Departmental investigation into switchboard fire aboard the Australian flag bulk cement carrier Goliath at Devonport, Tasmania on 23 August 1997

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MIIU

COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Contents

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Navigation (Marine Casualty) Regulations

investigation into the switchboard fire aboard the Australian flag

bulk cement carrier GOLIATH at Devenport Tasmania on 23 Auugust 1997

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Summary

At 2200 on 23 August 1997, the self-discharging bulk cement carrier *Goliath* was alongside in the port of Devonport, Tasmania, loading a cargo of bulk cement for discharge in Melbourne and Sydney. At about 2202, the ship's fire alarms sounded throughout the accommodation.

Cargo operations were suspended and the Chief and 1st Engineers made their way to the central control station. The ship's fire detection system indicated the alarm had been activated from the transformer room, adjacent to the main switchboard room. Joined by the 3rd Mate they went to the engine room where they could smell burning electrical insulation. The Chief and 1st Engineers entered the switchboard room then the transformer room to investigate, while the 3rd Mate waited in the engine room.

Although the transformer room was filled with quite dense smoke, the two engineers entered, but then noticed that the smoke was coming from the main switchboard room behind them. The smoke was accumulating rapidly and the men were forced to leave the transformer room almost immediately, before they could locate the source of the smoke.

In the engine room the 3rd Mate relayed the Chief Engineer's assessment to the Master, confirming a large fire and requesting the assistance of the Tasmanian Fire Service.

The 1st Engineer, wearing breathing apparatus, went back into the switchboard room and found the seat of the fire in the main switchboard, in the cubicle containing No.2 generator air circuit breaker.

A team from the Tasmanian Fire Service arrived at 2216 and by 2235 the firemen had extinguished the fire using CO_2 and dry powder extinguishers.

Wearing BA, the Chief and 1st Engineers removed the circuit breaker from its cubicle and cooled it with a water hose. The circuit breaker was damaged beyond repair and heat had caused considerable damage to the adjacent cubicles either side of No.2 circuit breaker.

Repairs, which were carried out by contractors over the next 18 days, included the replacement of all the ship's Hyundai manufactured air circuit breakers with new ones manufactured by Terasaki in Japan.

Sources of information

The Master and officers of *Goliath.*

Australian Maritime Safety Authority

NHP Electrical Engineering Products Pty Ltd

CSR Shipping Division

Lloyd’s Register of Shipping

Acknowledgment

The inspector also acknowledges the assistance of the Tasmanian Fire Service.

The Inspector gratefully acknowledges the assistance of the Australian Maritime Safety Authority, Devonport, in conducting the field investigation on behalf of the Marine Incident Investigation Unit.

Narrative

Goliath

Goliath is an Australian flag, self-discharging, bulk cement carrier of 11,754 gross tonnes, (15,539 tonnes summer deadweight), with an overall length of 143 m, a beam of 23.5 m and summer draught of 8.34 m. The ship was built in 1993 at Ulsan, in South Korea, by Hanjin Heavy Industries Co. Ltd. It is owned by Goliath Portland Cement, Tasmania, and is managed by CSR Shipping of Sydney.

The ship operates a regular service from the port of Devonport in Tasmania, to Melbourne and Sydney, at a service speed of 14.5 knots.

Goliath is fitted with a Sulzer 5RTA52 single acting, two-stroke diesel main engine of 6,400 kW. Electrical power, at 415 volts, 50 Hz, is provided by four diesel generators with a total generating capacity of 3.33mW and an emergency diesel generator of 480 kW.

The vessel is fitted with a bow thruster unit.

The vessel's complement consists of the Master, three mates, four engineers and 10 ratings. The machinery spaces are classified as UMS (Unmanned Machinery Spaces). Of the four engineers, three carry out the tasks of the duty engineer, rotating on a daily basis.

The ship's machinery is controlled from a control room (the CRT room) in the engine room, while cargo and ballast are controlled from a Central Control Station (CCS). The CCS contains a panel for the ship's automatic fire detection system and one for the engine room alarms. The CCS is situated on the main deck opposite the Fire Control Station

The Incident

At 2200 on 23 August 1997, *Goliath* was alongside in the port of Devonport, loading a cargo of bulk cement for discharge in Melbourne and Sydney. The vessel had arrived at about 0725 that day and was due to sail at 0500 on the following morning.

At about 2202, the ship's fire alarms sounded throughout the accommodation. The fire doors in the stairwell automatically closed.

