Explosion involving Styrene Monomer

Written by
Taslim Imad
Loss Prevention

The Accident -

On 28th September 2019, an explosion took place on board chemical tanker “Stolt Groenland / IMO 9414072” alongside a general cargo berth (Yeompo Quay) in Ulsan, Korea. At the time ship to ship (STS) operations were taking place with another vessel (Bow Dalian / IMO 9504205) which was moored port side of Stolt Groenland.

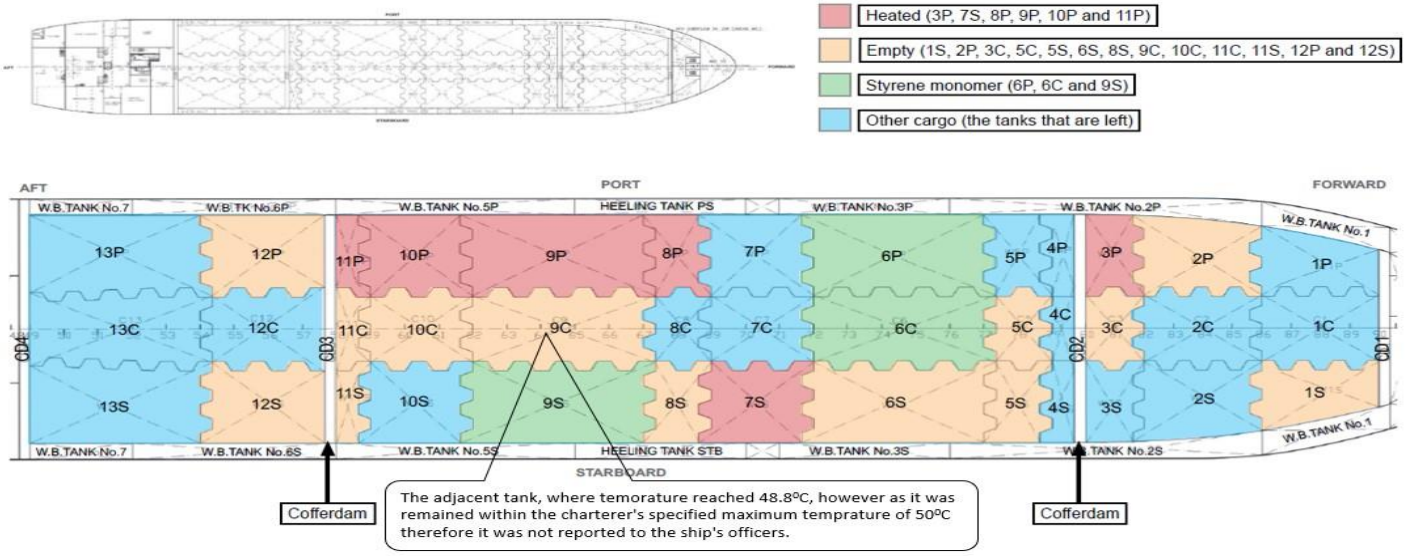
The Marine Accident Investigation Branch, UK (MAIB) published its investigation report into the explosion and fire that resulted from the runaway polymerisation of the styrene monomer cargo that the vessel was carrying. The catastrophic rupture of the cargo tank released a large quantity of vapour to the atmosphere, and this subsequently ignited. Full details and safety lessons can be found in the MAIB investigation report.

Ref MAIB Report 09/2021 – Fireball at Ulsan Bridge

Safety Lessons –

MAIB concluded that the following safety issues directly contributed to the accident and Club Members operating Chemical tankers are encouraged to review the report and take due account of the safety lessons that have been identified as a result of this serious accident –

- The explosion and fire resulted from the runaway polymerisation of the styrene monomer cargo in one of her cargo tanks.
- The polymerisation was initiated by the cargo’s elevated temperature during much of the voyage, this reduced the effectiveness of the 4-tert-Butylcatechol (TBC) inhibitor.
- The elevated temperature of the styrene monomer resulted from the transfer of heat from another heated cargo in the port side tanks, via the centre cargo tank.
- The precaution of not stowing the styrene monomer adjacent to the heated cargo was not sufficient in meeting the adequate segregation requirement of the IBC Code. The cargo handling sheet for styrene monomer stated that the maximum temperature of the cargo in adjacent tanks should not exceed 35°C. Similar guidance was provided by other industry bodies. The Styrene Monomer: Safe Handling Guide went further and stated that ‘styrene should not be loaded into cargo tanks adjacent or corner-to-corner to a cargo having a temperature of 30°C (86°F) or higher even if separated by a cofferdam’. The attending cargo surveyor in Ulsan noticed that the temperature of the cargo in the adjacent tank reached 48.8^{0}C but as it remained within the charterer’s specified maximum temperature of 50^{0}C the surveyor did



not discuss this with the ship's officer and no action was taken.

