preliminary risk analysis serves to adopt a series of prevention and protection measures, to be implemented as part of an effort to reduce accident occurrence or at least limit harmful consequences.

The objective of this analysis is to build awareness among actors. It relies upon an analysis of 80 illustrative accidents selected from the ARIA database that involve classified facilities. In light of the amount of data available, this synthesis does not purport to provide actual statistical elements, but still allows drawing valuable insight on risks related to confined atmospheres.

The ARIA record numbers included in the body of this report correspond to a partial sample of typical accidents. The summaries of accidents with underlined ARIA numbers in the text have been included at the end of the document. The complete list of summaries for all 80 events selected for this study is available in french on www.aria.developpement-durable.gouv.fr, under the heading «Analysis and feedback».

(1) Risks related to flammable atmospheres have not been covered in this summary; a detailed regulation is devoted to their prevention.

What are confined spaces ?

Composed of a completely-enclosed volume or a volume with limited air circulation and exchanges with the outside, the enclosed or confined space features restricted ingress and egress and is typically not adapted to any kind of permanent human presence, nor has it been designed for such presence.

This space may comprise a required corridor (e.g. air-lock chamber) and accommodate the occasional visit to perform cleaning, maintenance, refurbishment, etc. Such a space is capable of creating risks for individuals spending time inside due to its design, atmosphere or the hazardous materials it may contain.

A wide array of equipment or vessels that require inspection, control or maintenance may be concerned by these risks, including tanks, silos, reactors, pits, wells, sumps or sewer pipes, boilers, furnaces, and chimneys.

What makes an atmosphere hazardous ?

Within a confined space, the drop in oxygen content might stem from several sources:

- an excessive consumption of oxygen due to a «combustion» phenomenon: an electric generating set, motor-driven pump, torch welding, heating... or to technicians' breathing needs in an atmosphere with an insufficient rate of oxygen replenishment;

- an artificial modification to the atmosphere might also result from deliberate actions that consist of:

  - introducing gases «considered» inert, such as nitrogen or CFC in order to inert a given container capacity and thereby limit the risk of explosion by means of lowering the oxygen content (e.g. in reactors, silos, etc.);
  - injecting gases of the same type in order to reduce oxygen content within the space as a step to minimising fire risks (e.g. warehouses);
  - injecting nitrogen to protect against «smouldering fires» in silos for example or introducing combustion inhibitors or retardants of the «halon» or CO_2 type to facilitate eventual fire-fighting on the premises;
  - atmospheric modification might also result from the spurious triggering of corresponding systems (ARIA 35316, 35697).

Air composition and physiological data:

Oxygen: Striking the right balance

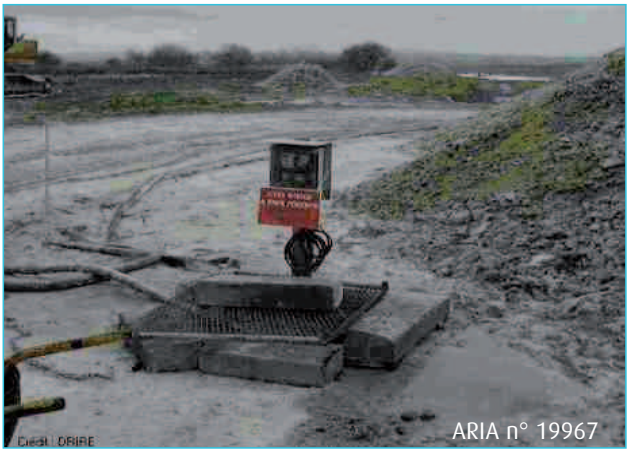
Air contains 78% nitrogen, 21% oxygen and 1% miscellaneous gases (this composition is valid for air at sea level). While not always fatal, a decrease in the oxygen concentration in air can have direct consequences on humans, namely:

- onset of breathing difficulties, loss of the ability to reason and rapid exhaustion starting below 16% oxygen;
- malaises and fainting spells at 12% oxygen;
- death in just a few seconds at 6% oxygen.

In contrast, an atmosphere with artificial oxygen enrichment increases the level of flammability for hazardous materials and, beyond a 23% concentration, causes euphoric effects on humans.