The Master went to his normal fire station, the wheelhouse, where the main fire alarm panel, the Public Address system and general alarms are situated. The Chief Engineer, having met the 1st Engineer in the alleyway, went to his fire station, the CCS, to check the location of the fire on the other fire detection panel. Already in the CCS were the Mate and 3rd Mate, who were on cargo watch. The Mate stopped cargo operations.

It was established from the fire detection panel that the fire alarm had been set off by a detector in the transformer room, adjacent to the main switchboard room. The Chief Engineer, 1st Engineer and 3rd Mate went immediately to the engine room to investigate. They reached the engine room about one minute after the alarm had sounded and, as they entered, they could smell burning electrical insulation. The 3rd Mate, who had a UHF radio with him, waited in the engine room. The Chief and 1st Engineers went through the small room containing engine monitoring equipment (CRT room), from where the 1st Engineer collected a portable CO_2 extinguisher, and then on into the main switchboard room.

The only entrance to the transformer room is through the main switchboard room. As they passed through the main switchboard room, the two men saw no smoke or anything else that seemed wrong. Cautiously, the Chief Engineer opened the transformer room door. Although the space was filled with quite dense smoke, the Chief and 1st Engineers ventured in to investigate. The room is reasonably large and extends around the side of the main switchboard room (see diagram, page ….). The Chief Engineer felt the casing of the main transformers and then noticed that the smoke was coming from the main switchboard room behind them, through a ventilation grille in the bulkhead.

The smoke was accumulating rapidly. The two men were forced to leave the transformer room almost immediately and evacuate the area. While retreating through the main switchboard room and the CRT room they noted that the smoke was quickly building up in this area. However, they could not detect the seat of the fire. Outside the CRT room the 3rd Mate relayed the Chief Engineer's report to the Master, confirming a large fire, together with a request for the assistance of the Tasmanian Fire Service. They also asked for breathing apparatus (BA) and portable CO_2 fire extinguishers. This radio message was received

on the bridge at 2207.

At 2208, a VHF call on channel 12 was made to Devonport Harbour Control informing them of the fire on board and asking for the fire brigade to be summoned. The information was relayed by Harbour Control to the Tasmanian Fire Service at 2209. By 2212, a muster had been carried out on the poop deck and all of the ship's complement had been accounted for.

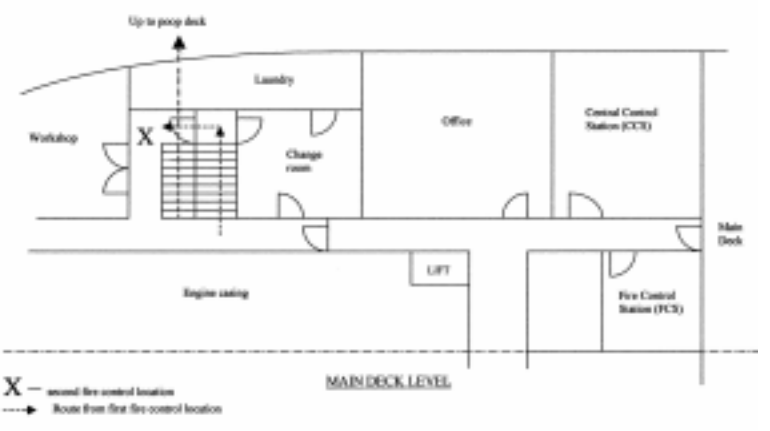
BA was brought to the workshop area. The 1st Engineer donned a BA and re-entered the main switchboard room with a CO_2 fire extinguisher. Through the smoke, which was by now extremely dense, he was able to distinguish a glow around the lower cubicle door associated with No. 2 generator air circuit breaker. Unable to proceed due to the heat and lack of visibility, the 1st Engineer left the space and relayed this information to the Chief Engineer.

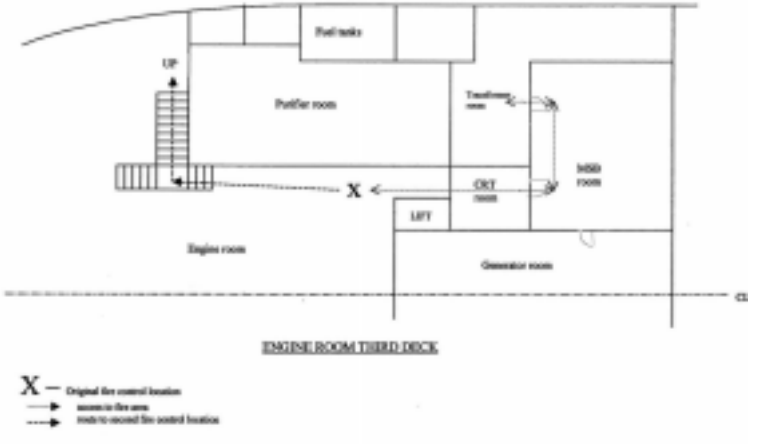
The engineers set about shutting down the two running generators, Nos. 1 and 2. In doing so it became necessary to stop Nos. 3 and 4 generators which were started automatically, on sequential start, by the power management system. The emergency generator started and placed itself on load. This machine was also stopped by the engineers, because they were concerned that it may energise the main switchboard. Emergency battery lighting was then operating.

