Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

202310/016 REPORT NO.: 14/2024 October 2024

MV *CMA CGM SAN ANTONIO*

Serious injury to a crew member, during maintenance work on the main engine in the port of Jebel Ali, UAE 21 October 2023

SUMMARY

On 21 October 2023, whilst the container vessel *CMA CGM San Antonio* was alongside a layby berth at Jebel Ali, one of the two third engineers was seriously injured in the engine-room during the untightening process of main engine cylinder head no. 5.

Crew members assisted the third engineer and administered first aid on board. However, the injuries to his face were serious enough to warrant admission in a shore hospital for further treatment.

Following the necessary treatment, the third engineer was repatriated.

The safety investigation concluded that the cause of the injury was the failure of one of the hydraulic jacks, which was being used by the third engineer to untighten the cylinder head studs.

The MSIU has issued one recommendation to the Company designed to ensure awareness among crew members on the safe use of the equipment.

MV *CMA CGM San Antonio*

FACTUAL INFORMATION

The vessel

CMA CGM San Antonio (**Figure 1**) was a Maltese registered container vessel of 28,592 gt. It was built in the Republic of Korea in 2005 at the Hyundai Mipo Dockyard Co. Ltd. The vessel's registered owners were CMA CGM SA The French Line and was managed by NSB Neiderelbe Shiffahrtsgesellschaft MBH & Co. KG., based in Buxtehude in Germany. *CMA CGM San Antonio* was classed by Det Norske Veritas, which also acted as the recognised organisation for the compliance of the International Safety Management (ISM) Code.

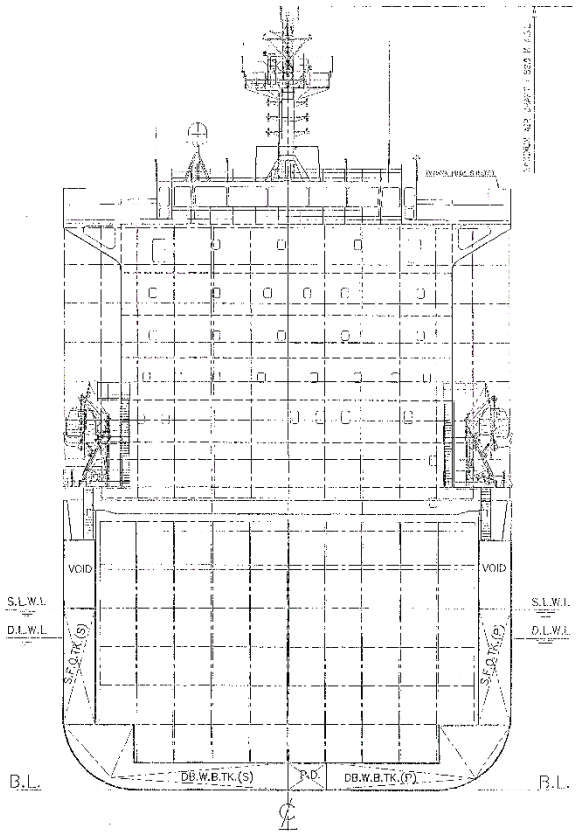

Figure 1: GA plan

CMA CGM San Antonio had an overall length of 222.15 m, a breadth of 30.00 m, and a summer deadweight of 39,383 tonnes, which corresponded to a summer draft of 12.02 m. Propulsive power was provided by a seven-cylinder Hyundai MAN B&W (7K80MC-C) slow-speed, marine diesel engine, producing 25,270 kW at 104 rpm. This drove a five-bladed, right handed, fixed pitch propeller, enabling the vessel to reach a maximum speed of 18.0 knots. The vessel was also fitted with a 1,100 kW bow thruster.

The vessel was fitted with six cargo holds and had a cargo capacity of 2,824 TEUs.

Manning

The Minimum Safe Manning Certificate stipulated a crew of 15[1]. At the time of the occurrence, there were 24 crew members on board. All crew members were Filipino nationals, except for the master (Romanian), the chief officer, the second engineer officer (Russian), and three engine-room crew members (Ukrainian).

The crew list included two crew members serving in the rank of third engineers. At the time of the accident, the vessel was alongside a layby berth with the Filipino third engineer being present in the engine-room and forming part of the overhaul team.