21%	Normal rate
19%	Tolerance threshold
17%	Lower threshold
16%	Breathing difficulties Flame extinction
12%	Fainting
6%	Cessation of breathing

(1) For human activity inside a space with an oxygen concentration of 19% or below, the French Labour Ministry has prepared a set of measures outlining special conditions, including preliminary medical authorisation.



Moreover, the presence or contribution of a toxic gas such as carbon monoxide, carbon dioxide, hydrogen sulphide, chlorine, sulphur dioxide or tetrachloroethylene can originate from combustion, a running heat engine, decomposition, a chemical or biological reaction, the fermentation of organic materials, a leak, or the evaporation of toxic liquids. These situations might also lead to impacts of varying severity for human health, yet still capable of being fatal depending on the type and concentration of the gas as well as on the length of human exposure.

Along the same lines, attention must also be paid to the heightened risk of explosion or fire due to the presence of dust or flammable gas (organic or metallic dusts, methane, butane, hydrocarbon vapours, carbon monoxide, etc.) or due to the release of vapours from the evaporation of flammable liquids.

Beyond these considerations, the site layout could cause additional risks of falling, drowning, electrocution (in silos, vats, tanks, etc.).

Lastly, the eventual difficulties encountered as a result of extreme temperatures (both highs and lows), inadequate lighting, topography or encumbrances (height, narrowness, etc.) must also be taken into account, and not just at the time of human intervention for whatever purpose, but also to ensure that rescue operations can easily gain access to provide assistance and evacuate victims.

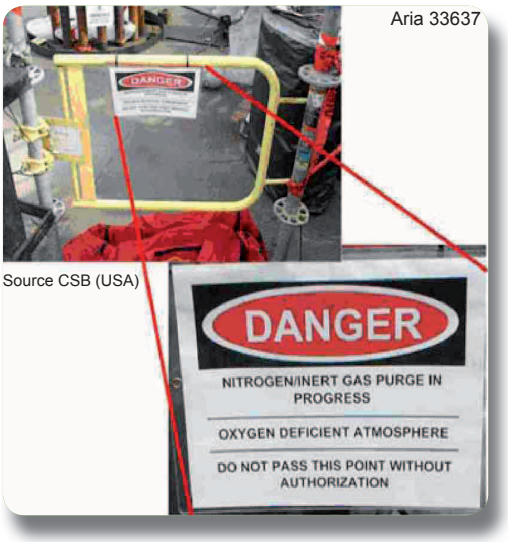
A sample of 80 accidents that occurred both in France and abroad have been extracted from the ARIA database in order to illustrate the two major risks for humans: asphyxiation and intoxication.

a) Sectors of activity involved:

Several sectors seem to be particularly exposed:

- Farming activities, involving the use of tanks and silos associated with the phenomena of normal or accidental evaporation or fermentation (e.g. CO, CH_4, CO_2, alcohol) of organic materials;
- Food processing industries, with a large number of intoxications that point to the ammonia used in refrigeration installations, accidental mixes of incompatible chemical substances (e.g. acid and bleach) and fermentation phenomena (CH_4, H_2S, etc.);
- Chemical processing and refining, with accidents implicating the introduction of nitrogen for inerting purposes or toxic gases (H_2S, NH_3, Cl_2, etc.) used or released during the various processes;
- The collection and treatment of industrial or agricultural wastes, in addition to their associated wastewater networks, with emphasis on the production of gaseous effluent by means of physicochemical reactions or fermentation (notably H_2S).

Gaseous releases might accidentally occur during process implementation, e.g.: anaerobic digestion, water treatment, ripening operations.



b) Human consequences

The victims of these accidents are most often employees: following a major ammonia leak of refrigeration installations in a warehouse, 2 employees were killed and 5 others burned as a result of being trapped in the basement (ARIA 15586); 3 workers were killed by hydrogen sulphide fumes when discharging waste (ARIA 31000).

Subcontracted personnel are also concerned during maintenance work or sampling campaigns carried out within the scope of inspections or controls: a consulting engineer was intoxicated while collecting wastewater samples (ARIA 17761), subcontractors died by anoxia inside a refinery during routine maintenance work (ARIA 33637). Moreover, many casualties can be counted among the company's workforce in attempting to rescue their colleagues without taking necessary precautions (ARIA 25604), or among rescue workers arriving on the scene without being sufficiently informed of the risks they would be facing (ARIA 11506).

