Marine Safety Investigation Report

VERY SERIOUS MARINE CASUALTY | **January 2024**

Constellation
Steam release fatality 10 February 2024

The Bahamas Maritime Authority

The Bahamas conducts marine safety or other investigations on ships flying the flag of the Commonwealth of the Bahamas in accordance with the obligations set forth in International Conventions to which The Bahamas is a Party. In accordance with the IMO Casualty Investigation Code, mandated by the International Convention for the Safety of Life at Sea (SOLAS) Regulation XI-1/6, investigations have the objective of preventing marine casualties and marine incidents in the future and do not seek to apportion blame or determine liability.

Reports website
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casualty@bahamasmaritime.com

What happened

On the afternoon of 9 February 2024, the Bahamas flagged LPG tanker Constellation was on enroute from Sheiko, China to Houston, U.S.A. During routine inspections the second engineer reported fluctuations in pressure and temperature from the auxiliary boiler. A decision was taken by the chief engineer to inspect the boiler the following day.

Following an inspection on the morning of 10 February 2024, it was identified that the furnace exhaust drainpipe was blocked with carbon deposits. A fitter, motorman and a wiper were assigned the task of removing the furnace drainpipe and unblocking it.

When opening an adjacent handhole cover in an attempt to gain access to the furnace drainpipe from inside, the fitter suffered severe burns when he was exposed to steam and hot water. Despite immediate medical assistance on board and medical care ashore the fitter died as a result of his injuries.

Why it happened

The fitter took a decision to open up the handhole cover in the belief that he could gain access to the furnace drainpipe in order to unblock it. Unknown to him or the crew he was working with, the cover actually gave access to the water side of the boiler which was full of water at 127°C and pressurised to 2.5 bar.

Although a meeting was carried out in the morning, the work party did not assess all potential risks, including gaining access to the boiler from another entry point not specified or approved by the engineer in charge of the works.

What we can learn

A shared mental model is vital when work is being carried out on complex systems that are pressurised. Personnel working on such systems should be suitably trained and appropriately briefed.

All personnel working where a potential risk of harm exists are encouraged to exercise the Stop Work Authority if an unsafe condition arises but, if you don't understand the system, you cannot necessarily see the risk.

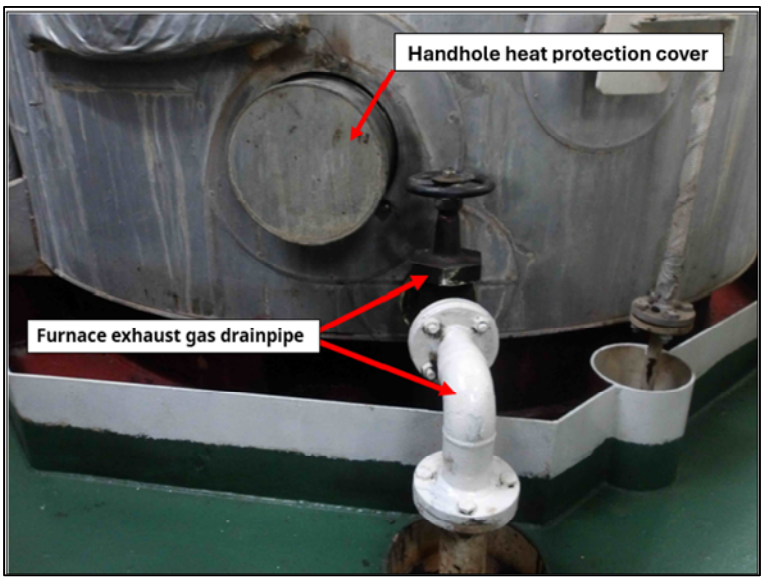
Narrative

All times in this report are local time (UTC -4)

On Friday 9 February 2024, the Bahamas flagged LPG tanker, Constellation was enroute from Sheiko, China, to Houston, USA. During passage the engineering department noticed pressure fluctuation and firing instabilities on the vessel's auxiliary boiler. Following a discussion with the engineering officers, the chief engineer stopped the boiler at 16:40 and changed the heating supply from steam to an alternative electrical boiler, in order to investigate the source of its malfunction the following day.

