

Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

“The sole objective of a safety investigation into an accident under these Regulations shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of such an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame.”

As the full investigation report will not be published within 12 months of the accident date, this interim report is published, pursuant to Regulation 14(2)(b) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012.

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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Interim report on the investigation of the explosion and fire on board the chemical tanker *Stolt Groenland* on 28 September 2019, Ulsan, Republic of Korea

The information contained in this interim report is based on investigations to date. Readers are cautioned that there is the possibility new evidence may become available that might alter the circumstances as depicted in this report.

NARRATIVE

On 17 August 2019, *Stolt Groenland*, a Cayman Islands registered chemical/products tanker operated by Stolt Tankers B.V. sailed from Houston, USA for passage to Kobe, Japan via the Panama Canal. The tanker was carrying 20 different chemical cargoes in 37 of its 39 cargo tanks. After discharging four cargo tanks off Kobe on 23 September and six cargo tanks at the Odfjell Terminal in Ulsan, Republic of Korea, between 26 and 27 September, *Stolt Groenland* moored alongside the Yeompo Quay in Ulsan. Two further cargo tanks were then discharged via a ship to ship transfer with *Stolt Voyager*. On completion, *Stolt Voyager* moored ahead of *Stolt Groenland*.

At about 0600 on 28 September, the Singapore registered chemical/products tanker *Bow Dalian* secured alongside *Stolt Groenland*'s port side. The purging of *Bow Dalian*'s cargo tanks with nitrogen supplied from shore-side vehicles was then commenced in readiness for a ship-to-ship cargo transfer with *Stolt Groenland*.

Image courtesy of <https://www.fleetmon.com>



Stolt Groenland

At 1043, vapour started to release from the pressure vacuum valve for *Stolt Groenland's* number 9 starboard (9S) cargo tank, which contained styrene monomer. About 2 minutes later, a high-level alarm indicated that the level in 9S cargo tank had reached 95%, soon followed by a high-high-level alarm indicating that the level had increased to 98%. By now, *Stolt Groenland's* on-watch deck officer and chief officer had made their way to the cargo control room and they saw from the cargo monitoring system that the pressure inside 9S cargo tank was rapidly rising. Suddenly, at 1050, two explosions were seen and heard in rapid succession in way of the tanker's cargo manifold (**Figure 1**). The resulting fireball passed very close to a road bridge above the quay (**Figure 2**).



Figure 1: Tank rupture and ignition of released vapour



Figure 2: Fireball viewed from the Ulsan bridge

Stolt Groenland's and *Bow Dalian's* crews immediately operated and directed foam monitors towards the respective cargo manifolds. *Bow Dalian's* cargo manifold drench system was also activated. The fire on board *Stolt Groenland* was very intense and large plumes of thick black smoke were emitted. *Stolt Groenland's* crew evacuated using the free-fall lifeboat at the stern while *Bow Dalian's* crew were taken off by Korean Coastguard boats that had arrived at the scene.

DAMAGE AND INJURIES

The fire was fought from the shore and from the water and lasted until early the following morning. The damage in way of *Stolt Groenland's* cargo manifold and accommodation block was extensive (**Figure 3**). The following persons were injured: *Stolt Groenland's* gangway watchkeeper, who was blown over the guardrails by the force of the explosion; a deck rating on board *Bow Dalian*; and, a number of shore workers, including firefighters and police during the emergency response.

STYRENE MONOMER

Styrene monomer is used to make plastics, paints and synthetic rubber. It is a colourless to yellowish oily liquid with an aromatic odour and is highly flammable. It has a flash point of 32°C (90°F). It is also toxic and reactive and is generally stable at ambient temperature. Polymerization¹ of the monomer is initiated by heat or contact with peroxides. The polymerization process is exothermic and the monomer's temperature may rise to the point where the reaction becomes very rapid and self-sustaining (runaway polymerization). Normally, temperatures above 65°C (149°F) are needed to initiate runaway polymerizations.

To reduce the possibility of polymerization in storage and during transportation, Tert-Butylcatechol (TBC) inhibitor is added to styrene monomer, typically at a concentration of between 10-15ppm, but higher levels might be needed depending on storage conditions and expected voyage duration. The depletion of TBC over time and its effectiveness as an inhibitor are affected by temperature, oxygen levels and water.

INVESTIGATION

On 28 September, the Maritime Authority of the Cayman Islands requested the MAIB investigate this accident in accordance with the International Maritime Organization Casualty Investigation Code². During the on-site investigation in Ulsan, the MAIB was assisted by the Korean Maritime Safety Tribunal. In addition, the Singapore Transport Safety Investigation Bureau supported MAIB's evidence collection on board *Bow Dalian*, along with the vessel's owners.