The general public is only on rare occasion affected; one example would be the death of a child at a household waste landfill (ARIA 10911).

c) Accidents causes

While physical defects such as leaks (ARIA 15586, 11265, 24858), broken machinery (ARIA 5451) or faulty pipes (ARIA 5989, 30375) in a weakened state are sometimes highlighted as accident causes, organisational breakdowns are far and away the predominant component of the accidental sequences recorded, as exemplified by:

- risk analyses that were never conducted or incomplete, especially prior to undertaking maintenance work (ARIA 24118, 25604), plus unidentified risks of chemical reactions between incompatible substances (ARIA 35), or the anaerobic fermentation of wastes stemming from vegetable and animal sources, household refuse or sludge (ARIA 3681);

- insufficient oversight (ARIA 24118, 33637) and monitoring of works (ARIA 33637), inappropriate installation guidelines or safety measures (ARIA 5989), failure to provide subcontractors with the proper drawings and plans for their assignment (ARIA 17761), poor working conditions for assigned personnel with inadequate safety guidelines, failure to obtain a work permit for confined spaces (ARIA 17761), and incomplete atmospheric controls performed during the works (ARIA 29444);

- lack of communication between technicians or when using subcontracted personnel (ARIA 1547);

- frequent unavailability of safety procedures in the event of an incident, unsuitable protective equipment, and the non-existence of an emergency evacuation plan (ARIA 9370, 15586).

Testimonial

Some process-related risks may not be known to maintenance, relegated instead to the areas of «safety» and «production»; in practice, an all-encompassing approach is necessary before starting any work.

Only after a site inspection with the Head of Safety, identification of all fluid-carrying pipes arriving or crossing the confined space, an atmospheric test and other relevant listed measures have been performed can a work permit be approved by «Safety» and «Production» units as well as the in-house or external crew foremen.

Such organisational deficiencies regarding hazardous equipment guidelines, poorly-planned work assignments, unavailability of adequate tools, and lack of knowledge on the current state of installations also induce errors from individuals that can in turn cause accidental emissions due to improper manoeuvres: valve opening, poorly-closed containers (ARIA 22822, 10820), falls (ARIA 32381, 22971).

III - NECESSARY PRECAUTIONS

The invisible and stealthy nature of dangerous atmospheres often lies at the origin of accidental mechanisms. An effective identification and prevention of these risks must entail a coherent preliminary analysis, coupled with improved knowledge of all the processes or materials being implemented, even sporadically, during specific tasks or more general works.

Moreover, the need to have personnel enter into tight and relatively unventilated spaces must draw management's attention to the tremendous importance of such an analysis as a means of developing an appropriate set of prevention and protection measures.

The conclusions of this preliminary assessment, whose scope is commensurate with the considerable stakes involved, are intended to better inform both the in-house and subcontracted personnel concerned. Successful completion of work assignments conducted in confined spaces necessitates the following steps:

- designate a direct or delegated supervisor;
- establish a risk prevention plan (focusing on oxygen depletion, noxious gases, explosive atmospheres, etc.);
- develop a set of specific procedures for working in confined spaces along with appropriate instructions, and then communicate these elements to site personnel;
- keep a record of all hazardous equipment allocated to the site;
- calibrate the works in terms of space and time, given that the «confined personnel» will not be in visual contact with the outside;
- mark the specific zones and volumes where the work is taking place, display appropriate warning signs, lay out gas detectors with an alarm relay in order to alert personnel;
- provide personnel and rescue teams with well-adapted means of protection: masks in case of gas leaks, insulated breathing units, etc.;
- install all mandatory systems: forced aeration or ventilation, lighting and additional direction signs;
- verify the good working order of this equipment prior to use;
- grant the work permit to employees or subcontractors while stressing upon them the hazards inherent in the facilities and materials implemented onsite;
- indicate to them as well the procedures to follow in case of incident/accident and the resources available as a first response;
- monitor on a permanent basis any worker entering the confined space by at least a second person, who in turn is to be monitored whenever entering the space on a rescue mission;
- inspect the atmosphere both before and during the entire set of works, until the system returns to normal operations;
- adopt a rapid worker evacuation procedure for situations where the risk analysis dictates the necessity.