At 07:45 on Saturday 10 February 2024, the engineering department convened in the engine control room (ECR) for the daily toolbox meeting. One of the items for discussion was the washing and flushing of the auxiliary boiler exhaust gas discharge drainpipe, suspected of being clogged up with carbon deposits, and seen as one of the most likely causes of the drop in pressure the day before. The fitter, motorman and a wiper were tasked with this work, overseen by the second engineer

The chief engineer and second engineer broke the group into teams and assigned tasks in order to complete works prior to taking part in planned shipboard drills later that day. Risk assessments were completed and discussed during the meeting as well as the raising of relevant permits to work.



Base of auxiliary boiler

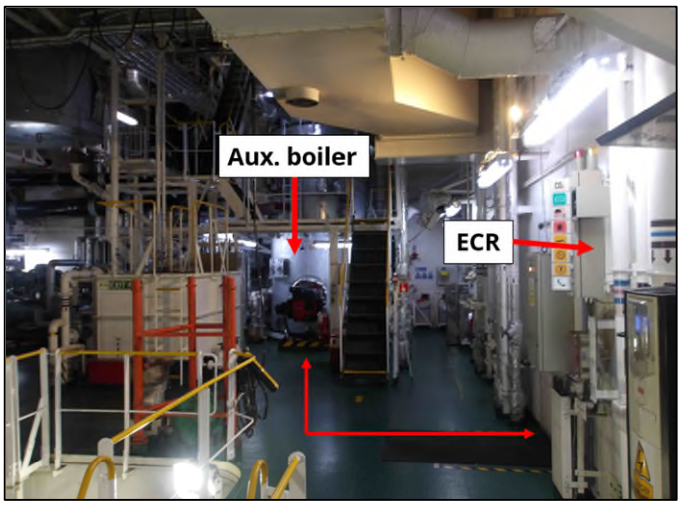
At 08:05, the teams left the ECR and commenced with their assigned tasks. Prior to the work commencing, the second engineer went over the work required with the fitter's team, and instructions were provided on the dismantling and cleaning of the exhaust gas drainpipe. This involved the removal of the pipe in two sections allowing for visual access to the furnace drainpipe opening on the side of the boiler.

The third and fourth engineers were tasked with opening the auxiliary boiler burner to service and replace worn parts in preparation for restarting and testing of its pressure. This process would be complete once the boiler had undergone its wash down and the exhaust gas drainpipes flushed out.

Auxiliary boiler with burner closed (left) and open during maintenance.

The second engineer was responsible for oversight of both teams and the work being carried out. He would rotate between the teams and their respective jobs, and where necessary provide assistance.

Whilst members of the engineering department set about completing their tasks, the chief engineer remained in the ECR to assist the electro-technical officer in testing of the alarms on the alarm panels, working with deck officers on the bridge to acknowledge and cancel them out as part of the checks in line with their planned maintenance system. Overall monitoring of the work being caried out on the auxiliary boiler was made easier due to the proximity of the ECR to the boiler.



Proximity of ECR to auxiliary boiler

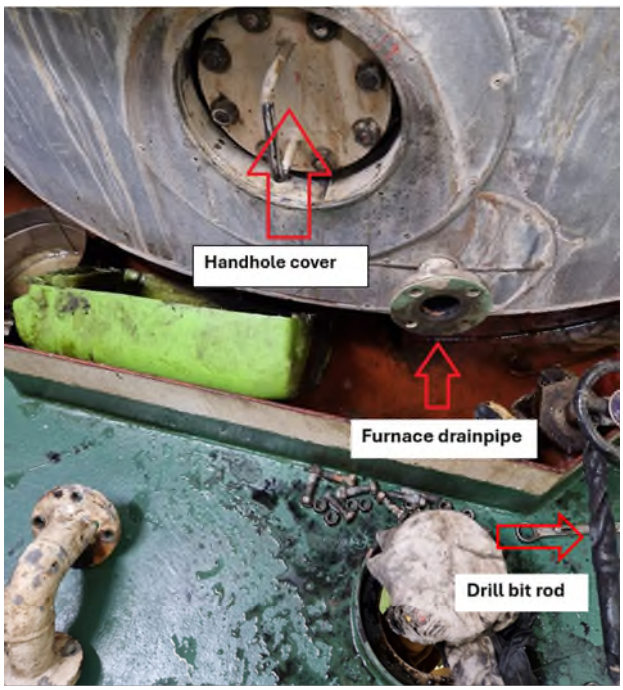
As part of the risk assessment and permit to work, the auxiliary boiler start-up and shut off switch was locked out and tagged out in the ECR to prevent any accidental start from occurring, and the associated fuel lines connected to the burner were isolated in preparation for the burner to be swung out for inspection and servicing.

