

**Departmental investigation
into the machinery space fire aboard the
U.S. flag seismic research vessel
CASEY CHOUEST
off Thevenard Island, W.A.
on
31 January 1996**



Report No 89



**Transport and
Regional Development**

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Sources of information

The two Masters, officers and crew, Casey Chouest

Casey Chouest Seismic personnel

United States Coastguard

Australian Maritime Safety Authority

PGS Ocean Bottom Seismic

Tidewater Port Jackson Marine Pty. Ltd.

Edison Chouset Offshore

Lloyd's Register of Shipping

ABS America

United Construction, Karratha

NHP Electrical Engineering Products Pty. Ltd

ACT Department of Urban Services

Caterpillar of Australia Ltd

Dixon Picard, Counsulting Marine Surveyors and Engineers

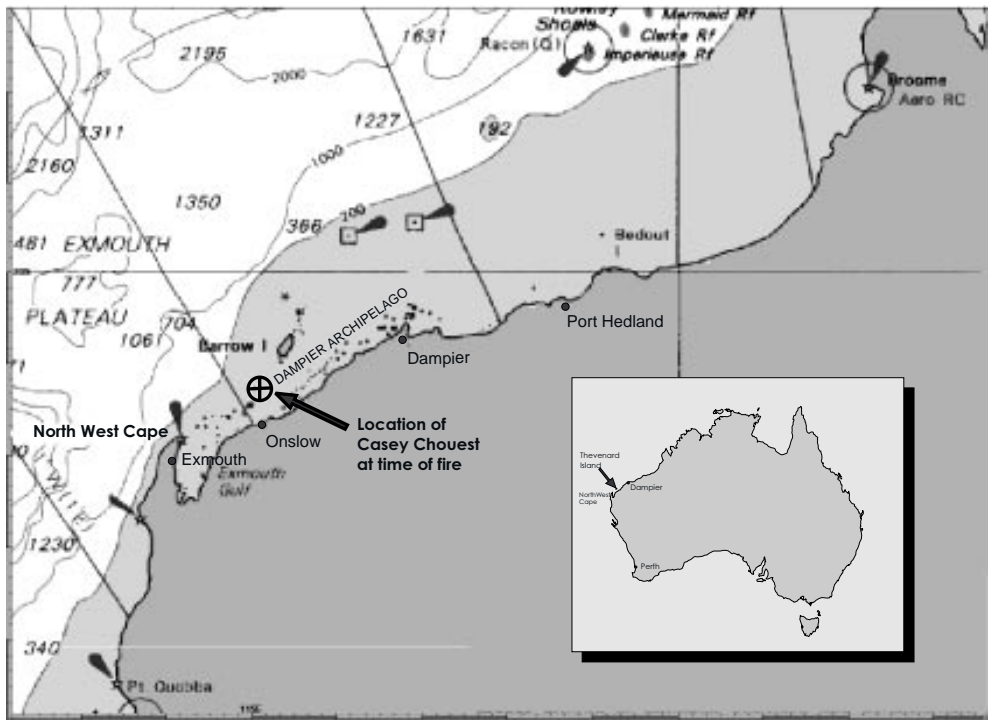
MM Cables

The Inspector gratefully acknowledges the cooperation and assistance of the United States Coast Guard, and particularly that of the Investigation Division, in the conduct of this investigation.

Summary

In the early morning of 31 January 1996, Casey Chouest, an offshore research vessel engaged in seismic survey operations, was in the prospect area known as Snark 3D, close to Thevenard Island in Western Australia. At about 0700, the fire alarm panel in the wheelhouse indicated a fire in the seismic compressor room space and smoke could be seen coming from the vents.

The crew and seismic staff mustered and closed down the space, starving the fire of oxygen and applying boundary cooling; eventually extinguishing the fire in the space. However, heat from the fire was conducted through the uninsulated steel bulkhead igniting combustible material stored against the common bulkhead in an adjacent space.



Portion of chart Aus328 showing location of incident

The fire fighting tug, Total Endeavour, was sent to the scene in response to a request from the Master and, using its fire monitors, applied boundary cooling to the hull while the crew continued boundary cooling on board.