The third engineer

The third engineer was a 49-year-old Filipino national. He had been serving in his present rank for 13 years. He held STCW[2] III/3 qualifications, issued by the Philippines' MARINA. This was the third engineer's first contract with the Company and had joined the vessel at the port of Jebel Ali on 20 August 2023.

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1 Provided that the unmanned machinery space (UMS) and the bridge control systems were operational, and at least two deck officers held Global Maritime Distress and Safety System (GMDSS) General Operator's Certificates (GOC).

2 IMO. (2020). International Convention on Training, Certification and Watchkeeping for Seafarers, 1978 (Consolidated ed.). London: Author.

Course of events[3]

At 0948, on 21 October 2023, the vessel was shifted from berth no. 84 to berth no. 22 at the port of Jebel Ali, to enable the crew members to overhaul main engine cylinder unit no. 5. The shifting operation was successful, and the vessel was all fast at its new berth by 1112.

At 1140, an engine-room crew toolbox meeting was called by the chief engineer in the engine-room. During the meeting, which was also attended by the second and the two third engineers, and one of the fitters, instructions for the job, a risk assessment, and enclosed space, and work permits were issued by the chief engineer, in preparation for the overhaul task.

By noon, all the crew members were set up and the overhaul task was initiated, with the dismantling of pipes from the exhaust manifold and the lubricating oil pump. 30 minutes into the job, the engine crew were ready to prepare the hydraulic jack (**Figure 2**), to untighten the cylinder head.

Figure 2: Hydraulic jack assembly used to untighten the cylinder head

[3] All times are local (+4 GMT).

At 1244, the engine-room crew members[4] rigged the hydraulic jack on all the studs of cylinder head no. 5. The third engineer was closest to the cylinder head, observing the work which was in progress (**Figure 3**). Using a hand pump, the chief engineer applied hydraulic pressure in the jack to commence the untightening procedure.

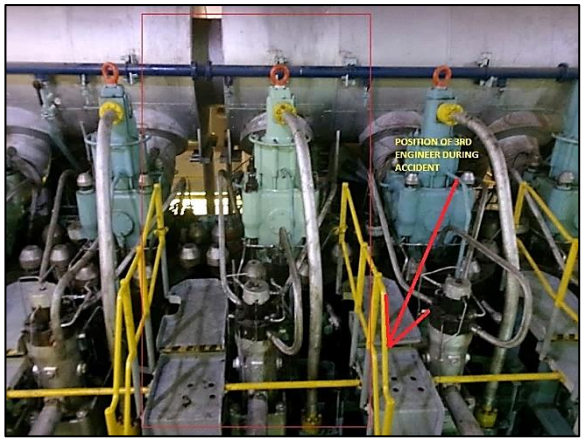


Figure 3: Picture showing the location of the third engineer, just before the accident

Several seconds later, when the pressure had reportedly reached about 450 bar, one of the hydraulic jacks failed. Hydraulic oil and some other pieces were ejected from the hydraulic jack at a tremendous pressure, hitting the third engineer in the face. It was immediately evident that the crew member had sustained facial injuries, which required medical attention.

The master was immediately informed of the accident by the chief engineer. The message was also relayed to the ship's agent, together with a request for an ambulance. Until the ambulance arrived on the jetty, the third engineer was transferred to the ship's hospital to be administered first aid.

The ambulance arrived at the gangway at 1316. The third engineer was helped and escorted down the gangway by the crew members and helped to the ambulance, which

[4] The engine-room crew members were the same crew members wo participated in the toolbox meeting.

left to the local hospital at about 1337. The main engine's unit no. 5 was subsequently completed successfully.