- The probability of heat being transferred from the heated cargo tanks to the styrene monomer cargo was not fully considered during the planning and approval of the cargo stowage plan.
- Calculations to predict heat transfer during cargo stowage planning were not conducted because they were complex and outside the capabilities of the ship operator and the tanker's crew. They were also outside the scope of the cargo stowage software.
- Instructions and guidance were clear that inhibited cargoes should not be stowed adjacent to heated cargoes, but the likelihood of heat transfer through adjacent or intermediate cargo tanks was not covered in detail.
- Despite being a requirement in Stolt Groenland's SMS, the temperature of the styrene monomer was not monitored, and the temperature alarms available on the cargo monitoring system were not set. The crew also either did not notice, or failed to recognise, the significance of the elevated temperatures of the cargoes discharged in the previous ports and berths.
- The absence of temperature monitoring of the styrene monomer was influenced by the crew's view that it was a benign cargo when inhibited, and that no previous problems or difficulties with its carriage had been experienced.
- Finally, and whilst not directly contributing to the accident, a similar dangerous styrene monomer polymerisation incident had occurred a couple of weeks earlier on board another Company ship, Stolt Focus. In this instance the heat generated by the polymerisation process was noticed before the critical runaway temperature was reached. The styrene monomer cargoes on board both tankers were loaded at a similar time from the same tank in the loading port and were exposed to similar environmental conditions. The incident on board Stolt Focus was not reported to the ship's Flag State or other masters in the Company's fleet.

Recommendations –

The following recommendations were made by the MAIB-

- Recommendations (2021/117[1], 2021/120[2] and 2021/121[3]) were made to the Cayman Island Shipping Registry, the Chemical Distribution Institute and Plastics Europe (Styrene Producers Association). These are intended to assist in ensuring that the guidance provided in certificates of inhibitor and styrene monomer handling guides is consistent and achievable given the limitations of equipment and testing facilities on board ships.
- A recommendation (2021/122[4]) was made to the Company aimed at ensuring the wider marine chemical sector benefits from the lessons learned from the earlier incident and the research initiatives that were carried out as a result of this accident.
- The International Chamber of Shipping (ICS) and INTERTANKO were also recommended
- (2021/118[5] and 2021/119[6]) to promulgate the report to their members.

[1] **2021/117** Propose to the IMO a revision to Section 15.13 of the IBC Code to:
- Include in the certificate of protection the actions to be taken in the event of a cargo falling outside of the manufacturer's specified oxygen and temperature limits, and that
- Any actions should be realistic, taking account of the limitations on board ships regarding the monitoring, adding, and mixing of inhibitor during the voyage.

[1] **2021/120 Chemical Distribution Institute** is recommended to amend its publication '*Chemical Tanker Operations for the STCW Advanced Training Course – A Practical Guide to Chemical Tanker Operations*' to make it clear that:
- The stowage of heated and inhibited cargoes can result in a dynamic situation in which the degree of heat transfer may be complex and difficult to predict.
- One tank separation between heated and heat sensitive cargoes might not be sufficient.
- Promulgate this report to its members.

[1]**2021/121 Plastics Europe (Styrene Producers Association)** is recommended to work with its members to incorporate the lessons learned from this accident in its *Styrene Monomer: Safe Handling Guide.*

[1] **2021/122 Stolt Tankers B.V.** is recommended to share with INTERTANKO the circumstances and lessons learned from the *Stolt Focus* incident and the results of its research into improved stowage software, to enable prediction of heat transfer and cargo behaviour.

[1] **2021/118 International Chamber of Shipping** is recommended to Promulgate this report to its members.

[1] **2021/119 INTERTANKO** is recommended to Promulgate this report to its members.