The involvement of management staff in overseeing the progress of all operations through to final completion, including release of assigned equipment and resumption of installation operations, is required in order to mitigate risks.

IV - BIBLIOGRAPHY

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ARIA 5989 - 01/12/1994 - 60 - RIBECOURT-DRESLINCOURT

20.15 - Production of nitrogen products and fertilizers

In a fertilizer production plant, an ammonia leak injured 3 workers, one of whom died. On December 1st, 1994, the weekly cleaning of the dryer was scheduled. The tubular reactor of this dryer was shut off at 6:25 am then cooled and purged. At 9:30 am, the dryer's ventilation was turned off, while at 9:45, the electrical unit undertook its semi-annual replacement of the inverter protecting the automated production system. This operation consisted of stopping all programmes, cutting the electrical power supply of the in-service inverter, connecting the backup inverter and then reinitialising the programmes. At 10 am, three maintenance workers entered the dryer. All production chains were shut down; two of the workers were cleaning the reactor supply impellers in front of the ammonia injection nozzle, while the third was inspecting the hot gas intake upstream of the injection nozzle. At 10:30, the automatic valve controlling ammonia injection into the dryer opened. The gas contained inside the pipe running between the automatic valve and a manual valve, which was closed at the time and located approx. 10 m upstream, was released. One worker was able to escape via the dryer supply chute after passing underneath the injection nozzle, while the two others facing the nozzle tried to reach the dryer access hatch located 25 m away. Only one of these two was able to get to the hatch and exit the dryer. After scrambling less than 10 m, the second man tripped. Wearing a mask, the maintenance foreman evacuated the crew member unable to advance (within 3 min). All three men complained of facial burns and breathing difficulties and were taken to hospital. One was slightly affected by the exposure, the second more seriously, while the worker who fell died 6 days later subsequent to the pulmonary burns he had sustained. The accident was due to poor coordination of these maintenance works, since the semi-annual replacement of inverters and the weekly cleaning, performed by two different teams, should never have been carried out simultaneously. Upon completion of the inverter replacement operation, the step of reinitialising the automation programmes had caused the two automatic valves controlling ammonia and phosphoric acid injection inside the dryer to open. The workers were verifying that pipes had successfully drained using a manometer, which was only able to indicate the pressure drop but under no circumstances could confirm that the pipe had been fully drained. When the valve opened, the quantity of ammonia left in the pipe (approx. 5 litres) was released. Following this accident, an additional valve was installed at the entrance to the reactor upstream of the automatic valve. In addition, specific guidelines were introduced that mandated: prohibition of all simultaneous operations; a 1-hour purge of the pipe between the two valves; modification of computer programmes to ensure that no valve could remain open during the re-initialisation sequence; and placement of a full seal after the manual valve during onsite work. Lastly, a thorough study of the plant's safety systems was planned.

ARIA 10820 - 19/01/1997 - 78 - CHATOU

96.01 - Laundry - dry cleaners

During start-up of one of the dry cleaning machines operated on a self-service basis, a customer smelled a strong odour and notified the shop manager. Perchloroethylene was seeping onto the floor underneath the machine. The manager shut down the facility, soaked up the solvent with a sponge and died 10 min later. Fire-fighters arriving on the scene spread absorbent products and ventilated the premises. A quarter-turn bleed valve on the solvent tank had been accidentally left open during a maintenance service call performed by an outside professional. When the machine was re-started, the circulation pump emptied the tank in spraying a pressurised stream of perchloroethylene (100 litres) outside of the retention area. The accident was caused by design flaws on the installation as well as by inadequate personnel training.

ARIA 10911 - 10/04/1997 - 48 - MENDE

38.11 - Collection of non-hazardous wastes

A child collecting scrap metal at a household waste landfill fell into a discharge nozzle 1 m in diameter and 10 m deep. The child was asphyxiated by a strong hydrogen sulphide concentration. In trying to save the victim, an adult passed out and died shortly after being hospitalised. A court prosecutor and the local gendarmerie carried out an investigation to determine the corresponding liabilities.

