Hydrogen Sulphide (H_2S) Knockdown: A Fatal Risk Beyond Enclosed Space Entry

ICHCA SAFETY ALERT

Recent research and analysis into H_2S hazards, independently initiated and funded by Vistrato Limited as part of its maritime safety and product-development programme, was undertaken by Technical Director Capt. Kevin Cribbin. Vistrato subsequently submitted its paper to the International Maritime Organization (IMO) through IBTA, with IFSMA and the Nautical Institute as co-sponsors. This Safety Alert also draws on Safety Alert 26-1 issued by the Bahamas Maritime Authority[i] to highlight a serious and potentially under-recognised hazard affecting ships and maritime operations worldwide: fatalities resulting from hydrogen sulphide (H_2S) "knockdown".

What is H_2S Knockdown?

An exposure to a high concentration of hydrogen sulphide can cause sudden collapse after only one or two breaths. A person may become unconscious before they have time to react, escape, raise the alarm or use emergency equipment.

While hydrogen sulphide is a well-known toxic gas hazard associated with enclosed spaces, the analysis identified numerous fatalities occurring outside enclosed spaces, such as during routine inspection, maintenance and cargo-related activities. In several of these cases, the victim did not intend to enter the space and may have been overcome within seconds of opening a tank, removing a cover, or disturbing equipment containing contaminated liquids or residues.

For ports, terminals, marine services providers, surveyors, inspectors, contractors and ship operators, the lessons are important.

You do not have to enter an enclosed space to be exposed to hydrogen sulphide risk

Fatal exposures have occurred while opening tanks, removing covers, disconnecting pipework, conducting inspections and carrying out other routine tasks.

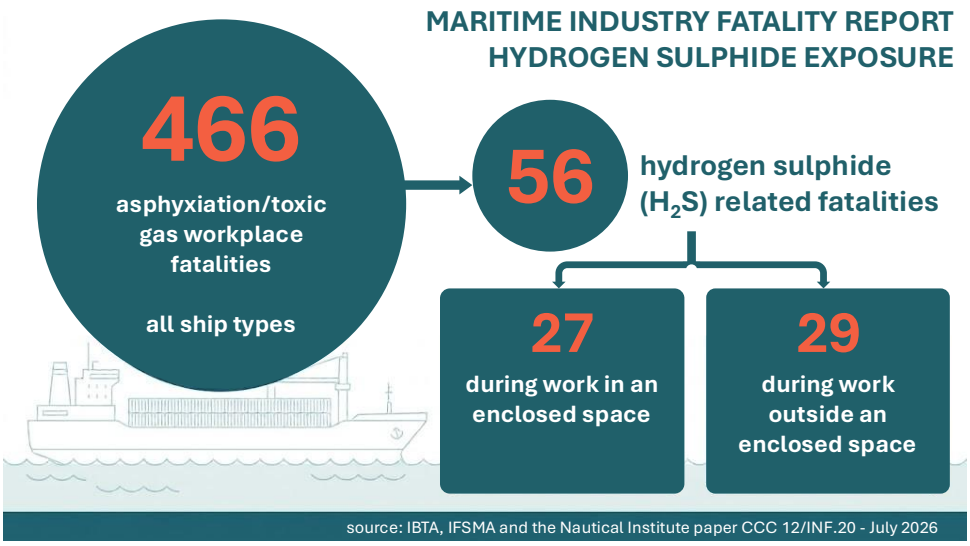
What is Hydrogen Sulphide?

Hydrogen sulphide (H_2S) is a highly toxic gas generated by the decomposition of organic material in oxygen-deficient environments.

Potential maritime sources include:

- cargo residues
- slops and oily residues
- bilges
- ballast tanks contaminated with organic material
- sewage and grey water systems
- food waste systems
- fuel oil and bunker tanks containing water contamination
- pipelines, pumps and treatment systems handling
- contaminated liquids

Hydrogen sulphide is colourless and may be present without warning. At higher concentrations, the gas can rapidly deaden the sense of smell, making reliance on odour detection particularly hazardous.