Extent of injuries

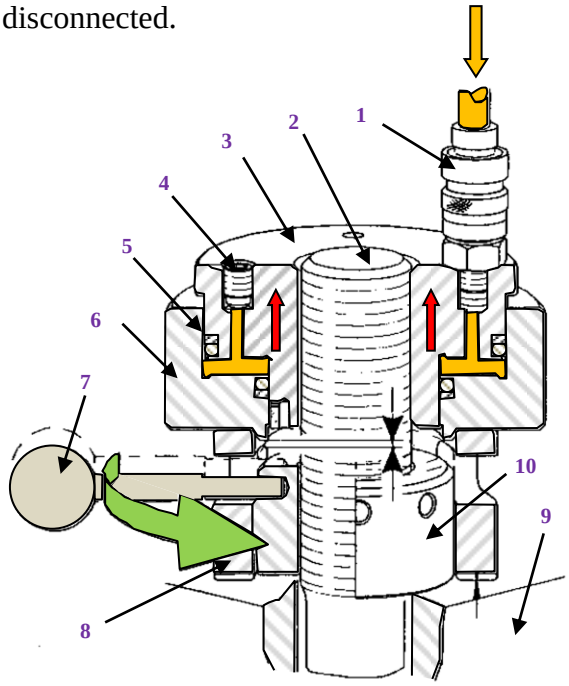
Medical examinations at the hospital revealed soft tissue injuries to the face. The third engineer complained of pain in his eyes and blurry vision from both eyes. CT scans showed comminuted fractures of the right and the left medial walls of the eye orbits, and a fracture of the right roof of the orbit. The third engineer sustained a deep cut lacerated wound, which extended from his right eyelid over the bridge of the nose, to the left eyelid region.

The third engineer responded well to the treatment and after seven days, he was found fit enough to be discharged and travel, although he still required assistance as he had no vision from his right eye and was seeing blurred from his left eye.

The hydraulic jack

The hydraulic jack used on board *CMA CGM San Antonio* was of the conventional type and relatively very common on board, for the tightening and untightening of nuts, which are specifically designed and manufactured for use with a hydraulic jack. The hydraulic tool assembly (**Figure 2**) consisted of a spacer ring, an air driven hydraulic pump, flexible hoses, distribution blocks and a pin / tommy bar. Two sets of sealing and back-up rings[5] served as the sealing components of the hydraulic jack.

To operate the hydraulic jack, the spacer ring is placed around each nut on the cylinder head. Each jack is then screwed to the stud, until the jack sits firmly on the spacer ring. When all the jacks are hand tight, each one is connected to the respective distribution block and the high-pressure pump by means of the high-pressure hoses. All the bleed screws are loosened. The system is then filled with oil by the pumping action of the hydraulic pump and the bleed screws are tightened when oil without air bubbles flows out. This procedure will allow the clearance between the piston and the cylinder of the jack to be adjusted (depending on the desired maximum lift of the stud). A final check is made to ensure that there is no clearance between the cylinder and the spacer ring surface. Oil pressure is gradually increased up to the value determined by the manufacturer. At that pressure, the nut should be able to be unscrewed and loosened using the tommy bar (**Figure 4**) and hydraulic pressure relieved before all high-pressure hoses are then disconnected.



10	Cylinder head hydraulic nut
9	Cylinder head
8	Tool's spacer ring
7	Tommy bar
6	Tool's stationary cylinder
5	Tool's sealing and back-up rings
4	Tool's bleeding screw
3	Tool's moving piston
2	Cylinder head stud
1	Snap-on coupling

Figure 4: Cross-section through the hydraulic jack, nut, and stud

[5] One set fitted on the moving piston and the other on the stationary cylinder.

Use and maintenance of the hydraulic jack

The stretching of the stud is relative to the pressure acting on the underside of the tool's piston (**Figure 4**). As described in the previous section, it is the stretching of the stud which will eventually allow the loosening (and tightening) of the nut, by means of the tommy bar.

Considering the tremendous pressures generated inside the tool, the manufacturers cautioned against, *inter alia*, blows / impacts to the tool, and the maximum lift (due to excessive application of hydraulic pressure). In order to guide the user, the hydraulic jacks were marked with a 'maximum lift', which was not to be exceeded.

The hydraulic tool was also engineered in such a way that in the event of a maximum lift being exceeded, hydraulic oil would leak at the bottom of the pressure chamber and out through the slots, machined in the spacer ring. The manufacturers cautioned further the that if this had to happen, more often than not, the lowermost sealing ring would be damaged and therefore it had to be inspected and replaced, if necessary.

The maintenance requirements of the hydraulic tool were not laborious, mainly limited top cleanliness, proper storage to prevent damage and replacement of defective sealing rings, whenever necessary. Nonetheless, a job was created in the country's planned maintenance system (i.e., applicable to all vessels in the fleet) to ensure that at prescribed, regular intervals, crew members check the hydraulic tools for completeness, cleanliness, and operation.

Risk assessments and the permit system

The safety investigation was provided with two 'Enclosed Space Entry' documents, two risk assessments documents, and a work planning meeting document. The 'Enclosed Space Entry' documents were relevant to the overhaul of the main engine unit no. 5 due to the necessity of crew members to access the crankcase and go down the cylinder liner to overhaul the crosshead and the big end bearing, and to take the necessary measurements, once the piston would have been lifted out of the cylinder liner.

