Interim report MO-2017-203: Burst nitrogen cylinder causing fatality on board the passenger cruise ship *Emerald Princess*, 9 February 2017

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Interim Report

Marine inquiry MO-2017-203

Burst nitrogen cylinder causing fatality on board the passenger cruise ship *Emerald Princess*

9 February 2017

Approved for publication: April 2017

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission and this report

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of the occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

It would not be appropriate then to use this interim factual report to pursue criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this preliminary report inadmissible as evidence in any proceedings. A full report will be released on completion of the inquiry.

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Important notes

Nature of this report

This interim report is an example of a preliminary report referred to in section 9 of the Transport Accident Investigation Commission Act 1990. It is not a draft report prepared for comment but a completed report, which the Commission believes is necessary or appropriate in the interests of transport safety.

This interim report presents the facts and circumstances established up to this point in the Commission's inquiry, and contains no analysis or findings. Any extrapolation of the information given in this report would be speculation.

Final report may include different information

The Commission intends completing a final report on the accident after it completes its inquiry. That report will contain an analysis of the facts of the accident, findings and any further recommendations. The information contained in the Commission's final report may differ from the information contained in this interim report.

Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this interim factual report are provided by, and owned by, the Commission.

Verbal probability expressions

The expressions listed in the following table are used in this report to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis.

Terminology (Adopted from the Intergovernmental Panel on Climate Change)	Likelihood of the occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

The *Emerald Princess*

Location of accident

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Abbreviations

SOLAS	Safety of Life at Sea Convention

Glossary

bar	a metric unit of pressure. It is equal to 100,000 Pascal, which is slightly less than the current average atmospheric pressure on Earth at sea level

Data summary

Vessel particulars

Name:	*Emerald Princess*
Type:	passenger ship
Limits:	unlimited
Classification:	Lloyds Register
Length:	288.61 metres
Breadth:	36.05 metres
Draught:	8.6 metres
Gross tonnage:	113 561
Built:	2007
Propulsion:	diesel electric (six Wärtsilä engines)
Service speed:	22 knots
Owner/Operator:	Princess Cruise Lines Limited
Port of registry:	Hamilton, Bermuda

Date and time	9 February 2017 at 1700	
Location	at the berth in Port Chalmers, Dunedin	
Persons on board	passengers:	3 113
	crew:	1 173
Injuries	one fatality	
Damage	burst nitrogen cylinder and damage to equipment on deck 8 adjacent to lifeboat No. 24	

1. Background information

1.1. At about 0730 on 9 February 2016, the passenger cruise ship *Emerald Princess* berthed in Port Chalmers, New Zealand. The ship was scheduled to depart the same day.

1.2. The *Emerald Princess* was fitted with 18 lifeboats, six passenger tenders and two fast rescue boats. The boats were stowed on deck 8 and could be lowered and raised using the lifeboat launching and recovery davits.

1.3. The davits were hydraulically powered by six hydraulic power packs, three power packs for each side of the vessel. The Safety of Life at Sea (SOLAS) convention required an emergency launching and recovery system to be provided so that the lifeboats could be launched even if the ship suffered a total power failure. To comply with this convention a stored energy system comprising a piston accumulator and a bank of four high-pressure nitrogen cylinders was fitted to each launching davit.

1.4. The nitrogen system had a nominal working pressure range of between 180 and 210 bar[1]. Prior to the vessel's arrival at Dunedin, the crew observed that the pressure of the nitrogen system for lifeboat No. 24 davit had dropped to about 165 bar.

1.5. On arrival at Dunedin the crew checked the system. The four nitrogen cylinders were connected by fixed pipes to a pneumatic distribution block. The crew checked all of the connections for leaks, but were unable to find any. They did not check the nitrogen cylinders because they thought it highly unlikely that the pressurised cylinders had been structurally compromised.

1.6. The crew then decided to replace the entire manifold in case there were leaks within the unit. They depressurised the system and exchanged the pneumatic distribution block with a new one. The crew then followed the standard procedure to re-pressurise the system.

1.7. During the final stage of the re-pressurising operation, one of the four nitrogen cylinders burst, fatally wounding an engine room fitter who was standing close by.

Inspection requirements

1.8. There was a total of 104 nitrogen cylinders on board the *Emerald Princess*. Ninety-six cylinders were from the batch of cylinders supplied with the ship at the new-build. They were manufactured in 2006.