Smoke and fumes were starting to affect the remaining areas of the engine room, activating other fire detector heads, so the officers and crew moved from outside the CRT room, up a set of stairs, to a position outside the workshop. This area remained as the fire control station for the remainder of the incident (see diagram, next page).

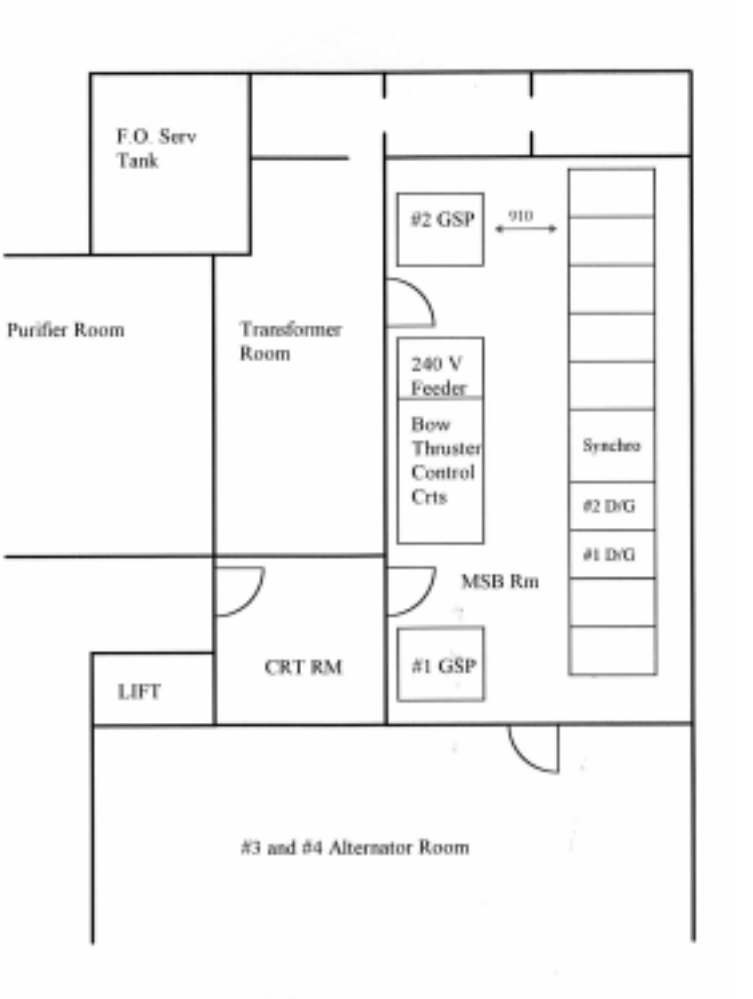
At about this time, logged by the 3rd Mate as 2216, a team from the Tasmanian Fire Service arrived. The Chief Engineer briefed the team on the situation and then commenced firefighting operations. Firemen were shown into the main switchboard room by an integrated rating and directed toward the affected area of the switchboard.

A crowbar had to be used to open the top door of No. 2 generator cubicle as the lugs for securing the door in the closed position had melted. The firemen extinguished the fire using CO_2 extinguishers. However, the heat was such that the fire continually re-ignited and it became necessary to use dry powder extinguishers.





Sketch plans Port of main deck and Third deck



Sketch Plan forward port side of third deck

The Chief Engineer, having returned to the main switchboard room wearing a BA, decided to remove the No.2 circuit breaker so that it could be cooled with fresh water. He experienced problems in removing the breaker and the 1st Engineer was called to assist.

Wearing a breathing apparatus (BA), the 1st Engineer entered the switchboard room. Although he read the instructions for removing a breaker, he experienced considerable difficulty with differing allen key sizes and with handles and components severely affected by heat. Eventually the circuit breaker was removed and cooled with a water extinguisher and fresh water hose.

