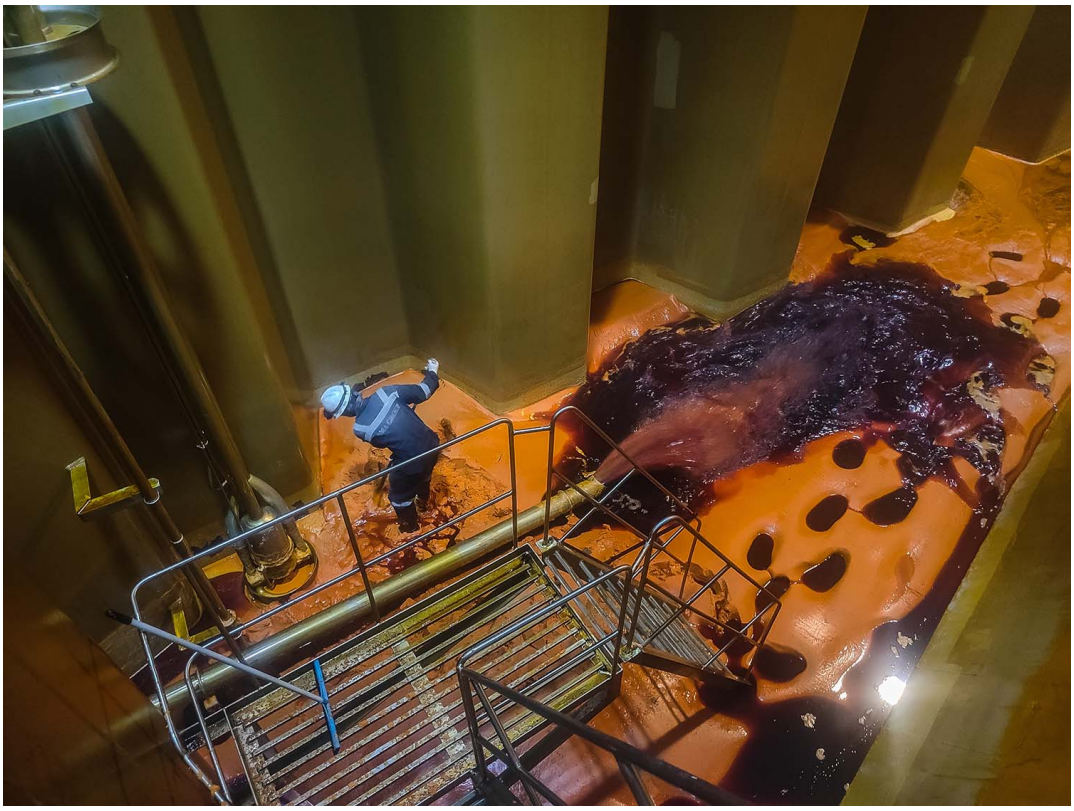

Safety risks of manual sweeping in vegetable and animal oil trades

Manual sweeping by the crew on tankers carrying vegetable oils and animal fat cargoes such as palm oil, coconut oil, or tallow to maximise cargo outturn, exposes crew to serious safety risks, such as heat exhaustion, enclosed space entry hazards and burn injuries from hot surfaces. Without proper management, these risks can lead to severe injuries and can even be fatal.

Published 07 August 2025

Introduction

Vegetable oils and animal fats are characterized by their high viscosity and elevated pour points, making them prone to solidify under ambient conditions. To ensure efficient discharge, the cargo temperature is maintained well above its pour point that can sometimes reach 70°C. Additional measures are also often taken to optimize cargo discharge, such as continuous recirculation of the heated cargo. To maximize the amount of cargo discharged and minimize the quantity remaining on board (ROB), manual sweeping of the cargo is generally performed during the final stages of the discharge. Sweeping, sometimes also referred to as "squeezing" or "squeegeeing," involves physically pushing the residue towards the pump suction. The task is labour-intensive, hazardous and can substantially increase crew workload.