Having explained what was required of them, the second engineer left the fitter, motorman and wiper to dismantle and clear the furnace drainpipe. The second engineer then went to assist the third and fourth engineers with replacing the burner's nozzle, and the installation of electrodes to the burner which was situated on the opposite side of the boiler to where the other team were working.

Shortly after being briefed by the third and fourth engineer on their plan to service the burner, the second engineer returned to the fitter and motorman to check on their progress. When the second engineer noticed that the

drainpipe within the base of the boiler was clogged. The wiper and fitter were instructed to unclog the furnace drainpipe first before attempting to flush it through.

The motorman decided that the best course of action would be to use a purpose made tool (an adapted drill bit) to work the carbon deposits free. The fitter informed the motorman that he would go to the workshop and retrieve the drill bit rod to aide him in unblocking the build-up, hopeful that it would loosen allowing them to clear the line ready for flushing.



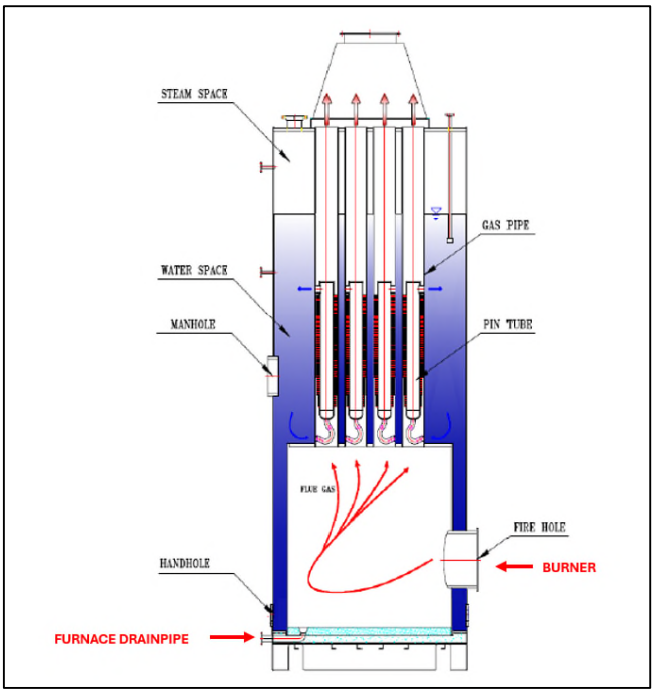
Furnace drainpipe and heat protection cover removed

While the fitter was away fetching the tools, the motorman set about cleaning the removed furnace drainpipe elbow and valve.

The fitter returned a short while later with a cordless impact driver and socket attachment. He informed the motorman and wiper that he was concerned that the tool could damage the inside of the drainpipe. The fitter stated that the best course of action would be to remove the handhole cover next to the drainpipe which would allow for easier access to investigate the drainpipe from inside.

The fitter first took a screwdriver and removed the outer heat protection. He then set about removing the nuts from the cover with the use of the impact driver. After loosening six of the eight nuts, the handhole cover was proving difficult to swing free and the fitter instructed the wiper to pass him a hammer in order to crack it open, suspecting that the gasket was seized.

The fitter took hold of the hammer and proceeded to hit the handhole cover, and at 08:45 the cover sprung loose resulting in the sudden release of steam and hot water which engulfed the fitter, the lower abdomen of the motorman and scalded the wiper's arm.



Cross-section of auxiliary boiler

Due to the sudden release of steam, the fire detectors were triggered and the fire alarm sounded. The high pitched noise accompanied by a large cloud of steam drew the attention of the engineers working on the opposite side of the boiler. The fitter, motorman and wiper, who had been struck by the steam and boiling water ran for cover which alerted the chief engineer in the ECR.

The second engineer immediately went to see if he could shut off the release of steam and boiling water, whilst the third and fourth engineer escorted the fitter, motorman and wiper to a safe area. The third and fourth engineer began removing the boilersuits of the fitter, motorman and wiper in order to prevent the acceleration of blistering from forming.

The chief engineer contacted the master and the officer on watch on the bridge and notified them of the incident. The general alarm was sounded, and the medical team despatched to meet the injured crew at the entrance to the engine room for transfer to the ship's hospital.

The second engineer managed to shut off the steam and hot water, before joining the third and fourth engineers for an update on the injured crew. At this point, the chief officer and second officer had made their way down to the entrance of the engine room and were ready to accompany the burn victims to the ship's hospital to commence with medical treatment.