ARIA 11506 - 21/03/1997 - CANADA - MONTREAL

15.1A - Production of meats for butcher shops

In a meat-packing plant, a crate while falling broke a heat-insulated pipe. The refrigeration unit emptied (in 30 min) and ammonia spread throughout the basement zone. An employee trapped in the space (due to bars placed on window openings) died from intoxication and burns. Unaware of the presence of NH3, the rescue teams brought with them inappropriate gear. The rescue mission lasted 90 minutes, with in all 19 employees and 5 fire-fighters being burned and intoxicated to a point of requiring hospitalisation. A poorly-located storage area, a corroded unprotected pipe, the lack of alarms / evacuation plans and the facility's internal layout (partially hidden emergency exits, etc.) all caused or exacerbated the accident conditions. A committee of experts was asked to submit recommendations (administrative monitoring of refrigeration, use of NH3, inter-organisational emergency response plan).

ARIA 15586 - 03/12/1968 - 69 - LYON

63.1D - Refrigerated warehousing

A major ammonia leak occurred on the refrigeration installations during defrosting of the air cooler in the cold storage rooms of a warehouse containing foodstuffs. Trapped in the basement, 2 employees died while trying to escape by a freight elevator (purposely blocked in order to simplify handling?) and 5 others were burned to varying degrees. An expansion plug (diameter: 93 mm, thickness: 4 mm, weight: 191 g), welded 10 years prior, had broken off from the end of a pipe (diameter: 82/89 mm, disused yet still not disassembled) leading into a corridor. The NH3, which was heated (due to the defrosting operation), arriving onto a cold pipe wall created thermal stresses and caused fatigue rupture of the plug. Such a sequence was facilitated by a lack of bond between the metal removed and the base metal. The pipes were inspected so as to eliminate welds and all questionable assemblies. As a result of this accident, defrosting guidelines were modified (limited number of workers present, access to premises prohibited, etc.). Moreover, the emergency exits were renovated and the personnel was equipped with appropriate protective gear.

ARIA 15747 - 30/07/1985 - 69 - SAINT-FONS

37.00 - Wastewater collection and treatment

During an unannounced spot inspection, a technician working with an external organisation was severely intoxicated, undoubtedly as a result of hydrogen sulphide fumes after entering through the sewer line without alerting the treatment plant operator. A second technician was also intoxicated in trying to rescue his colleague. Both inspectors were saved in the nick of time.

ARIA 17761 - 05/05/2000 - 74 - ALLONZIER-LA-CAILLE

51.2E - Wholesale of live animals

A young female employee working with a consulting firm, which for two weeks had been sampling wastewater in a knackery, died from asphyxiation and pulmonary oedema 5 min after entering a 2-m deep manhole located 100 m from the facility. Rescue personnel onsite after the accident measured a hydrogen sulphide concentration in excess of 120 ppm, i.e. more than 10 times the threshold authorised under the labour code for 15-minute exposure. The court prosecutor conducted an investigation in order to identify the exact causes and circumstances surrounding the accident. The manhole was sealed shut while awaiting conclusions of the ongoing enquiry. The plant had not established any procedures (reception, prevention, safety, onsite guidelines, etc.) intended for subcontractors, nor was any protocol or permit set up for personnel to enter and work in a confined space. The victim was not wearing an airtight outfit.

ARIA 19967 - 15/02/2001 - 50 - BAUPTE

10.89 - Production of other foodstuffs (not elsewhere classified)

Gases with hydrogen sulphide (H2S) contents killed 2 employees at a plant producing algae-based natural food additives. The insoluble fractions stemming from the extraction of gelling agents with no direct usability were being treated on a porous soil (composed of perlite) and then pressed. The filter cakes were leached (to dissolve the salt) over a 0.5-ha zone prior to composting. The drippings were channelled into two sumps, one of which was fitted with an accelerator pump for the in-plant treatment of effluent. The discharge hose separated at times, thus requiring that the sump be drained and the pump be adjusted. The two employees were performing this task when the accident occurred. The warning was sounded 3 hours later, once it was confirmed that the two men had not returned; both of them would be found at the bottom of the sump. H2S concentrations in excess of 500 ppm were measured. The gendarmerie conducted an investigation into the matter, supported by an expert appraisal. This type of accident often goes underestimated and can arise from any anaerobic fermentation of sludge or compost in the presence of cavities that allow gas to accumulate in confined spaces. High contents (6,000 ppm and above) can overwhelm personnel to the extent that the sense of smell is lost and fainting happens almost instantaneously. In this case, heavy rainfall had prevented handling the accumulations and stimulated the formation of H2S; the proportion of soluble gas in the effluent created an additional hazard. The piping was altered to avoid access to the sump; furthermore, supervision of the filter cakes was optimised.