The first 'Enclosed Space Entry' permit was issued on 21 October 2023 at 1800, and had a validity of eight hours *i.e.*, until 22 October 2023 at 0300. The second 'Enclosed Space Entry' permit indicated that it had been closed at the expiry time, confirming that the working task had been completed safely. The time on the first document would have coincided with the start of work on the internal spaces of the main engine, after the cylinder head would have been removed after the accident.

The risk assessment documents related to the entry into the enclosed space inside the main engine for the overhaul of main engine unit no. 5, and the actual overhaul of the main engine unit.

The risk assessment for the overhaul of unit no. 5 referred to the "checking (of) lifting and hydraulic tools" (by the second engineer), as a control measure for the mitigation of the risk related to:

- Bedplate and tie rod
  - retighten foundation bolts;
  - retighten tie rods.
- Cylinder
  - exchange cylinder liner;
  - overhaul / exchange exhaust valve.

The document did not identify the hydraulic tools. Furthermore, there was no reference to the dismantling and removal of the cylinder head.

The final document provided to the safety investigation was a record of the agenda of the toolbox meeting (work planning meeting), which was convened on 21 October 2023 between 1540 and 1557, after the vessel came alongside and just before the overhaul tasks were initiated. The document

indicated that the required tools and equipment had been discussed as one of the agenda items. No additional remarks were entered in the document for this agenda item.

Environment

The vessel's records indicated that at the time of the occurrence, the sky was clear, with good visibility. The sea was calm, and the air and sea temperatures were recorded at 35 °C and 28 °C respectively. The artificial light inside the engine-room was considered was adequate.

ANALYSIS

Aim

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, and to prevent further marine casualties or incidents from occurring in the future.

The hydraulic jack sealing arrangement and maximum piston lift

As for any hydraulic jack, the one used on *CMA CGM San Antonio* had a maximum lift[6] value stamped on it. The maximum lift on this hydraulic jack was 10 mm (**Figure 5**). The operations manual cautioned that beyond this maximum travel, the lower sealing and back-up rings may be damaged and would have to be replaced.

A photo taken soon after the accident showed the upper sealing ring displaced from its recess on the moving piston (**Figure 6**).

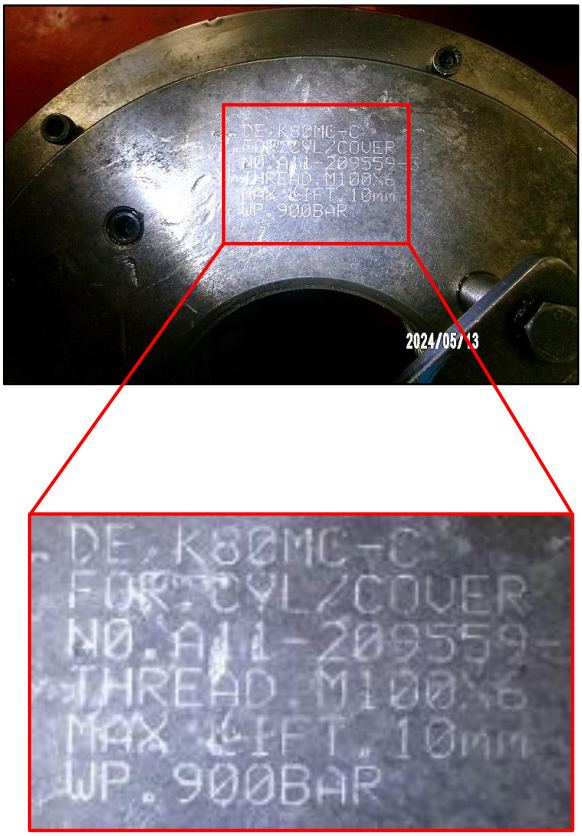


Figure 5: Maximum working pressure and lift, stamped on the hydraulic jack assembly

Figure 6: Displaced upper sealing ring

The retrieved parts (which have been sent to the metallurgical lab) had a small part (about 50 mm in length), which had broken off and was missing. The disassembly of the hydraulic jack after the accident revealed no damages. The safety investigation did not exclude that the injuries to the crew members could have been caused by the missing part

[6] Maximum lift is the maximum safe distance, which the moving piston can travel inside the stationary cylinder.

of the back-up ring. However, it was considered also possible that the injuries may have been caused by the leaking hydraulic oil under the pressure build up, being generated at the time by the jack to stretch the stud.