Following discussions with the company's designated person ashore, and shoreside medical assistance service providers, the master altered course for the nearest port of Rio Haina, Dominican Republic.

Once at the ship's hospital, it became apparent to the chief officer and second officer that the fitter had suffered severe burns and blistering to more than fifty percent of his body. The fitter was placed on a bed and the second officer attempted to alleviate the pain and reduce the possibility of more blisters forming by applying cold wet dressings and cool soothing burn gel, along with the administering of pain killers.

After assessment and treatment, the motorman asked if he could rest in his cabin, assuring the officers that he would rest and keep his lower leg and groin area clean and apply burn gel as and when required in preparation for transfer to the hospital. Both the chief officer and second officer agreed. The wiper was treated for a minor burn to his upper arm which did not require any further medical care.

The second officer, supported by the chief officer, remained with the fitter throughout the course of the day and into the early hours of the following morning when the vessel berthed in Rio Haina.

On arrival at the berth at Rio Haina, medics were already on the quay having been requested earlier by the master. Due to the risk of further skin damage, transfer by stretcher was not an option and the second officer helped the fitter walk to the ambulance which the patients to the burn's unit at the hospital in Rio Haina to begin treatment but, after four days, the fitter died of complications from his burns.

Vessel and Crew

The Bahamas registered Constellation was a 225 metre liquid petroleum gas tanker. Constellation's 27 crew were made up of 19 Filipino nationals, three Ukrainian nationals, three Croatian nationals, one Russian national and a Latvian national, who all held appropriate qualifications for their respective roles on board.

The victim was 50 years old and had served in rank with the company for five years. On the day of the casualty, he was assigned to a team in the engine room, and had come off his rest period following a period of 8 hours work from 08:00 to 17:00, preceded by his regular work pattern of day shift.

Previous similar cases

The Bahamas Maritime Authority has recorded two previous cases involving the release of steam and hot water in the last six years.

Navigator of the Seas (2020) Bahamas
In preparation for inspection and maintenance, a feedwater tank had been emptied, confined space entry paperwork had been completed and the deck team assigned to the task had discussed the hazards and control measures identified in the job safety analysis. A short while later, with three crew members inside, there was a sudden release of steam into the tank. All three managed to exit the tank but two seafarers suffered significant burns. Both were evacuated to a hospital that afternoon, but one seafarer died from injuries, five days later.
www.bahamasmaritime.com/wp-content/uploads/2022/09/Navigator-of-the-Seas-MSI-Report-final.pdf

Norwegian Escape (2018) Bahamas
An assistant engineer observed a leakage in the vicinity of an insulated hot potable water pipe in the engine room. A motorman and oiler were tasked to remove the insulation material and tighten the coupling while the system was under an operating pressure of 8 to 9 Bars and with a temperature of around 65°C. Whilst tightening the coupling, it failed - resulting in a pressurised release of steam and hot water. The motorman and oiler suffered severe burn injuries due to the exposure to steam and hot water.
www.bahamasmaritime.com/wp-content/uploads/2020/10/BMA-Investigation-Report-Serious-crew-injuries-onboard-the-Norwegian-Escape.pdf

Analysis

The purpose of the analysis is to determine the contributory causes and circumstances of the casualty as a basis for making recommendations to prevent similar casualties occurring in the future.