ARIA 24118 - 27/02/2003 - 93 - ROMAINVILLE

24.4A - Manufacturing of basic pharmaceutical products

In a sterile room of a pharmaceutical plant, a technician became unconscious while validating the cleaning phase on a reactor. This 32 year-old technician, who had been working in the room for 7 years, entered into the reactor used for synthesising antibiotics and corticosteroids without first checking out the equipment (which entails electrical and mechanical deactivation of all moving parts and verification of the breathable and non-explosive atmosphere). He lost consciousness from anoxia due to the nitrogen inerting and after inhaling solvent vapours present inside the reactor. The employee was hospitalised in very critical condition (therapeutic coma) but died 19 days later. Afterwards, the operator made a point of reminding personnel at all sites of the rules for entering confined spaces, in addition to the existence of EHS management system tools intended to identify any and all discrepancies. The police and labour inspection officials led the follow-up investigation.

ARIA 31000 - 08/11/2005 - GERMANY - RHADEREISTEDT

38.22 - Treatment and disposal of hazardous wastes

At a site specialised in recovering biogas from organic waste, hydrogen sulphide (H2S) fumes killed 3 employees along with a truck driver who had arrived at the site to unload slaughterhouse waste. Another person was seriously intoxicated and required hospitalisation. The extremely high H2S concentration inside the dock area slowed the response time of fire-fighters, about ten of whom suffered varying degrees of intoxication. An extended ventilation period (more than 24 hours) was necessary before authorising re-entry into the building. As dusk fell, the truck arriving from the Netherlands parked in front of the facility until the following morning. The tragic event unfolded while the truck's contents were being unloaded in a dock area, closed in order to keep the foul smell from spreading, into a 100-m³ pit equipped with 2 stirrers and whose lid had to remain open due to malfunction of the electric motor used for activation. The unloaded materials, in the form of liquid wastes high in sulphur content, with pH near 8.5 and at a temperature of 60°C, were pig intestines and organs; they had been loaded onto the truck 24 hours prior and were similar to the kinds of waste typically delivered once or twice a week by the slaughterhouse. The reaction between these substances and the materials already present in the pit (animal waste or dairy residue, with a relatively low pH according to post-accident analyses) would have caused a strong release of H2S. Both the temperature of the container and the stirring action facilitated dispersion of the toxic gas throughout the dock area. Moreover, the venting mechanism located at the bottom of the pit, responsible for discharging foul air to the outside via a biological filter, had been improperly assembled. A follow-up investigation was conducted.

ARIA 31863 - 12/06/2006 - 78 - POISSY

81.29 - Other cleaning activities

During scouring of a settling tank within the city of Poissy's sewer network, three utility employees, ranging in age from 22 to 44, died and a fourth was severely injured, most likely subsequent to the release of hydrogen sulphide (H2S) gas. Twice a year, a crew of four working with a sanitation and public works company were responsible for cleaning the settling pit for the «La Collégiale» urban district. This operation consisted of suctioning the contents of the 30-m3, 5-m deep pit into trucks for the purpose of extracting sludge and other waste. According to the company, which had been under contract with the City for 20 years, this preventive maintenance step, which got underway at 9:30 am, was intended to guarantee the smooth flow of wastewater through the sewer system. Around 10 am, three members of the work crew abruptly succumbed to intoxication (according to a first responder) as the crew probably reached a pocket of H2S gas, which was highly toxic given its formation from decomposed organic materials. The fourth worker, who was the 48 year-old father of one of the fatal victims and happened to be positioned slightly further back, was in serious condition and had to be transported to hospital. Once a passer-by was able to relay the alert, a team of nearly 50 fire-fighters, accompanied by some 20 emergency vehicles, showed up at the site in the company of four medical rescue teams. Two enquiries were undertaken, one judicial the other organised through the labour inspection office, which sought to verify whether all protocols required for this type of assignment were in fact being respected. The company's management indicated that its sanitation technicians were specially trained to work in confined atmospheres and moreover that they were operating with atmospheric controllers as well as emergency respirator masks. An autopsy was ordered by the court prosecutor in order to identify the exact reasons for the three deaths.