1.9. The Bermudan regulations required the nitrogen cylinders to be internally inspected and tested every 10 years. It had been 10 years and seven months since the cylinders had been manufactured.

1.10. The ship's planned maintenance system recorded the requirement for a 10-year inspection and test. A further line of inquiry is the nature of the periodic inspections of the nitrogen cylinders by on-board staff and the manufacturer or its authorised representative.

1.11. The SOLAS convention requires that lifeboat launching appliances be inspected annually by their manufacturers or their authorised representatives.

1.12. The banks of nitrogen cylinders were fitted on a covered but open deck and as such were exposed to salt spray and sea air.

1.13. Each bank of four cylinders sat within a steel frame unit, secured by a steel band approximately three-quarters of the way up the base of the cylinder. The base of each cylinder was fitted with a steel foot, which had been heat shrunk around the base of the cylinder to allow the cylinder to stand upright in the base of the steel frame unit (see Figures 1 and 2).

[1] Bar is a metric unit of pressure. It is defined as exactly equal to 100,000 Pascal, which is slightly less than the current average atmospheric pressure on Earth at sea level.

Figure 1
Typical four-cylinder installation on the *Emerald Princess*

Figure 2
Damaged storage frame that held the burst cylinder

Post-accident inspection and testing

1.14. The remains of the burst nitrogen cylinder were recovered together with the other three cylinders from the same frame. The top of the burst cylinder was never found, having possibly been ejected into the sea. A randomly selected representative cylinder from another bank of cylinders was also retained.

1.15. All five cylinders were taken to the Transport Accident Investigation Commission's (Commission's) technical facility in Wellington, New Zealand, where an examination was made by a contracted independent expert metallurgist.

1.16. The burst nitrogen cylinder had suffered significant corrosion at the point of failure, which was situated approximately 150 millimetres below where the steel securing band had clamped the cylinder within its frame. The corrosion had developed on the outside of the cylinder. The internal surface was clear of corrosion. Corrosion had reduced the thickness of the cylinder wall by about 75% at the point of failure (from six millimetres to about 1.5 millimetres). A second area of corrosion was noted near the bottom of the cylinder and a third area where the protective coating had been scraped away to observe the cylinder's identification details.

1.17. The metallurgist's initial assessment was that the failure had occurred as a result of overload caused by corrosion thinning.

1.18. A number of other cylinders on board the ship were observed to have similar corrosion-related damage. Significant corrosion damage was also observed on the accumulator, which is the pressurised vessel connecting the nitrogen cylinders and the stored energy system.

Figure 3
Burst nitrogen cylinder together with the other three cylinders in the set

Figure 4
Significant corrosion around the top of other cylinder in the bank

Figure 5
Significant corrosion at the point of failure

2. Recommendations

2.1. General

2.1.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to all Flag States, the International Association of Classification Societies, the manufacturer of the lifeboat alternative launching system and the Cruise Lines International Association.

2.1.2. In the interests of transport safety, it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

2.2. Recommendation to Navalimpianti Tecnimpianti Group

The nitrogen cylinders that formed part of the stored-energy alternative launching system on board the *Emerald Princess* were stowed in a harsh marine environment and had significant external visible corrosion.

The initial indications are that the nitrogen cylinder burst as a result of overload in the area of corrosion thinning.

The circumstances of this accident raise the question of whether the current inspection requirements for a competent person are adequate for a pressure vessel stored in a harsh marine environment.

The nitrogen cylinders were inspected annually by the manufacturer's authorised representative, and the most recent inspection was two weeks prior to the accident. On each occasion the cylinders were found in satisfactory working condition. The Commission is concerned that there might be other pressure vessels part of the same system or similar systems that could pose a significant danger to seafarers and passengers.

On 10 April 2017 the Commission recommended to the manufacturer that, as a matter of urgency, it contact all known ship owners that have the same or similar emergency launching and recovery systems installed on their vessels, informing them about the circumstances of this accident, and advising them to have the systems inspected immediately by a competent person to check whether the nitrogen cylinders and other pressure vessels associated with the systems are fit for purpose. Any nitrogen cylinders deemed unfit due to corrosion should be removed for further assessment. (010/17)

On 21 April 2017, Navalimpianti Tecnimpianti replied in part:

> We shall highlight that the interim report does not reflect that our last service intervention commented that, even if the launching appliance was in satisfactory working condition, the nitrogen bottles were reported aged and consequently recommended replacement.
>
> As per your recommendation, please be informed that we are promptly contacting all out customers having the same or similar equipment on board and our service networks is following up to support our customers in this dedicated inspection. Any nitrogen cylinder deemed unfit due to corrosion will be required to be removed for further assessment.