Cause of injury

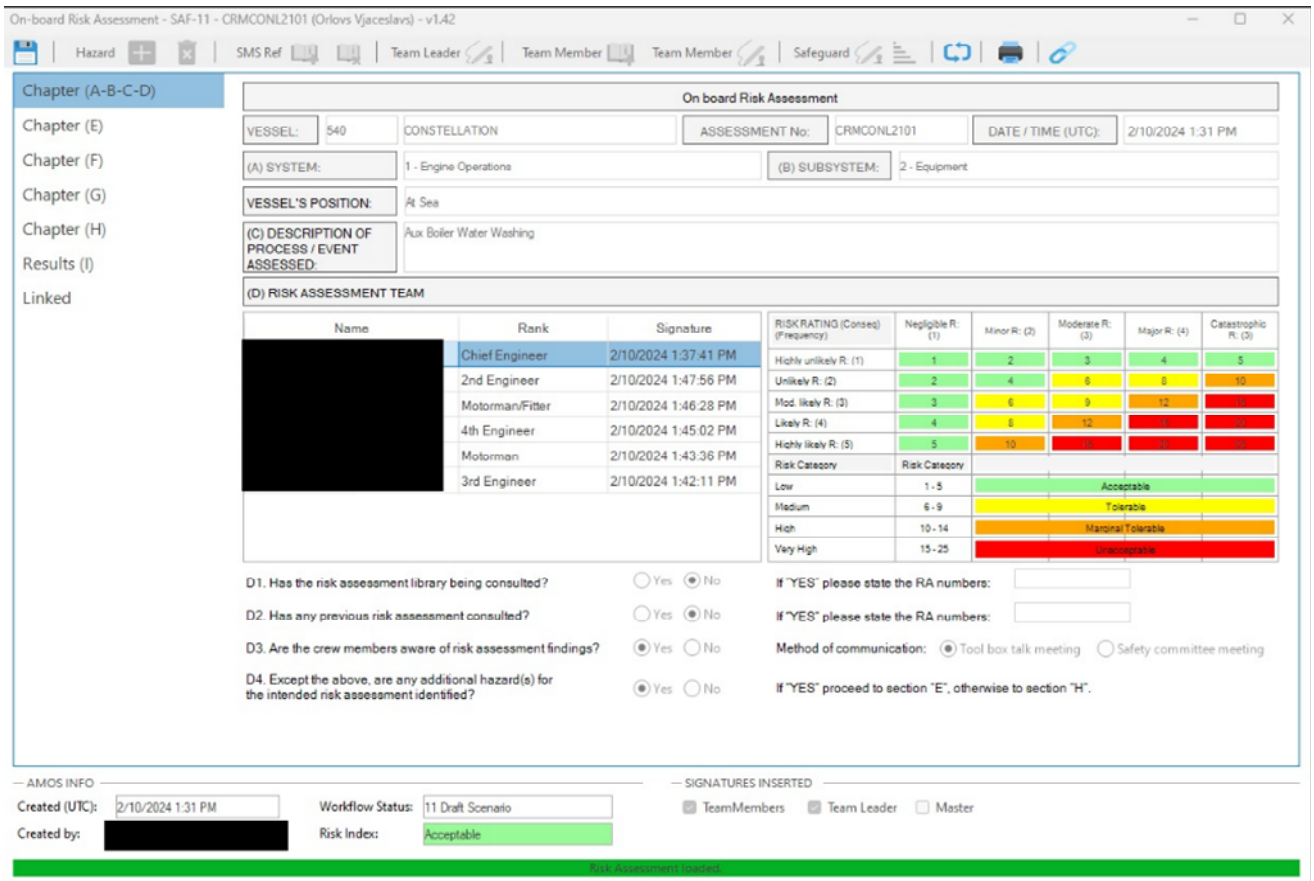
The cause of injury was the sudden release of pressurised hot water and steam when the fitter opened a sealed handhole cover to the water space of the auxiliary boiler that was filled with water at 127°C and pressurised to 2.5 bar. The fitter was not familiar with the arrangement of the boiler and unaware that the space would be pressurised with steam or hot water present.