Members have informed us that there is no technological alternative that can fully replace this manual process. Crew are usually offered some monetary compensation to do this task, although employing shore based personnel is also an option. A single discharge operation may involve up to 30 tank entries solely for the purpose of sweeping. When factoring in the additional entries required for subsequent tank preparation for the next voyage, the total number of annual cargo tank entries can exceed one thousand.

Atmospheric hazards

Extensive information is available regarding enclosed space entry risks, e.g., ventilation, gas measurement, pressure differentials etc. Please see Gard's articles Crew fatality in a cargo tank and Improved safety recommendations for entering enclosed spaces onboard ships . However, below we will focus on some of the key points in relation to vegetable oils.

• *Thermal degradation:*
Heating vegetable oils to elevated temperatures can lead to thermal degradation, producing potentially harmful gases. While these vapours may not always be pungent or visible, they may contain aldehydes, carbon monoxide, or other oxidation by-products at such temperatures or contain impurities.

• *IBC Code:*
The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), which does not classify most vegetable oil cargoes as having toxic vapours, places a heavy burden on crew members, who must rely on shippers for accurate information, especially when heating these cargoes. An example is ‘Coconut Oil’, where ‘T’, which indicates a presence of toxic vapours, is not specified in Chapter 17, Column K.

• *Inaccurate Safety Data Sheets (SDS):*
Safety data sheets provided by the shipper might be generic and may not represent accurate composition of the cargo. For example, for a cargo of coconut oil, we have seen an SDS that mentioned 'no toxic gases', while another specifically identified the potential for 'carbon monoxide production' under 'physical and chemical properties.' This inconsistency can create a false impression of the cargo.

• *Undetected toxic gases:*
The crew may be unaware of the likely presence of toxic gases and overlook their concentration checks as a part of the pre-entry procedure. Crew may test for more commonly encountered enclosed space gases (oxygen, hydrocarbons, CO and H_2S) but may not anticipate or detect specific low-level toxins or irritants generated by heated oils or may not have the appropriate equipment to test.

• *Oxygen depletion:*
The potential for oxygen depletion due to spoilage or bacterial activity within vegetable oil cargoes presents a significant hazard.

Case Study 1: Multiple fatalities due to atmospheric hazards

The vessel had two cargo oil tanks loaded with Coconut Fatty Acid Distillate oil maintained at a temperature of 45°C and there was a three-hour stagger between discharge and stripping of these tanks. Circulation of cargo and sweeping were successfully completed, and preparations were made to enter the second tank as it attained a stripping level.

Four deck ratings entered the second tank, followed by a fifth. Meanwhile, the Bosun and an officer were at the entrance, also preparing to enter. The last crew member to enter noticed four of his colleagues had collapsed at the bottom of the tank and immediately shouted to the Bosun and officer not to enter. All five deck ratings had collapsed. Although they were all evacuated, only one of the five crew members survived.

The subsequent investigation revealed the presence of carbon monoxide, inadequate ventilation, and depleted oxygen in different parts of the tank. Post-incident measurements showed that the carbon monoxide concentration in the tank exceeded 200 ppm at multiple points. It was also noted that. according to the ship's Master and Chief Officer, neither had prior experience in transporting this type of cargo.

Heat-related hazards

As the ambient temperature threshold for safe crew work and the maximum duration of man entry are not specifically defined, this task demands efficient management of the factors that can induce heat exhaustion. See, for example, the NIOSH Heat stress guidelines which set out the risk levels and corresponding protective measures. Temperatures ranging from 39°C to 46°C are classified as high risk, necessitating the implementation of additional precautions. When temperatures exceed 46°C, the risk level escalates to very high or extreme, requiring aggressive protective measures. Recommended work/rest schedules for heavy labour in environments above 40°C include a 20-minute work period followed by a 40-minute rest period. Given that temperatures inside cargo tanks can surpass 50°C during the final stages of discharge, owners and managers must develop specific procedures to address these conditions. Some of the key points to consider include, but are not limited to:

• *Environmental factors:*
In high ambient temperatures (above normal body temperature at 37°C) and high humidity, the body's ability to dissipate heat through radiation is significantly reduced. While working during hot and humid daylight hours can be particularly strenuous, night operations introduce additional hazards such as inadequate lighting and disruption of the circadian rhythm.