The investigation established a sequence of events initiated by a massive short circuit in the cable from a dedicated generator supplying power to the hydraulics for the reels which deploy the seismic gun cables. An incorrectly sized bracket, securing the armoured cable, had caused damage to the armouring and the rubber sheath surrounding the three phase conductors. The evidence indicated that the insulation breakdown had proceeded over a long period until the cable failed to perform under normal load conditions. The evidence also indicated that the fault current started to flow from one phase to the earthed bracket. This earth fault increased over time causing heating of the cable conductors in the section of cable adjacent to the bracket. This, in turn, contributed to the complete failure of the cable due to phase to phase and phase to earth fault current.

As the trip settings on the circuit breaker were set far too high, it did not trip and the cable fault imposed a fault current level on the generator high enough to momentarily cause a locked rotor condition in the generator. The high inertia from the generator caused mechanical failure of the bottom end bearing in no.4 unit. The connecting rod came through the side of the crankcase and pressurisation of the crankcase blew much of the sump oil, out of the hole in the side, over the D399 Caterpillar engine below and to starboard of it. The oil self-ignited on the turbo-charger casing of the D399 engine and burning oil in the bilge melted the polycarbonate bowl of the forward fuel filter on the D399, allowing fuel under pressure to escape and spray over the engine and into the bilge thus adding to the fire.

The burning fuel in the bilge flowed to the starboard aft corner of the seismic machinery room, against the space in the reel-room where large numbers of oil filter elements were stored in cardboard cartons. These stores were ignited by heat conducted through the uninsulated steel bulkhead.

The fire was extinguished at about 1045, approximately 3¾ hours after the first alarm.

Casey Chouest

Casey Chouest is an American flag offshore research vessel, equipped for geophysical survey, owned by Edison Chouest Offshore of Galliano, United States. It is 54.87 m in length, has a beam of 12.2 m, a moulded depth of 4.27 m, and a maximum draught of 3.917 m. The vessel has twin screws, powered by two 16 cylinder Caterpillar D399 diesel engines, with an aggregate power of 1655 kW. It is fitted with a bow thruster, the diesel engine of which also powers the emergency fire pump.

The vessel was built in 1981 and was measured under national, United States, tonnage rules as having a gross tonnage of 246 and a net tonnage of 167.

In July 1987, the vessel was remeasured under the provisions of the 1969 International Tonnage Convention, which came into force on 10 February 1983, resulting in a new gross tonnage of 1151 and a net tonnage of 345.

Casey Chouest appears to have undergone considerable structural modification with areas above the waterline enclosed. During the course of the investigation information was sought from the vessel's owners, Edison Chouest Offshore, regarding details of the structural modifications, the installation of the seismic machinery, the relevant plan approvals and the standards applied to the installation. This information, however, was not forthcoming.

Casey Chouest had been on charter to PGS-OBS since 16 July 1995. PGS-OBS took over the vessel after it had been chartered to Northern Geophysical, which ceased trading about that time. Before that, the vessel had been chartered to Teledyne Geophysical, a company which ceased operations in about 1992.

Normally, Casey Chouest operated with an American crew employed by Edison Chouest. However, when PGS-OBS was engaged by Western Australian Petroleum Pty Ltd (WAPET) to undertake seismic surveys in the shallow waters off the north-west of Western Australia, because the vessel was to operate from Australia, an Australian crew was engaged in accordance with the industry practice. PGS-OBS contracted Tidewater Port Jackson Marine to supply the crew under a standard crewing agreement. An American master, employed by Edison Chouest, remained on board Casey Chouest to satisfy United States shipping laws.

The vessel was inspected for compliance with Australian crew accommodation standards and general condition at Dubai in the United Arab Emirates on 26 September 1995, by a representative of Tidewater Port Jackson and an official from the Maritime Union of Australia. It was noted that the vessel “seems to be in very good condition for age”. PGS-OBS applied to the Australian Maritime Safety Authority for the vessel to be a declared vessel under the provisions of section 8A of the Navigation Act 1912, bringing the vessel under the provisions of the Act. The Declaration was made on 23 October 1995.

A crew of twelve Australians (including a Master) joined the vessel in Jakarta on 21 October 1995. In addition there were, at any time, about 13 seismic staff conducting the offshore survey operations.

The vessel was inspected by AMSA to check its general condition and its safety equipment to ensure that it substantially complied with the Australian Uniform Shipping Law Code. Some relatively minor deficiencies were noted and rectified. Casey Chouest started operations on 1 November 1995. The vessel operated in a “team” system with two Tidewater vessels, Owen Tide and Dickerson Tide, and the Edison Chouest vessel Trail Blazer.