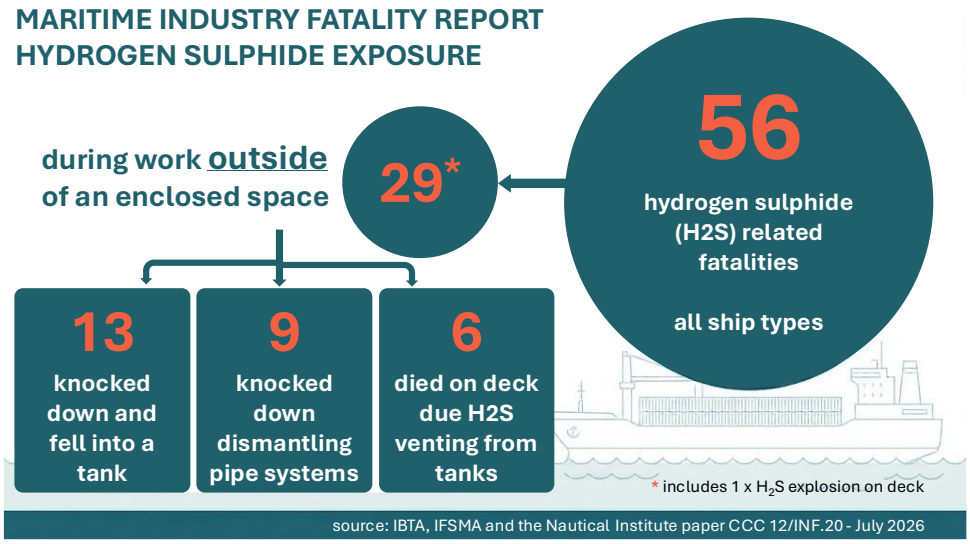
H_2S "Knockdown"

Unlike many toxic atmospheres where symptoms may develop progressively, exposure to very high concentrations of H_2S can result in immediate unconsciousness, potentially after only one or two breaths. Victims may collapse where they stand, fall from height, fall into tanks or suffer fatal injuries during the fall itself.

The paper to IMO reports numerous cases where personnel:

- collapsed while opening tank manholes
- fell directly into tanks they had just opened
- were overcome while dismantling pumps or pipelines
- collapsed on deck due to venting gases
- became casualties while attempting rescue

Of the 56 H_2S-related fatalities identified in the study, 29 occurred outside enclosed spaces or piping systems, demonstrating that workers may be exposed before entering a space or even while conducting external activities.



Impact for Ports and Terminals

Although many documented incidents occurred onboard ships, the underlying conditions that generate H_2S may also be encountered during certain port, terminal, ship repair and ship-shore interface activities.

Activities potentially exposed to this risk may include:

- opening tank access covers
- ship inspection activities
- cargo tank and ballast tank inspections
- slops handling
- waste reception operations
- bilge management
- sewage and grey water system maintenance
- pipeline disconnection activities

- tank cleaning operations
- bunker-related maintenance
- marine survey work
- terminal tanker operations
- ship repair and dry dock activities
- work involving food waste, sludge or
- contaminated wastewater

The ship-shore interface may be vulnerable where terminal personnel, surveyors, contractors and service providers are involved in vessel inspections, maintenance or cargo-related operations.

Situations Requiring Particular Attention

The cases identified by IBTA, IFSMA and the Nautical Institute draw attention to :

- opening manholes or access hatches
- breaking containment on any pipework
- disconnecting hoses or valves
- draining tanks, bilges or pipelines
- disturbing stagnant liquids or residues
- working near vents from tanks or treatment systems
- inspecting spaces that contain organic residues
- or wastewater

A hazard may still exist even when:

- the space is not being entered
- no odour is apparent
- previous gas tests were satisfactory
- the operation is considered routine

Key Lessons from Fatalities

IBTA, IFSMA and the Nautical Institute analysis highlights several recurring themes:

Exposure can occur unexpectedly

Victims did not have to enter the hazardous space. In some cases exposure occurred immediately when a hatch, manhole or system was opened.

Routine tasks can become high risk

Incidents occurred during normal inspection, maintenance or cleaning activities rather than during unusual operations.

Rescue attempts can create additional casualties

Several incidents involved multiple fatalities when co-workers attempted to assist without understanding the atmospheric hazard.

H_2S sources may be overlooked

The generation of hydrogen sulphide may occur in systems not traditionally viewed as high-risk, including bilges, grey water systems, sewage systems and tanks containing oily residues mixed with water.

Practical Risk Controls

The responsibility for managing H_2S risk rests principally with the dutyholder. Organisations should adopt a hierarchy of controls approach, seeking first to eliminate the hazard or prevent exposure where practicable. Where elimination is not possible, risk should be reduced through a layered combination of design, engineering and operational controls. Priority should be given to measures that create safe conditions and separate people from the hazard, rather than relying primarily on procedures, worker behaviour or personal protective equipment (PPE).

1. Eliminate or Reduce the Hazard at Source

The most effective control is to prevent the generation, accumulation or release of hydrogen sulphide in the first place.

Dutyholders should consider:

- preventing the accumulation of organic residues, sludge, wastewater and other materials that may generate H_2S.
- reviewing cleaning, flushing and maintenance regimes for tanks, bilges, pipelines and waste systems.
- minimising stagnant liquids and deposits where decomposition can occur.
- recognising that mixtures of seawater, oily residues and organic materials may create conditions for significant H_2S generation.
- identifying whether alternative maintenance approaches can be used that avoid opening systems containing potentially contaminated residues.