• *PPE:*
Wearing temperature-resistant Personal Protective Equipment (PPE) like aprons and trousers can further prevent cooling.

• *Rapid onset of heat exhaustion:*
Due to fast salt and water loss from the body, the onset of heat exhaustion can be rapid. Furthermore, subtle symptoms like dizziness or nausea can be overlooked or unnoticed by individuals focused on completing the task quickly.

• *Cumulative risk:*
Existing fatigue or continued exposure due to repeated entries by the same personnel can significantly elevate the risk of exhaustion.

Case Study 2: Heat exhaustion and burns due to slipping/tripping

The vessel was carrying palm oil which was maintained at a temperature of 59 °C. To facilitate stripping of the tank, hot palm oil was circulated in the tank while crew prepared to enter for manual sweeping. A three-man team entered and accomplished majority of the sweeping within 18 minutes. A subsequent entry was necessary to complete the operation which was made after a very brief rest period in fresh air. During the subsequent tank entry, one of the crew members suffered from extreme heat exhaustion and collapsed on to the heating coils sustaining severe burns. He was promptly evacuated and survived.

Case Study 3: Unconscious induced by heat exhaustion

A vessel was carrying crude palm oil. The temperature was maintained at 55°C to prevent it from solidifying and facilitate discharge. As one of the loaded tanks reached stripping level, a team of three deck crew prepared to enter for manual sweeping. Although established safety protocols limited continuous exposure to

30 minutes, the crew remained inside for over an hour. One of the crew members began experiencing difficulty breathing, dizziness, and eventually lost consciousness. Prompt assistance from the other crew members enabled his evacuation, and first aid was administered. Fortunately, the vessel was in port, allowing rapid mobilisation of shore medical support, which led to the successful revival of the affected crew member.

Refer: MPA Singapore, SRS E-Bulletin Case Study 'Taking Precaution when Working in Cargo Tank'

Burn hazards

As cargo heating would typically be maximized during the final stages of stripping, the crew can be exposed to:

• *Direct contact:*
Burns or scalding from direct contact with heating coils while working in proximity.

• *Hot recirculated oil:*
Contact with hot recirculated oil from other tanks.

• *Splashes:*
Inadvertent splashes due to puddling.

Slip, trip and fall hazards

Although guidance on these hazards is available within the COSWP, supplemented by Gard articles Keep eye out for slip trip fall hazards onboard , Steady on the stairs and Watch out for open manholes and displaced deck gratings , the viscosity, fatty acid composition, and lubricity of these cargoes heighten the risk of crew losing their grip or foothold while accessing the cargo tank and during the operation itself.

Manual handling Injuries

Manual sweeping involves repetitive and strenuous physical effort, often carried out in awkward positions within confined spaces. These factors significantly increase the risk of musculoskeletal injuries, including strains, sprains, and lower back injuries. The risk is further compounded when crew members are fatigued or working under tight timelines to expedite the operation.

Cargo contact

Certain grades of vegetable oils and animal fats may cause skin irritation, dermatitis, or allergic reactions upon direct contact. Prolonged exposure, due to inadequate protective clothing, can lead to occupational skin disorders. Even seemingly benign oils may contain residual contaminants or undergo degradation that increases their irritant potential.

Underlying operational challenges

The practice of entering tanks for manual sweeping is compounded by several systemic and operational complexities.

• *Using onboard crew:*
A prevailing preference to use onboard crew rather than shore-based service providers may reduce operational costs but significantly increases the workload on already limited crew resources.

• *Absence of technological solutions:*
The continued lack of automation hinders operational efficiency, increasing reliance on manual labour and limiting opportunities for optimisation.

• *Vessel design:*
Design variations and tank configurations can have a substantial impact on cargo handling efficiency. For instance, a drop line with a deck heat exchanger in the aft section of a tank may hinder the effective recirculation and overall heating of cargo in the forward section of the tank. Furthermore, the heating coils can restrict cargo flow, potentially leading to product solidification below the coil level.