Equally important to consider, was the cause of the displaced sealing ring. The upper sealing ring could not be displaced out of its recess because of the stationary cylinder walls unless:

- the working pressure exceeded 900 bar, the safety drain passages were blocked, and the maximum lift of 10 mm was exceeded;
- the back-up ring was damaged and could not support the upper O-ring when subjected to the hydraulic oil;
- the clearance between the piston and the cylinder exceeded the 3.0 mm stipulated in the operations manual; or
- a combination of these factors.

Exceeding the maximum working pressure was not considered to be the most plausible option. The hydraulic jack assembly was designed not to exceed this pressure. Pressure relief orifices would align with the oil chamber below the moving piston, relieving the pressure below the hydraulic jack. Moreover, crew members who were on site recalled that the working pressure at the time had only reached 50 % of the maximum.

The other possibilities appeared more plausible, although no accident data was available to confirm the precise dynamics. The importance of the back-up ring is critical to support the O-ring, when the assembly was subjected to the working pressure. To this effect, the safety investigation did not exclude the possibility that the back-up ring had been damaged before the accident (and went unnoticed by the crew members), and consequently failed during the application of the working pressure, resulting in the O-ring being pushed out of its recess and popping out of the moving piston.

The safety investigation also took note of the importance of the clearance between the stationary cylinder and the moving piston before hydraulic oil pressure is applied. A table on the instruction manual specified that for a maximum lift of 10 mm, the clearance between the two hydraulic jack assembly components was 3 mm. The clearance had to be measured by a feeler gauge. If this clearance was not adhered too and perhaps even exceeded, the moving piston lift could then reach a position, high enough for the upper O-ring to pop out of its recess.

A combination of these two factors[7] was not excluded either.

Sealing arrangements in the hydraulic jack

Instructions on the manufacturer's manual specified that both sealing rings had to face each other when mounted on the moving piston and the stationary cylinder. This was critical because the back-up ring's function was to support the sealing ring to withstand the tremendous pressures generated when the hydraulic jack was operated[8].

The safety investigation did not come across accident data which suggested that the sealing and back-up rings had been mounted incorrectly, following the previous use of the tool. Therefore, this was not considered a contributing factor to the accident.

[7] Damaged back-up ring and excessive clearance between the stationary cylinder and moving piston.

[8] The hydraulic pressure required to dismantle main engine components was in the region of 800 bar to 990 bar. The assembly of main engine components required a pressure of 900 bar.

The hydraulic fluid

The instructions on the manual also specified the type of hydraulic oil, which had to be used, cautioning further that the use of other types of oils, especially those which are normally alkaline, could damage the back-up rings.

It was confirmed that the hydraulic fluid used was Gulfsea Hydraulic Oil 32. The chemical properties of the fluid met the criteria stipulated by the manufacturers of the hydraulic jack and therefore, the type of hydraulic fluid in use was not considered as a contributing factor to this accident.

Results from the lab

The damaged sealing and back-up rings were sent to a metallurgical laboratory for analysis. For comparison purposes, new O-rings were also sent to the laboratory. Shore hardness testing was carried out using Bareiss Digi Test durometer[9]. Measurements were taken on the O-ring samples on both the surface and on the previously cut cross sections.

Moreover, a Fourier-transform Infrared (FTIR) spectroscopy was carried out to obtain a unique IR spectrum, reflecting the materials' chemical makeup. Attenuated total reflectance Fourier-transform infrared spectroscopy was carried out. The hardness data (**Table 1**) and the infrared spectra of both O-ring samples (**Figure 7**) confirmed that the O-rings were virtually identical with no indicator of change or degradation being detected.