The safest exposure is no exposure.

2. Design and Engineering Controls

Where H_2S generation cannot be eliminated, priority should be given to preventing exposure through engineering and physical controls.

Examples may include but are not limited to:

- designing work to avoid personnel being positioned directly over manholes, vents, openings or breaking-containment points.
- using remote opening, sampling or inspection arrangements where practicable.
- providing mechanical ventilation before opening tanks or systems where H_2S may have accumulated.
- establishing physical barriers or exclusion zones around tank openings, vents and work areas where gas release may occur.
- ensuring hazardous atmospheres are dispersed away from workers, contractors and bystanders.
- reviewing system design and maintenance arrangements to minimise the potential for trapped contaminated liquids within pipes, pumps and treatment systems.

The objective should be to separate people from the hazard rather than relying on them to detect or avoid it.

3. Safe Work Planning and Control of Operations

H_2S knockdown events have occurred during planned maintenance, inspection, cleaning or cargo-related activities.

Controls may include but are not limited to:

- identifying tasks involving tank opening, system entry, breaking containment, pipeline disconnection or disturbance of residues
- assessing whether H_2S may be generated, present or suddenly released
- incorporating H_2S release scenarios into work planning rather than focusing solely on confined space entry risks
- ensuring permits, risk assessments and job plans consider personnel working outside spaces as well as those intending to enter them
- controlling access to affected areas, preventing unnecessary personnel exposure
- coordinating activities between vessel, terminal, contractor and service provider personnel and ensuring a shared understanding of the hazard

The critical question should not simply be "Is anyone entering the space?" but also: "Could anyone be exposed when the space or system is opened?"

4. Atmospheric Monitoring and Verification

Atmospheric monitoring should be viewed as one layer of protection within a broader risk control strategy. Dutyholders should consider:

- selection of gas detection equipment suitable for the anticipated hazards
- the operating limits and detection ranges of monitoring equipment
- high concentrations of H_2S may develop rapidly and may exceed the capabilities of some instruments
- use of monitoring to support decision-making, not as a substitute for hazard elimination or engineering controls
- establishing monitoring arrangements before disturbing tanks, bilges, pipelines or other potentially contaminated systems

Monitoring can provide important information about conditions, but it does not remove the hazard.

5. Competence, Information and Supervision

Training, awareness and supervision remain important, but should support higher-level controls rather than replace them. Training may include but is not limited to:

- understanding that H_2S is not solely an enclosed space hazard
- recognising the kinds of tasks/operations that may result in sudden H_2S release
- understanding the potential for immediate incapacitation or "knockdown"
- creating awareness of the dangers associated with unplanned rescue attempts
- role-specific information relevant to the activities and workplace

A competent workforce is better able to work safely within a system that has already been designed to control risk.

6. Emergency Preparedness and Rescue

Because H_2S knockdown can occur suddenly and incapacitate workers within seconds, arrangements for emergency response should be established before work begins. Controls may include but are not limited to:

- developing response plans for potential H_2S exposure incidents.
- preparing retrieval and rescue arrangements appropriate to the task/conditions
- ensuring emergency responders understand the risks presented by hazardous atmospheres

- reinforcing procedures that prevent impulsive rescue attempts which may create additional casualties
- routinely reviewing and exercising emergency arrangements

Emergency response is a necessary layer of defence, not the primary means of controlling risk.

7. Personal Protective Equipment (Last Line of Defence)

PPE should be regarded as the final layer in the hierarchy of controls.

Where a residual risk remains after other measures have been applied, organisations should determine whether respiratory protective equipment or other PPE is required and ensure it is:

- appropriate for the identified hazard.
- correctly selected, maintained, tested and worn
- supported by training and supervision
- integrated into the wider risk management strategy

PPE is not a substitute for eliminating hazards, preventing releases or controlling exposure through engineering measures.

Conclusion

Hydrogen sulphide knockdown can create risk inside and in some circumstances even before someone enters a confined/enclosed space. Dutyholders should consider reviewing whether their current risk assessments, procedures and control measures adequately address the potential for H_2S release during inspection, maintenance, cargo handling and other activities.

With thanks and appreciation of the IMO, Bahamas Maritime Authority, IBTA, IFSMA, the Nautical Institute and Vistrato in working to raise health and safety standards across the industry.

International Cargo Handling Coordination Association

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[i] Link to BMA safety Alert https://www.bahamasmaritime.com/wp-content/uploads/2026/01/SA008-Safety-Alert-26-01-Hydrogen-Sulphide.pdf