OSHA®
Fact Sheet

Shipyard Employment

Hazards during the Repair and Maintenance of Refrigeration Systems on Vessels

The repair and maintenance of refrigeration systems can present hazards to both workers servicing these systems and those in the general area. The two main types of hazardous refrigerants used in vessel refrigeration systems are **ammonia** and **halocarbons** (the most commonly recognized is Freon®). The latter include chloroflourocarbons (CFCs), hydroflourocarbons (HFCs), and hydrochloroflourocarbons (HCFCs), such as chlorodifluoromethane (R-22) or difluoromonochloromethane (R-134A). Worker exposure to these compounds may occur during maintenance and repair activities, or as a result of leaks. Depending on which refrigerant is used, different precautions may be required.

Ammonia

Ammonia, in liquid or gas form, can present hazards to workers' skin, eyes, nose, and lungs. Liquid ammonia is a clear fluid that evaporates quickly at room temperature. As a gas, ammonia is colorless and has a strong odor that is suffocating, pungent, and penetrating. It is much lighter than air, so if ammonia gas escapes from a refrigeration system or a storage container, it may collect in high areas or ceilings. Liquid releases can form aerosols that may tend to accumulate at low points. Therefore, it is important to take atmospheric readings at various locations within a space to ensure that it is safe for workers.

While ammonia has a low odor threshold (as low as 2 ppm), which makes it easy to detect even in low concentrations, workers who have been exposed to ammonia regularly (or repeatedly) may experience a significant reduction in their ability to detect ammonia by smell. Exposure to ammonia at 300 ppm is immediately dangerous to life and health. Where there is a potential for overexposure to ammonia, employers must provide workers with proper safety equipment and ensure its use (29 CFR 1915.152(b)). Personal protective equipment (PPE) should be used when there is a possibility of exposure above 50 ppm. See 29 CFR 1915.154 (29 CFR 1910.134) for detailed information on proper respiratory protection. Ammonia is flammable at all concentrations and explosive between 15% and 28% (150,000 - 280,000 ppm) in air. If ammonia is released in an enclosed space with an ignition source, an explosion may occur.

Photos: Amy Sly, Sound Testing, Inc.

Examples of refrigeration systems aboard vessels.

Employers with systems containing 10,000 pounds or more of ammonia must follow the requirements in 29 CFR 1910.119 (Process Safety Management of Highly Hazardous Chemicals) for controlling hazards associated with a release of ammonia.

Employers must: [1]

- Identify hazards through a process hazard analysis and ensure that they are controlled to protect workers (29 CFR 1910.119(e)). The hazard analysis must be revalidated at least every five years (29 CFR 1910.119(e)(6)).
- Develop and implement written operating procedures for workers on vessels to follow based on the results of a detailed hazard analysis (29 CFR 1910.119(f)(1)). OSHA requires that these procedures be reviewed as often as necessary and certified as current and accurate at least annually (29 CFR 1910.119(f)(3)).
- Verify that refrigeration equipment complies with good engineering practices and that it is operated in a safe manner (29 CFR 1910.119(d)(3)(ii), (iii)).
- Train maritime workers on the safety and health hazards associated with using ammonia, on emergency operations (including shutdown), and on safe work practices that apply to their job tasks (29 CFR 1910.119(g)(1)(i)).
- Check on each worker who works alone at regular intervals by sight or verbal communication, including at the end of the job assignment or workshift, whichever occurs first (29 CFR 1915.84).

Common Exposure Thresholds for Ammonia

Range	Hazards
2–55 ppm	Normal range of odor threshold *Note: If the smell of ammonia is detected and/or you experience eye irritation, leave the area immediately and notify the appropriate person.*
70 ppm	Tingling or burning in eyes, nose, or throat; can cause watering of eyes, sneezing, and coughing
300 ppm	Severe irritation of eyes, nose, or respiratory tract, which becomes intolerable after a few minutes; difficulty breathing; possible burning in lungs (IDLH level)
2,000 ppm or more	Can be fatal after a few breaths

[1] The Process Safety Management standard has 14 enforceable elements. This summary highlights certain key requirements of 29 CFR 1910.119, but employers covered by the standard must comply with all 14.

For additional information on worker safety when exposed to ammonia see:

- OSHA Safety and Health Topics Page – Ammonia Refrigeration
- OSHA eTool - Ammonia Refrigeration

Halocarbons

The use of certain halocarbons (CFCs and HCFCs) is being phased out in the United States, although it is expected that these refrigerants will not be fully removed from use until around 2030. In addition to trying to use alternative refrigerants that are safer for workers and the environment, employers still must assess work activities to determine if such hazards are present, or are likely to be present (29 CFR 1915.152(b)). Where a workplace assessment determines that using PPE is necessary, the employer must equip affected workers with the type of PPE that will protect them from the identified hazard(s) and explain its selection in a manner that each worker understands (29 CFR 1915.152(b)(1) and (2)).

Halocarbons, which exist both as a liquid or gas, are not easily ignited and do not burn rapidly if ignited. Halocarbons are heavier than air, which can lead to asphyxiation in a confined space due to the displacement of oxygen. As a liquid, many of these colorless compounds are volatile and give off vapors with a faint sweet odor. Overexposure to halocarbons can cause dizziness due to the lack of oxygen, which is a warning sign of the onset of asphyxiation. At higher exposure levels and with long periods of worker exposure, central nervous system depression, cardiac arrhythmia, and death may result.