Access to *Stolt Groenland* was controlled by the Korean Coastguard and restricted by the toxicity of the atmosphere on board. MAIB inspectors eventually boarded the tanker on 8 October 2019 with the co-operation and assistance of Stolt Tankers B.V., the vessel's operator. A further inspection was carried out on 12 November 2019. Stolt Tankers B.V. has provided a copy of the data saved on the tanker's voyage data recorder capsule.

¹ Polymerization is a chemical reaction in which two or more molecules combine to form larger molecules that contain repeating structural units. However, if a large amount of monomer is involved, and if the reaction is strongly exothermic, the monomers may combine too quickly. Consequently, heat and pressure increase.

² IMO Resolution MSC 255(84)

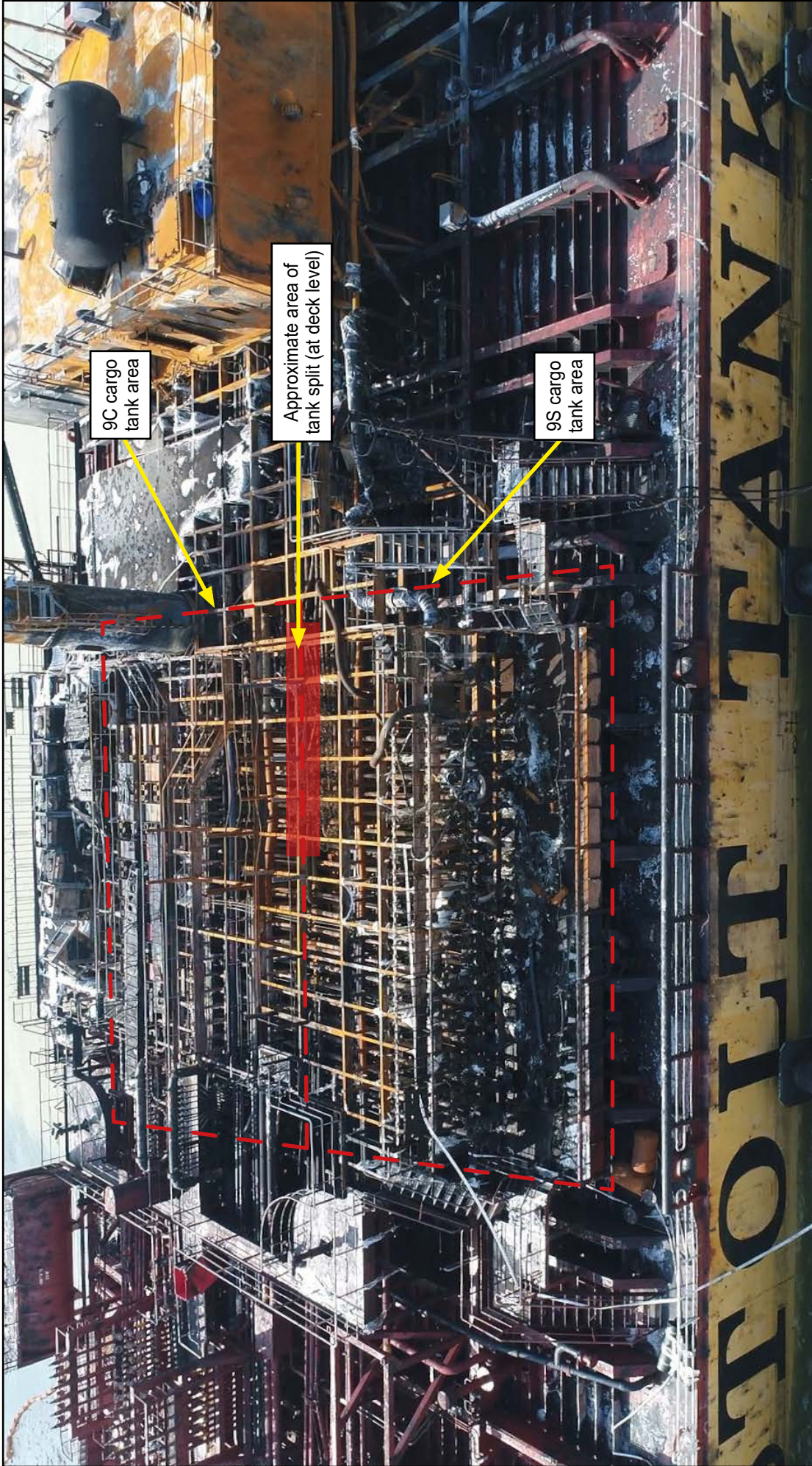


Figure 3: Stolt Groenland starboard cargo manifold

INITIAL FINDINGS

The explosions on board *Stolt Groenland* were probably caused by the rupture of the deck above 9S cargo tank, followed immediately by the ignition of the styrene monomer vapour that was then released. The rupture was due to over-pressurisation and the likely sources of the ignition were static electricity, sparks or elevated steel deck plate temperatures resulting from the tank rupture. A large hole was found in way of the tank's common bulkhead with number 9 centre (9C) cargo tank (**Figure 4**) and its hatch cover had been blown off. No cargo operations or deck maintenance were in progress at the time. VDR data showed that the temperature of the styrene monomer had reached 100°C at the time of the explosion. Such an elevated temperature indicates that the cargo was polymerizing.