The fire was reported as under control at 2230 and extinguished at 2235.

When satisfied that the situation was safe, the Fire Service requested that the space be ventilated. The engine room top hatch was opened to supply natural ventilation at 2239 and, by 2250, the 1st Engineer had started the emergency generator and an engine room fan to provide forced ventilation.

That night, the engine room remained manned and the emergency generator supplied power to the vessel.

The Australian Maritime Safety Authority stipulated that, before the vessel could sail from Devonport, repairs were to be completed in full and that No.2 circuit breaker was to be sent, for investigation, to the Australian service agents for Terasaki. It was also stipulated that contractors in Tasmania were to internally inspect the other circuit breakers.

Contractors carried out repairs over the next 18 days during which all the ship's circuit breakers were replaced with a Lloyd's approved type.

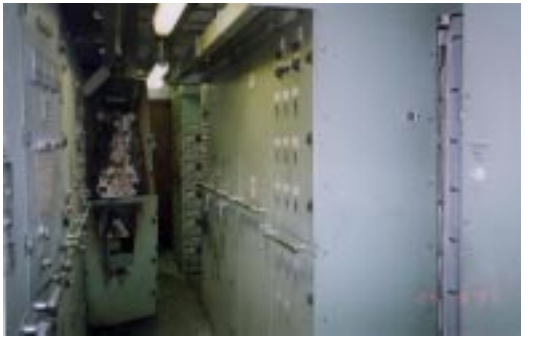
Fire damage No.2 ACB back C.T's on outgoing lines

Fire Damage No.2 ACB view

Fire damage No.2 D/G upper level

Heat detector above synchronising panel

Hyundai type circuit breaker



View of main switchboard room

Comment and analysis

No.2 generator circuit breaker

The source of the fire appeared to be an internal fault in No.2 generator air circuit breaker. The circuit breaker for No.2 generator was manufactured by the Hyundai Electric Engineering Co. of Ulsan, Korea. The data plate carried the following details:

Hyundai Electric Engineering Co. Ulsan, under licence to Terasaki, HAT 25 3-pole, 660 volt, 50-60 Hz, 2,500A, ambient temp. 45°C. LR approved

The fire destroyed the circuit breaker and its associated control equipment. Heat damage had affected the adjacent cubicles either side of No.2 cubicle. These cubicles contained the circuit breaker for No.1 generator and the generator synchronising panel. Neither No.1 generator, nor No.2 generator, could be connected and the synchronising panel was inoperative. The remainder of the main switchboard had suffered some smoke damage. See photographs pages ….

Subsequent examination of the circuit breaker indicated, among other things, serious overheating of the copper leads to the soft start contactors and the overcurrent coil.

The circuit breaker was forwarded to NHP Electrical in Victoria, the Australian agents for Terasaki in Japan. Their report on the examination of the breaker contained the following information:

“The breaker is extensively damaged with the internal insulating parts having been completely consumed by fire. Damage to accessories mounted on the breaker and the wiring to them is extensive. The circuit breaker carriage has been damaged by the fire.

The main current carrying path of the circuit breaker is intact, but the centre pole shows signs of overheating. The plug-in contacts of the main circuit are in good condition (except for damage due to the fire).

From the above observations, the source of the problem would be the overheating of the centre pole causing the insulating parts to ignite. The cause of the thermal failure of the centre pole is unknown."

At the time of the fire, No.2 generator, and hence its circuit breaker had a total of 17,780 running hours, although with no "open/close" counter fitted, it was not possible to determine the number of cycles the circuit breaker had carried out.

Surveys and Inspections

Air circuit breakers are items surveyable on a five year cycle. They are also part of the annual survey, but the extent of this survey is left to the professional judgement of the attending surveyor.

Subsequent to the fire, it was revealed that the vessel's first electrical survey, including the affected air circuit breaker, was due in January 1998. The Chief Engineer was not aware of any visual inspections of any circuit breaker having been made since the ship was built and there were no records held of any such inspections.

The report, dated 2 June 1997, of an infra-red examination carried out in Melbourne to detect hot spots on the ship's switchboards, noted that no defects had been revealed. This examination, however, did not include a visual inspection of the circuit breakers. There is no record to show whether No.2 generator was connected to the switchboard during the infra-red examination but, at that time, the vessel was discharging cargo and for this operation, nos. 1,2 and 3 generators would normally be required to be on line.