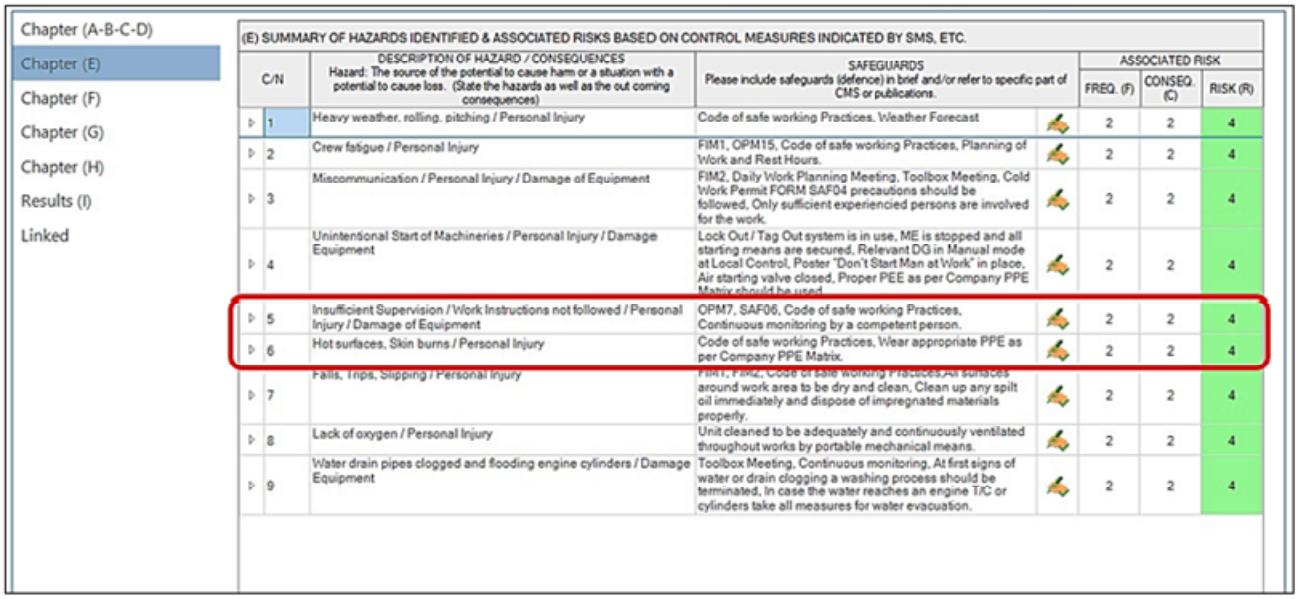
Safety Management System

The Company operated a Safety Management System (SMS) onboard. The chief engineer had oversight for ensuring compliance with the SMS, and that these procedures are followed within the engineering department.

Dorian LPG had a positive commitment to ensuring the safety of its crew, whereby it continually reviewed the SMS. In particular, the relevance of risk assessments undertaken, permits to work, policies, procedures, protection equipment, checklists, forms, and associated records were routinely reviewed.

For the work on the boiler, the risk assessment completed was generic for “engine operations”:





Chapter (A-B-C-D)
Chapter (E)
Chapter (F)
Chapter (G)
Chapter (H)
Results (I)
Linked

(E) SUMMARY OF HAZARDS IDENTIFIED & ASSOCIATED RISKS BASED ON CONTROL MEASURES INDICATED BY SMS, ETC.

C/N	DESCRIPTION OF HAZARD / CONSEQUENCES Hazard: The source of the potential to cause harm or a situation with a potential to cause loss. (State the hazards as well as the out coming consequences)	SAFEGUARDS Please include safeguards (defence) in brief and/or refer to specific part of CMS or publications.	ASSOCIATED RISK FREQ. (F)	CONSEQ. (C)	RISK (R)
1	Heavy weather, rolling, pitching / Personal Injury	Code of safe working Practices, Weather Forecast	2	2	4
2	Crew fatigue / Personal Injury	FIM1, OPM15, Code of safe working Practices, Planning of Work and Rest Hours.	2	2	4
3	Miscommunication / Personal Injury / Damage of Equipment	FIM2, Daily Work Planning Meeting, Toolbox Meeting, Cold Work Permit FORM SAF04 precautions should be followed, Only sufficient experiencied persons are involved for the work.	2	2	4
4	Unintentional Start of Machineries / Personal Injury / Damage Equipment	Lock Out / Tag Out system is in use, ME is stopped and all starting means are secured, Relevant DG in Manual mode at Local Control, Poster "Don't Start Man at Work" in place, Air starting valve closed, Proper PEE as per Company PPE Matrix should be used.	2	2	4
5	Insufficient Supervision / Work Instructions not followed / Personal Injury / Damage of Equipment	OPM7, SAF06, Code of safe working Practices, Continuous monitoring by a competent person.	2	2	4
6	Hot surfaces, Skin burns / Personal Injury	Code of safe working Practices, Wear appropriate PPE as per Company PPE Matrix.	2	2	4
7	Falls, Trips, Slipping / Personal Injury	FIM1, FIM2, Code of safe working Practices,All surfaces around work area to be dry and clean, Clean up any spilt oil immediately and dispose of impregnated materials properly.	2	2	4
8	Lack of oxygen / Personal Injury	Unit cleaned to be adequately and continuously ventilated throughout works by portable mechanical means.	2	2	4
9	Water drain pipes clogged and flooding engine cylinders / Damage Equipment	Toolbox Meeting, Continuous monitoring, At first signs of water or drain clogging a washing process should be terminated, In case the water reaches an engine T/C or cylinders take all measures for water evacuation.	2	2	4

Extracts from engine operations risk assessment

The hazard of injury from hot surfaces, and skin burns was considered to be very unlikely and the outcome as minor, despite the system being at 127°C and pressurised to 2.5 bar. The only controls identified were the use of personal protective equipment (considered as standard for work in the engine room). Further controls for personal injury were limited to continuous monitoring.