Table 1: Shore hardness measurements

Shore A Hardness	Failed	New
	75.1	76.8
	73.1	78.8
	75.1	77.1
	80.1	74.3
	80.5	76.5
Mean ± St. Dev.	76.8 ± 3.0	76.7 ± 1.4

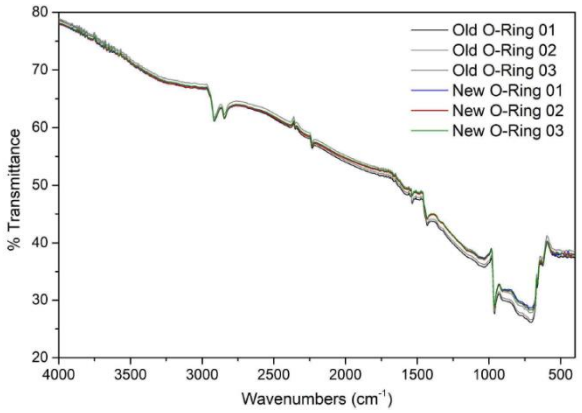


Figure 7: FTIR spectra of both samples, superimposed

Risk prediction and assessment

Risk prediction, assessment and control are considered to be the cornerstones of any safety management system. The risk assessment documents made available to the safety investigation, did not suggest that the hazard related to the maximum lift had been picked up and therefore, the risk was not considered and mitigated by the two crew members doing the assessment. Subject that both crew members were actively engaged in the risk assessment exercise, this agreement on hazards and related risks, and control measures suggested collaboration rather than individualistic risk perception.

[9] The instrument measured the hardness of polymers representing mechanical strength as a function of resistance to macro indentation.

The safety investigation was cognisant that the hydraulic jack was used regularly. In fact, prior to the accident, the jack had been used for the overhaul of an exhaust valve on the main engine. That suggested that the crew members were aware of the 10 mm maximum lift, imposed by the manufacturers.

It has to be submitted that it may not be possible for individuals doing the risk assessment to foresee all possible events, which may eventually lead to the accident. The risk assessment exercise, in which the hazard and risk could have potentially been addressed was under the job description "[o]verhaul main engine piston on Unit No. 5," – Job step: liner, cylinder cover, cylinder head. The safety investigation was of the view that very typical of risk assessment exercises, given that the core activity described in the document was the overhaul of the piston (rather than the overhaul of the cylinder head), it appeared that the step had not been considered during the exercise.

Missing on this step may have also been made more possible if the list of hazards, risk and control measures had not been evaluated with other crew members, who already had experience of main engine units' overhaul. The safety investigation did not come across any information, which suggested that the (draft) document had been discussed with other crew members.

CONCLUSIONS

1. The upper sealing ring of the hydraulic jack became displaced from its recess, leading to an injury to the crew member.
2. The safety investigation did not exclude the possibility that the back-up ring had been damaged before the accident and went unnoticed by the crew members.
3. The possibility of excessive clearance between the two hydraulic jack components was not excluded. If so, the moving piston lift could reach a position, high enough for the upper O-ring to pop out of its recess.
4. The risk assessment documents made available to the safety investigation, did not suggest that the hazard related to the maximum lift had been picked up.
5. The failure of the O-rings was neither attributed to its quality nor to material degradation.

RECOMMENDATIONS

NSB Neiderelbe Shiffahrtsgesellschaft MBH & Co. KG is recommended to:

14/2024_R1 distribute this safety investigation report to ensure that crew members serving on board Company managed ships are aware of the findings and discuss the outcome of the safety investigation during on board safety management meetings.

SHIP PARTICULARS

Vessel Name:	CMA CGM San Antonio
Flag:	Malta
Classification Society:	Det Norske Veritas
IMO Number:	9294173
Type:	Container vessel
Registered Owner:	CMA CGM SA The French Line
Managers:	NSB Neiderelbe Shiffahrtsgesellschaft MBH & Co. KG
Construction:	Steel
Length Overall:	222.15 m
Registered Length:	210.00 m
Gross Tonnage:	28,592
Minimum Safe Manning:	15
Authorised Cargo:	Containers

VOYAGE PARTICULARS

Port of Departure:	Khalifa, UAE
Port of Arrival:	Jebel Ali, UAE
Type of Voyage:	Coastal
Cargo Information:	Containerised cargo
Manning:	24

MARINE OCCURRENCE INFORMATION

Date and Time:	21 October 2023 at 16:46 (LT)
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	Jebel Ali (Lay-by berth)
Place on Board	Engine-room
Injuries / Fatalities:	One injury
Damage / Environmental Impact:	None reported
Ship Operation:	Normal service - Maintenance
Voyage Segment:	Alongside
External & Internal Environment:	Clear sky with good visibility. Calm sea and an air temperature is 35 °C. Artificial light inside the engine-room.
Persons on board:	24