ARIA 32459 - 05/11/2006 - 45 - EPIEDS-EN-BEAUCE

YY.YY - Undetermined activity

Carbon monoxide (CO) fumes seriously intoxicated a professional painter working in an enclosed space; 8 fire-fighters and 4 others sustained less severe exposure. This collective intoxication was once again due to malfunction of an electric generating set operating in a confined space.

ARIA 33637 - 05/11/2005 - UNITED STATES - DELAWARE CITY

19.20 - Oil refining

Two technicians working with a subcontractor died from anoxia in a refinery while carrying out maintenance work on a down reactor that was part of a hydrocracking unit.

One of the technicians descended (or perhaps fell?) into a reactor filled with a nitrogen atmosphere in order to recover a roll of adhesive tape left inside and lost consciousness. The second employee on the exterior platform climbed down into the reactor to rescue his colleague and became unconscious as well. A third technician on the scene sounded the alarm. The emergency response team arrived in approx. 10 minutes, each wearing a self-contained breathing apparatus, and evacuated the two victims who could not be resuscitated. The oxygen content inside the reactor, as measured by rescue personnel, was less than 1%.

The follow-up investigation pointed to inadequate warning signage (absence of any signs indicating «risk of asphyxiation due to a nitrogen atmosphere» or barriers blocking access to the opening leading inside the reactor), an erroneous work permit with no mention of the presence of nitrogen in the reactor and a lack of information and training provided to personnel on the inherent hazards associated with oxygen-deficient spaces.

ARIA 35697 - 08/11/2008 - RUSSIA - VLADIVOSTOK

84.22 - Military defence

Aboard a submarine conducting tests, a fire protection device was accidentally triggered around 6 pm, releasing a chloro-fluoro gas. The refrigerant did not reach the nuclear part of the vessel, yet still spread quickly into two of the six submarine compartments: 17 civilians and 3 marines fatally succumbed, and 21 others were intoxicated to varying degrees. According to authorities, a defect in the fire protection system would have caused the accident. Some crew members were sleeping at the time. The consequences of this accident were also exacerbated due to the presence of 208 people (including 120 naval engineers and workmen) aboard a vessel normally designed to carry 73 officers; a former marine noted that the lack of experience among civilians on board in the use of oxygen masks might explain the high number of casualties.

TECHNOLOGICAL ACCIDENTS ONLINE

Safety and transparency are two justifiable requirements of our society.

Therefore, since June 2001 the website www.aria.developpement-durable.gouv.fr of the Ministry for ecology, energy, sustainable development and the sea has been giving lessons learnt from the analysis of technological accidents to professionals and general public. The main sections of the website are presented both in French and in English.

Under the general sections, the Internet user can, for example :

inquire for the state's action, access to wide extracts of the ARIA database, discover the presentation of the European scale of industrial accidents, inquire for the parameter concerning the dangerous substances used to complete the "on the spot communication" in case of accident or incident.

Accidents description, which is the raw material of any method of experience feedback, constitutes an important part of the ressources of the site : event, consequences, origin, circumstances, established or presumed causes, actions taken and lessons leamt.

Hundred detailed and illustrated technical reports present accidents selected for their particular interest. Numerous analysis grouped by technical subjects or by activities are also available. The section dedicated to the technical recommendations develops various topics : fine chemistry, pyrotechnics, surface treatment, silos, tyre storage, fire license, waste treatment, handling ... A multicriteria research engine enables reaching information about accidents arisen in France or abroad.

The website www.aria.developpement-durable.gouv.fr grows richer constantly. Currently, more than 35 000 accidents are online and new topics will be regularly added.

The summaries of the accidents presented in this document are available in french at:

www.aria.developpement-durable.gouv.fr

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