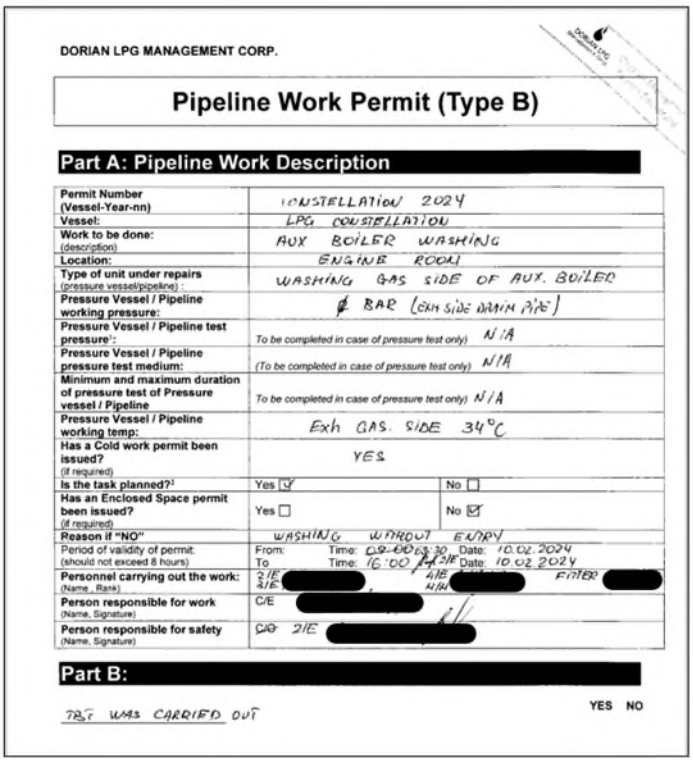
Although the engineering officers were familiar with the internal workings of the boiler systems and pressurised hot water lines, the fitter, motorman and wiper were not.

Furthermore, no discussion was carried out during the morning toolbox meeting on the recommended means of removing carbon deposits prior to flushing, and thereby removing the need to use a purpose made tool to chisel away at the internals of the drainpipe.

The SMS documentation contained defined procedures to operate and maintain the auxiliary boilers but there was no specific advice on wash down or flush through procedures, or the need for a formal risk assessment, for isolating or opening up of handhole covers adjacent to the furnace drainpipes.

Engine department crew had undergone onboard familiarisation into their areas of work and systems in operation, including the auxiliary boilers. The fitter and motorman's familiarisation covered the fundamentals on routine checks but did not provide them with detailed information on the systems they were working on.

Daily tasks were discussed during morning meetings at the start of each day in the ECR. The fitter did not perceive any danger of accessing the handhole cover to investigate the furnace drainpipe from the inside, which was informed by the assessment of risk and by the completion of the Pipeline permit to work which indicated zero pressure and 34°C temperature (exhaust gas side).



DORIAN LPG MANAGEMENT CORP.

Pipeline Work Permit (Type B)

Part A: Pipeline Work Description

Permit Number (Vessel-Year-nn)	CONSTELLATION 2024
Vessel:	LPG CONSTELLATION
Work to be done: (description)	AUX BOILER WASHING
Location:	ENGINE ROOM
Type of unit under repairs (pressure vessel/pipeline) :	WASHING GAS SIDE OF AUX. BOILER
Pressure Vessel / Pipeline working pressure:	4 BAR (EXH SIDE DRAIN PIPE)
Pressure Vessel / Pipeline test pressure[1]:	To be completed in case of pressure test only) N/A
Pressure Vessel / Pipeline pressure test medium:	(To be completed in case of pressure test only) N/A
Minimum and maximum duration of pressure test of Pressure vessel / Pipeline	To be completed in case of pressure test only) N/A
Pressure Vessel / Pipeline working temp:	Exh GAS SIDE 34°C
Has a Cold work permit been issued? (if required)	YES
Is the task planned?[2]	Yes ☑ No ☐
Has an Enclosed Space permit been issued? (if required)	Yes ☐ No ☑
Reason if "NO"	WASHING WITHOUT ENTRY
Period of validity of permit: (should not exceed 8 hours)	From: Time: 09:00 Date: 10.02.2024 To Time: 16:00 Date: 10.02.2024
Personnel carrying out the work: (Name, Rank)	2/E [redacted] 4/E [redacted] FITTER [redacted]
Person responsible for work (Name, Signature)	C/E [redacted]
Person responsible for safety (Name, Signature)	C/O 2/E [redacted]