It is unclear if any problem had existed prior to the incident, although the Chief Engineer, who had been with the vessel since it was built in 1993, could recall no significant problems with these circuit breakers.

In the manufacturer's manual, recommendations are made concerning 6 and 12 monthly inspections:

"*Frequency of periodic inspection*

While it is most appropriate that the user works out his own inspection plan for his breakers according to the switching frequency, the values of normal making and breaking currents, the magnitude of fault current

interrupted, service conditions and environmental conditions, it is recommended to perform a simplified inspection once every 6 months and a full inspection once a year".

During the repairs there was some speculation that the Hyundai Electrical Engineering Company, who manufactured the breakers under licence from Terasaki, may have modified the breakers.

Following examination by the Australian agents for Terasaki, the owners contacted the Hyundai Electric Engineering Co. in Korea with a view to forwarding the circuit breaker to them for further analysis. No reply was received from Hyundai.

Following the fire, Lloyd's Register of Shipping stipulated that the circuit breaker should be replaced by a complete new unit.

A considerable amount of PVC insulation on electrical cables was burned during the fire. When this occurs, highly corrosive hydrogen chloride is formed which must be promptly removed before severe corrosion affects components. Due to the extensive smoke damage, this operation would have necessitated the removal, disassembling, cleaning and testing of all the large circuit breakers in addition to any necessary repair work. As a result of both financial and risk management considerations, the owners and ship managers together decided to replace all of the ship's air circuit breakers with AT15 and AT25 models manufactured by Terasaki in Japan.

The damaged circuit breaker, the source of the fire, was scrapped.

At the time of building, *Goliath's* Hyundai-manufactured circuit breakers were on the Lloyd's Register Type Approved List, however when no.2 was due to be replaced after the fire it was found that such circuit breakers were no longer listed. The Marine Incident Investigation Unit contacted the Lloyd's Register Type Approval Department in Croydon, UK, to establish why Hyundai-manufactured circuit breakers had apparently been removed from the type approval list.

Lloyd's Register replied that Lloyd's Register "approval" for Hyundai circuit breakers had not been withdrawn.

Before 1990 Lloyd's Register published lists of "Approved Type Tested" products. In 1990 the "Approved Type Tested" scheme was discontinued and replaced by a "Type Approval" scheme. It seems that not all equipment manufacturers applied for Certification under the Type Approval Scheme. Although equipment may not be certified as type approved, it may, nevertheless, meet Lloyd's Register requirements.

Fire detection

A heat detector, part of the automatic fire detection system, was situated above the main switchboard, within one metre horizontally of the cubicle. It seems that the cubicle had limited the heat radiation by the fire and, although covered in soot, the detector had not operated during the incident. This detector was later tested and found to be operational.

The fire detection system had been set off by a sensor in the transformer room. The fire in No. 2 cubicle had melted the insulation of cables within the circuit breaker cubicle, generating large amounts of smoke, but the spread of fire was limited by the fire retardant properties of the cabling and the cubicle casing. The smoke path to the transformer room was by way of a fixed ventilation grill in the common bulkhead between the transformer and main switchboard rooms.

A lack of flame, or radiated heat, together with undetected smoke in the initial stages, contributed to the difficulties of locating the source of the fire.

Firefighting

The vessel is equipped with three BA sets, each with two spare bottles. This is one set and two bottles above the minimum required for *Goliath.* During the incident all nine of the vessel's BA bottles had been used in the three BA sets.

Five of the ship's CO_2 hand held extinguishers had been discharged. The Tasmanian Fire Service had also used ten BA bottles and 2 dry powder extinguishers.

It was reported that, had the vessel been at sea, the fixed CO_2 system would have been used due to the rapid exhaustion of the ship's limited supply of BA bottles. The officers and crew responded to the incident

in a generally appropriate manner. However, there are areas of concern which should be noted as lessons to be drawn from the incident.

Often the first casualty in an emergency situation is that of communication between key personnel. Neither the Chief nor 1st Engineers carried a UHF radio on their initial inspection of the transformer room. The Master was unaware of what was going on for a period of five minutes, between the time the fire alarm sounded at 2202 and 2207.

Although it was reasonable for the Chief and 1st Engineers to make the initial inspection without BA, both remarked that they were fortunate that their escape route from the transformer room had not been cut off. On *Goliath* it is necessary to go through two spaces between the engine room and transformer room. Although these spaces are ventilated, the two men were isolated by three sets of doors from the immediate backup, the 3rd Mate.