• *Manning constraints:*
Two key challenges exist with regards to manning. Firstly, minimum safe manning (MSM) levels can vary significantly between Flag States, with MSM certificates showing a range of 13 to 16 personnel. Secondly, this minimum crew level is often insufficient to meet the vessel's operational demands. This becomes a significant safety concern, especially when simultaneous tank entries are undertaken.

• *Rescue equipment:*
Adding to the existing challenges, a lack of rescue equipment poses a serious risk. When multiple cargo tanks are entered simultaneously, there may not be enough rescue gear at each tank entrance. This can significantly delay rescue efforts during an emergency, making a quick evacuation difficult and substantially increasing the overall risk to personnel.

• *Inefficient cargo planning:*
Suboptimal cargo planning can lead to the need for multiple simultaneous tank entries, compounding operational risks and reducing overall efficiency.

• *Charterparty clauses and fixture decisions:*
While some charterers may exclude manual sweeping for certain cargo grades, most vessels transporting vegetable or animal oils still require tank entry, underscoring a persistent operational burden driven by the need to maximise outturn. Some charterers are taking a proactive approach by providing owners and crew with guidance on the risks of solidifying cargoes. This also includes advice on things such as heat management procedures and manning constraints.

Key recommendations

As highlighted, man-entry for sweeping remains a primary method to achieve minimal ROB of vegetable and animal oils. This also helps reduce pre-wash duration for the next cargo. Ensuring crew safety during such operations requires a unified and coordinated effort from both charterers and owners/managers (and their crew). The following recommendations, while not exhaustive, are crucial:

Operational planning:

• *Early dialogue with commercial counterparts:*
Initiate early dialogue between the owner/manager and charterer to explore alternative options, including employment of shore-based gangs for sweeping, and incorporate appropriate charterparty clauses to prevent future disputes. Furthermore, the additional time necessary to safely carry out sweeping operations in all cargo tanks should also be considered and incorporated into the overall laytime calculations.

• *Local regulations:*
Obtain information from local agents on any domestic regulations pertaining to working in hot environments.

• *Efficient discharge plans:*
Formulate efficient cargo discharge plans that maximise the utilisation of fixed pumps, stagger man entries into multiple tanks, and allow sufficient additional time for the operation when planning the turnaround.

Developing and implementing procedures:

• *Heat management guidelines:*
Develop heat and fatigue management guidelines, including things such as maximum man-entry time, minimum rest periods between consecutive entries, and how to recognise symptoms of dehydration.

• *SDS verification:*
Verify Safety Data Sheets (SDS) and consult chemical experts when needed to ensure accurate cargo composition and hazard information.

• *Toxic gas release:*
The crew needs to be aware of the toxic gases that a cargo can release when heated, such as carbon monoxide from coconut oil. Also, because of the varying densities of these gases, gas checks must be performed at different levels of the tank with the ventilation turned off. This ensures that the vapour sample is not diluted, giving the crew an accurate reading.

• *Simultaneous tank entries:*
Limit the number of simultaneous tank entries to manage the risk effectively, taking into consideration things such as crew fatigue, rest hours, ventilation equipment and availability of standby responders and equipment for a rescue operation.

• *In-house expertise:*
Maintain a continued emphasis on developing in-house expertise, especially when new personnel are involved.

Personal safety:

• *Safe manning levels:*
Align the minimum safe manning levels with operational demands and IMO guidance.

• *Appropriate PPE and detection equipment:*
Equip the vessel with PPE capable of withstanding cargo characteristics (temperature and chemical composition), and gas meters/chemical detection tubes to detect the full range of gases likely to be present.

• *Training:*
Train personnel in the correct use of detection equipment, recognising heat-related symptoms, rescue from tanks, and providing the necessary first aid.

This quick reference card can effectively assist to align stakeholder approaches, fostering a safer working environment, and ensuring the secure execution of this critical operation.

We would like to thank Pratap Pawar and Abner Carvalho of Anglo Eastern Ship Management (Singapore) for their assistance in preparing this insight.