2.3. Recommendation to International Association of Classification Societies

2.3.1. The nitrogen cylinders that formed part of the stored-energy alternative launching system on board the *Emerald Princess* were stowed in a harsh marine environment and had significant external visible corrosion.

The initial indications are that the nitrogen cylinder burst as a result of overload caused by corrosion thinning.

The accident raises the question of whether the current inspection requirements for a competent person are adequate for a pressure vessel stored in a harsh marine environment.

The Commission is concerned that there might be other pressure vessels part of the same system or similar systems that could pose a significant danger to seafarers and passengers.

On 10 April 2017 the Commission recommended to the International Association of Classification Societies that it inform all of its members about the circumstances of this accident and advise them to alert their surveyors to pay special attention to any corroded nitrogen cylinders or other pressure vessels when conducting their Class or Flag State surveys, particularly when inspecting pressure vessels stored in an open marine environment. (011/17)

On 10 April 2017, the International Association of Classification Societies replied in part:

> In accordance with attached IACS "Guidelines of Marine Accident Investigation Reports" you are kindly invited to direct any recommendations from Marine Accident Investigation to the vessel's Classification society for Class matters and flag Administration for Statutory matters please.

2.4. Recommendation to the Cruise Lines International Association

2.4.1. The nitrogen cylinders that formed part of the stored-energy alternative launching system on board the *Emerald Princess* were stowed in a harsh marine environment and had significant external visible corrosion.

The initial indications are that the nitrogen cylinder burst as a result of overload caused by corrosion thinning.

The accident raises the question of whether the current inspection requirements for a competent person are adequate for a pressure vessel stored in a harsh marine environment.

The Commission is concerned that there might be other pressure vessels part of the same system or similar systems that could pose a significant danger to seafarers and passengers.

On 10 April 2017 the Commission recommended to the Cruise Lines International Association that as a matter of urgency it contact members, informing them about the circumstances of this accident and warning them to have the systems inspected immediately by a competent person. Any corroded nitrogen cylinders or other associated pressure vessels should be removed for further assessment. (012/17)

On 13 April 2017, Cruise Lines International Association replied:

> In response to your letter addressed to us dated 10 April 2017 (regarding MO-2017-203), I can confirm that we have reviewed your request, the interim report, and the relevant proposed recommendation. We would be pleased to timely address this recommendation with our membership, upon publication of the actual report. We would further ask that the final version of the report affirmatively state our commitment to do so. CLIA represents approximately 95% of the world's oceangoing cruise ship capacity, so our engagement on this should have a broad reach to the potentially affected community.

2.5. Recommendation to the Director of Maritime New Zealand

2.5.1. The nitrogen cylinders that formed part of the stored-energy alternative launching system on board the *Emerald Princess* were stowed in a harsh marine environment and had significant external visible corrosion.

The initial indications are that the nitrogen cylinder burst as a result of overload caused by corrosion thinning.

The accident raises the question of whether the current inspection requirements for a competent person are adequate for a pressure vessel stored in a harsh marine environment.

The Commission is concerned that there might be other pressure vessels part of the same system or similar systems that could pose a significant danger to seafarers and passengers.

On 10 April 2017 the Commission recommended to the Director of Maritime New Zealand that he inform all New Zealand surveyors and port state control officers about the circumstances of this accident and advise them to pay special attention to any corroded nitrogen cylinders or other pressure vessels when conducting their Class or Flag State surveys, particularly when inspecting pressure vessels stored in an open marine environment. (013/17)

On 20 April 2017, Maritime New Zealand replied:

> On 20 April 2017, Maritime New Zealand issued Safety Bulletin 34 to all New Zealand Surveyors and Port State Control Officers, trainee Port State Control Officers, Maritime Officers and their respective managers. This bulletin will also be posted on Maritime New Zealand's public website- http://www.maritimenz.govt.nz/commercial/safety/safety-updates/safety-bulletins/

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