Figure 4: 9S tank rupture

Stolt Groenland had loaded 5,250 tonnes of styrene monomer at the LBC terminal in Houston, U.S.A. between 7 and 8 August. The cargo was distributed between three stainless steel cargo tanks: numbers 9S, 6P and 6C. Prior to loading, the tanks had been washed and inspected and wall wash tests had been conducted; no problems were recorded. The tanks were not purged with nitrogen before loading and none were adjacent to heated cargoes in accordance with cargo loading instructions.

The concentration of TBC inhibitor in the styrene monomer in the shore tank was 11.3ppm but this was increased by the addition of 3 US gallons of liquid TBC to each of the destination tanks before loading was commenced. The target concentration of the TBC was 17ppm. The loading was overseen by an American Cargo Assurers cargo surveyor acting on behalf of the supplier of the styrene monomer, Ineos Styrolutions, and the purchaser, Samsung C&T Corporation.

The certificate of inhibitor, issued by the cargo surveyor at the time of loading, stated that the TBC should remain effective for between 60 and 90 days. It also stated that the inhibitor was oxygen dependent and that the ideal temperature for the styrene monomer was between 60°F and 85°F (15.5°C – 29.4°C). *Stolt Groenland* did not carry additional inhibitor.

ACTIONS TAKEN

Stolt Tankers B.V. engaged salvors to assist in making *Stolt Groenland* safe. The discharge of the remaining chemical cargo from the undamaged tanks was completed by Stolt personnel on 29 October 2019.

The Ulsan Regional Office of Oceans and Fisheries has prohibited the transport and unloading of some hazardous cargoes, including styrene monomer, at several terminals under the Ulsan bridge.

OTHER RECENT INCIDENT

On 20 November 2019, the MAIB was informed of an incident on board the Cayman Islands registered chemical/products tanker *Stolt Focus* in which the temperature of a styrene monomer cargo had steadily increased. Efforts to stabilize the temperature, including the injection of additional inhibitor, were unsuccessful. Following consultation with chemists ashore, the crew distributed the cargo between four cargo tanks and mixed it with sea water, which stabilized the styrene monomer.

THE MAIB INVESTIGATION WAY AHEAD

The MAIB's investigation will focus on, among other things:

- the factors contributing to the initiation of the polymerization of the styrene monomer,
- cargo monitoring, and
- the emergency response.

The MAIB will continue to work closely with all the stakeholders involved in order to progress the investigation as swiftly as possible and ensure appropriate action can be taken in order to

further reduce the likelihood of similar accidents in the future. Once the MAIB's investigation is complete, a report will be drafted and distributed to key stakeholders for a 30-day consultation period prior to it being published.

In the interim, chemical tanker owners/operators are reminded to:

- Adhere to the carriage and storage instructions details on the safety data sheet, the certificate of inhibitor, and those provided by the charterer.
- Witness the addition of inhibitor into each cargo tank.
- Closely monitor cargo temperature for unexplained increases.

They should also ensure that their crews are familiar with the action to take in the event of the styrene monomer self-heating/polymerizing.

REQUEST FOR INFORMATION

The MAIB is seeking any information from ship owners, ship and terminal operators, or individuals regarding any accidents or 'near-misses' involving the carriage of styrene monomer on board ships, including any actions subsequently taken. The MAIB's email address is maib@dft.gov.uk and further contact details are at www.gov.uk/maib.

VESSEL DETAILS

Vessel's name	<i>Stolt Groenland</i>
Flag	Cayman Islands
Classification society	Det Norske Veritas Germanischer Lloyd (DNVGL)
IMO number	9414072
Type	Chemical/Products Tanker
Registered owner	Stolt Tankers B.V.
Manager	Stolt Tankers B.V.
Year of build	2009
Construction	Steel
Length overall	182.72
Gross tonnage	25881
Authorised cargo	Chemicals/Products

VOYAGE PARTICULARS

Port of departure	Ulsan, Republic of Korea
Port of arrival	Ulsan, Republic of Korea
Type of voyage	International
Cargo information	31178 tonnes of chemicals
Manning	25

MARINE CASUALTY INFORMATION

Date and time	28 September 2019 at 1050 (UTC+9)
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Ulsan, Republic of Korea
Place on board	Cargo tanks/Deck
Injuries/fatalities	1 (<i>Stolt Groenland</i>), 1 (<i>Bow Dalian</i>). 15 shore workers/officials were also reported to have been injured.
Damage/environmental impact	Toxic fumes
Ship operation	Moored alongside
Voyage segment	Moored alongside
External & internal environment	Daylight. Air temperature: 24°C. Wind: light airs
Persons on board	25