The evidence indicates that there was a delay of over five minutes before the BA and portable CO_2 extinguishers were gathered into the workshop, the fire control point. The evidence is also that the 1st Engineer re-entered a smoke filled space alone, separated from backup by the two doors of the CRT room. Ideally any entry in BA should be undertaken as a two-person team, with a backup team in case the first team experiences difficulties. The limited number of BA sets, however, does not make a two-person backup team feasible.

There is conflicting evidence on the use of the BA sets and BA control procedures. The 3rd Mate stated that he kept track of BA entries and that he and the 2nd Mate verified that the BA sets were correctly worn. One of the ship's BA sets was worn by the 1st Engineer and the other by the Chief Engineer. Neither had undertaken a "low pressure test" to confirm an effective seal on the BA face mask prior to entering the space, a very important safety check. The Tasmanian Fire Service noted that, while the brigade firefighters followed strict BA control procedures, the ship's staff seemed to be coming and going unmonitored.

The Fire Service also noted that the ship's fire fighters were inappropriately dressed in unbuttoned overalls and without gloves. They were also concerned that there was some confusion with the low pressure warning whistles on the ship's BA sets. The ship's staff seemed so focussed on their functions that they

were having to be made aware of their whistles.

Early in the incident, the Chief Engineer stopped the emergency generator as he wanted to ensure that the main switchboard was completely dead. When a blackout occurs and the emergency generator starts up, the bus tie circuit breaker between the emergency switchboard and the main switchboard should drop out and the emergency power circuits should be separate from circuits fed through the main switchboard. In Goliath, however, it became evident, after the fire, that there is a 220 volt feedback to the main switchboard synchronising panel. Burned wiring in this panel started sparking when the emergency generator was later started.

The emergency generator supplies the only power available for the emergency fire pump. In the event the emergency fire pump was not required but, had the fire spread, it may have been.

Fire drills were conducted on *Goliath* on a monthly basis, the fire scenario varying on each occasion. The last drill held before the incident was on 19 August.

Members of the Tasmanian Fire Service who attended the incident reported that it was vastly different from any fire incident that they had previously encountered. They were, on the whole, satisfied by the support they received from the ship's staff, but in addition to the comments above, they noted they could have received a fuller briefing on their arrival about the fire and the status of the electrical systems.

Periodic visits by local fire services to a vessel are very important for both parties to understand, and familiarise themselves with, the arrangements and services that each can supply.

Conclusions

These conclusions identify the different factors contributing to the incident and should not be read as apportioning blame or liability to any particular individual or organisation.

1. The fire in the main switchboard was caused by an internal fault in the air circuit breaker for No.2 generator.

2. Damage to the circuit breaker was such that, on subsequent examination, it was not possible to determine exactly what had caused the fault, although overheating of the centre pole in the main current carrying path was probably the triggering factor.

3. No inspections, in accordance with the manufacturer's recommendations, had been carried out on the ship's circuit breakers since the vessel was delivered, and their first survey was not due until five months after the incident.

4. A heat detector, located above, and very close to, the cubicle containing the No.2 generator circuit breaker proved ineffective at giving an early alarm as heat was contained largely within the cubicle and the main problem was the generation of large quantities of smoke from the insulation of cables.

5. In general, the response to the fire by the ship's officers and crew was appropriate and, with the assistance of the Tasmanian Fire Service, the fire was successfully confined to No. 2 switchboard cubicle. However, shortcomings in briefings, the use and monitoring of BA sets and dress worn by ship's staff during firefighting are areas that require examination.

Submissions

Under sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or the relevant part of the report. Sub-regulation 16(4) provides that such a person may provide written comments or information relating to the report.

The final draft of the report was sent to the following:

The Master of "*Goliath*"

The Chief Engineer of "*Goliath*"

CSR Shipping

Submissions were received from CSR and the Chief Engineer. The text of the report has been amended accordingly.

Details of Goliath

IMO No.	9036430
Flag	Australia
Classification Society	Lloyd’s Register of Shippping
Vessel type	Bulk cement carrier (self-discharging)
Owner	Goliath Portland Cement
Managing Agents	CSR Shipping, Sydney
Year of build	1993
Builder	Hanjin Heavy Industries Co. Ltd., Ulsan, Korea
Gross tonnage	11,754
Net tonnage	3,526
Summer deadweight	15,539 tonnes
Length overall	143 m
Breadth, extreme	23.50 m
Draught (summer)	8.335 m
Engine	KHIC Sulzer 5RTA52
Engine power	6400 kW
Service speed	14.5 knots
Crew	18 (Australian)