When performing hot work in the presence of halocarbons, decomposition products such as hydrochloric acid (HCl), hydrofluoric acid (HF) and carbonyl halides may form. These compounds can be toxic at very low concentrations. All hot work should be stopped during any halocarbon refrigerant leak to prevent worker exposure to such toxic compounds, as well as the risk of fire or explosion.

Numerous halocarbon refrigerants are used in cooling systems and new, more environmentally friendly compounds are constantly being developed. Many of the newer halocarbon refrigerant replacements do not have Permissible Exposure Limits (PELs). Depending on the refrigerant used, employers should consult the PELs listed in 29 CFR 1915, Subpart Z, or the manufacturer's Safety Data Sheet (SDS). Some common halocarbons used as refrigerants include dichlorodifluoromethane (R-12), dichlorotetrafluoroethane (R-114), and trichlorofluoromethane (Freon 113). These specific compounds are assigned a PEL of 1,000 ppm. Refer to their common exposure thresholds below.

Common Exposure Thresholds for Halocarbons (R-12, R-114, and Freon 113)	
Range	**Hazards**
1,000 ppm	Normal range of odor threshold
75,000–100,000 ppm	Agitation and dizziness
200,000 ppm	Drowsiness, or unconsciousness
300,000 ppm or more	Can be fatal after just a few breaths

Safety Requirements and Recommended Best Practices for Ammonia- and Halocarbon-Based Systems

- Employers must provide and ensure that workers use appropriate protective equipment (such as impervious clothing, gloves, splash-proof safety goggles, face shields - eight-inch minimum) to prevent repeated or prolonged skin contact with liquid refrigerants (29 CFR 1915.152(a)).
- Employers must provide and ensure that workers wear appropriate respiratory protection determined to be necessary by a workplace hazard analysis (29 CFR 1915.152(b) and 1915.154 (see 29 CFR 1910.134). Where atmospheric conditions are immediately dangerous to life or health (IDLH), such as during a leak, employers must provide workers with appropriately protective supplied-air respirators or escape-only respirators that meet the requirements of 29 CFR 1910.134(d)(2). Air-purifying respirators, which would not adequately protect workers in IDLH atmospheres, may not be used.
- When workers' responsibilities include responding to a possible refrigerant leak, employers must have a written emergency response plan in place (29 CFR 1910.120(q)(1)). The plan must include an explanation of worker personnel roles, lines of authority (including designation of a "senior official"), necessary training, communication protocols, and PPE (see 29 CFR 1910.120 (q)(2)(i) through (q)(2)(xii), and (q)(3)(i)).
- Note: All ignition sources must be secured and effective ventilation installed to rid the area of refrigerant vapors (29 CFR 1915.12(b)(2)). Unprotected personnel may not return to the affected area, especially bilge areas, until the atmosphere has been tested and the space is determined to be safe (29 CFR 1915.12(b)(3)).
- Verify atmospheric safety, using a detector tube or other appropriate instrument, to ensure that no dangerous level of halocarbon or ammonia is present (29 CFR 1915.12(b)).
- In the event that a refrigerant leak occurs and there is no immediate way to identify or reasonably estimate worker exposure to the potential respiratory hazard, employers must consider the atmosphere to be IDLH and initiate the appropriate emergency procedures necessary (29 CFR 1910.134(d)(1)(iii)).
- Use mechanical ventilation to bring concentrations of airborne refrigerants within the Permissible Exposure Limit (PEL)/Recommended Exposure Limit (REL) (29 CFR 1915.12). If concentrations are still above an acceptable level, proper respiratory protection must be provided (29 CFR 1915.154 (see 29 CFR 1910.134)).
- Ensure that all refrigerant, including vapor, is removed and that the pressure is at 0 psig before disassembling a refrigeration system.
- Before hot work is performed on refrigerant lines, they should first be purged using inert gas to reduce combustion and toxicity hazards. The work area must then be tested and certified by a Marine Chemist or a U.S. Coast Guard-authorized person as "Safe for Hot Work" (29 CFR 1915.14(a)(1)).
- When repairs are completed, retest the lines to determine if the leak was successfully repaired. If the repairs do not stop the leak, shut down the unit until it can be properly repaired.
- When refrigerants are stored in compressed gas cylinders, workers should handle them with extreme caution, as there is the potential for frostbite due to escaping liquid refrigerant. If liquid refrigerant comes into contact with a worker's skin, wash the exposed area immediately with water and treat the skin for frostbite. Liquid leaks can produce extremely large volumes of vapor upon release, presenting toxicity and/or fire and explosion hazards.
- Refrigerants kept in pressure vessels, drums or containers must be stored a safe distance from an open flame, hot metal, or other sources of artificial heat that may lead to an explosion (29 CFR 1915.173(c)).
- Evaluate the location and interaction of refrigeration systems with other equipment to identify potential hazards such as fire or explosion (29 CFR 1910.120(c)(7)). For example, there is a greater potential for an ignition source to be located in a main propulsion room than in an auxiliary machine space.

Workers' Rights

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary the worker understands) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.

- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation, including reporting an injury or raising health and safety concerns with their employer or OSHA. If a worker has been retaliated against for using their rights, they must file a complaint with OSHA as soon as possible, but no later than 30 days.

For additional information, see OSHA's Workers page.

How to Contact OSHA

For questions or to get information or advice, to report an emergency, fatality, inpatient hospitalization, amputation, or loss of an eye, or to file a confidential complaint, contact your nearest OSHA office, visit www.osha.gov or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

For assistance, contact us. We can help. It's confidential.

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: 1-877-889-5627.

DSG FS-3836 11/2015