Part B:

TEST WAS CARRIED OUT YES NO

Extract from Pressure Vessel Pipeline work permit for auxiliary boiler gas side washing

The Company operated a Stop Work Authority programme as part of its controls to manage safety onboard. Each crew member was reminded of the importance to stop any work activity they deem unsafe or posing a potential risk to the system or person performing the task. The motorman and wiper did not make an intervention to the fitter removing the handhole cover as the fitter had confidence in carrying out the task and they were not aware of any safety risk.

An opportunity was missed to stop the fitter from opening the handhole cover due to a lack of system knowledge within the team - they simply did not have a mental model of the internal workings of the auxiliary boiler or the pressurised and superheated water that was present.

Human Factors

Management onboard must be fully satisfied that all hazards of an operation have been considered before accepting the control measures likely to overcome them. Furthermore, management must understand human capabilities and limitations when applying that knowledge to the design of work, systems, tools, processes, and equipment.

In opening the handhole, the fitter was trying to complete the task as efficiently and safely as possible. Nothing about the design of the cover alerted him to the fact it led to the water space of the boiler. As the water space was at operating temperature the whole boiler was hot - therefore the prospect of the cover being hot would not have raised any flags to an increased risk.

The drain itself was prone to clogging – so much so, that the crew had manufactured a tool to clear the blockage - an opportunity was missed in the design of the drain to prevent clogging, thereby negating the need for manual intervention to unblock it.

Conclusions

The fitter sustained severe burns to over fifty percent of his body, when he removed a handhole cover to the hot and pressurised water side of the auxiliary boiler, releasing steam and hot water.

The fitter was tasked with clearing the furnace drainpipe and opened the handhole without the knowledge or approval of the second engineer. The fitter was not aware of the risks to him or his colleagues who were in close proximity when he took the decision to open the handhole cover.

Unaware of the risks faced by the fitter, motorman and wiper, the second engineer was focused on the work on the opposite side of the boiler meaning the team did not have adequate supervision or decision support.

The engineering department did not consider the risks associated with work adjacent to the hot and pressurised side of the boiler when assessing the risk of the work or during the morning toolbox meeting. The permit to work explicitly stated there was no risk from pressure or heat.

Although the Company promoted stop work authority, neither the motorman nor the wiper intervened and enforced it because the risk was unknown.

Action taken and Recommendations

Dorian LPG has:

- Amended guidance on work related to boilers, aligning risk assessment control measures with manufacturer's instructions.
- Revised the fleet's onboard risk assessment library to incorporate additional controls for works carried out on pressurised systems and boilers.
- Shared findings from their internal investigation as lessons to be learned throughout their fleet.
- Updated its procedures with the aim of improving the master's and chief engineers' oversight and control of all aspects relating to boilers.
- Introduced a gamified training program designed to enhance the behaviour of "Care" a with the aim of maintaining a safe working environment onboard.

Considering the actions taken, there are no recommendations.

Vessel particulars	
Vessel name	Constellation
Vessel type	Liquid Petroleum Gas tanker
Flag / IMO number	Bahamas / 9734680
Registered owner	Constellation LPG Transport LLC
Manager	Dorian LPG Management Corp.
Classification Society	American Bureau of Shipping
Built	2015, Ulsan, Republic of Korea
Length / breadth / moulded depth	225m / 36.6m / 18.64m
Gross / net tonnage	48,060 / 18,641
Minimum safe manning	16
Authorised cargo	Liquid Petroleum Gas

Voyage Particulars	
Departure port	Sheiko, Peoples Republic of China
Arrival port	Houston, Texas, United States of America
Distance / duration	1677 nautical miles / 6 days
Cargo information	In ballast
Crew	27 crew

Marine Casualty Information	
Severity of casualty	Very Serious Marine Casualty
Date / time	10 February 2024 / 08:45 LT
Geographical location	15°24.4'N 070°00.6'W (Caribbean Sea)
Place onboard	Machinery space
Injuries / fatalities	One fatality, one injured
Damage / environmental impact	No structural damage/ environmental impact
Ship operation	Making way
Stage of passage	Deep sea
External environment	Daylight. Wind: N'ly Force 2.
Internal environment	Air conditioned, well lit.