Seismic operations

The operation consists of a vessel laying a cable fitted with transducers along the sea bed to detect shock waves produced by the “gunship” traversing this line firing arrays of pneumatic “guns” which, electrically fired by solenoid valves, produce underwater blasts by the rapid release of the compressed air.

Casey Chouest was fitted out as the “gunship” for the survey operations being conducted by PGS-OBS. In this role, the vessel is equipped with two very large high pressure compressors which supply air to the gun strings.

The two Cherco high pressure compressors fitted for this purpose were each driven by a Caterpillar D399 engine, the same type of engines as were fitted for the ship’s propulsion. These were part of the machinery fitted in the “compressor room” or seismic machinery space. This space was on the main deck level, immediately aft of the seismic staffs' accommodation, forward of the reel space and above the engine room. In all there were eleven accesses to the seismic compressor room from the accommodation, seismic space, engine room, reel room and open deck.

In addition to the compressors, there was a small generator fitted to provide electrical power to the hydraulic machinery. It was used for powering the reel drums which deploy and retrieve the paravanes and the gun strings as well as for supplying a number of other specialised items of seismic equipment. This generator was driven by a Caterpillar D343 diesel engine.

The fire

In the early morning of 31 January 1996, Casey Chouest was in the prospect area known as Snark 3D, close to Thevenard Island in

Western Australia. The vessel had just returned from Exmouth where it had taken on bunkers. At 0415, the PGS Shift Leader started the starboard Caterpillar D399 engine and Cherco compressor in preparation for deploying the seismic gear. At about 0450, the ship started streaming the seismic gear which consisted of two paravanes and four gun strings. This procedure was completed at about 0615 and, upon completion, the vessel steamed backwards and forwards on a north-east/south-west course waiting for the cable-laying vessels Dickerson Tide and Owen Tide II to lay the “line” on the sea bed, which Casey Chouest was going to “shoot”.

The weather conditions were fine and warm with light airs and there was a slight swell. The Australian Master was on watch on the bridge when, at just on 0700, an automatic alarm was activated in the bridge fire panel indicating a fire in the compressor room. The Australian Master left the bridge to tell the Second Engineer, who was just starting work on the anchor windlass, to go down and check the compressor room. As he returned to the bridge, he could see the PGS Gun Mechanic running up the deck and, behind him, smoke billowing from the mushroom vents forward of the funnel. The Gun Mechanic confirmed that there was a fire in the compressor room.

The Australian Master sounded the general alarm and made an announcement over the ship’s public address system that there was a fire in the compressor room. As members of the crew arrived at the muster point just abaft the bridge, he instructed them to start shutting down the space. Flames were visible around the funnel on the starboard side of the main deck and paint was beginning to blister on the funnel and on the mushroom vents.

The American Master arrived on the bridge and the Australian Master handed the watch over to him before going out to take charge of the muster station. He initiated a head-count of the crew and seismic personnel, then instructed the Integrated Ratings (IRs) of the fire party

to run out two hoses on the upper deck before he re-entered the bridge and started the engine-room electric fire pump using the remote start. With the hoses, the crew started boundary cooling the upper deck, the funnel and the mushroom vents. The Chief Engineer had arrived on deck and he and the Second Engineer took charge of closing down the ventilation, flaps and mushroom vents for the machinery spaces.

Because the gun strings had already been deployed, it was necessary to keep Casey Chouest under way, in order that the paravanes could keep the four gun strings apart to avoid tangling them.

Leaving the Second Engineer closing down the compressor room, the Australian Master and the Chief Engineer went to the bow-thruster space to start the emergency fire pump which is driven, through a clutch, by the bow thruster diesel engine. The firemain being fully pressurised, they returned on deck. After gathering more hands, the Australian Master, the Mate and the Second Engineer started closing all the doors, both internal and external, leading to the compressor room. A fire hose was run out in the lower alleyway. They encountered thick smoke from both the PGS workshop and from the hospital area, but were unable to see flames or feel heat.

The Second Engineer tried to close the door leading from the engine room to the compressor room. The engine room, by this time, was full of smoke, so he closed the door between the engine room and the alleyway, then returned to don a breathing apparatus (BA) set. Equipped in a BA set and helped by an IR, also wearing a BA set, it took a further three attempts to finally close the door.

Further alarms were sounded by the vessel's fire detection system, indicating fires in the seismic crew's quarters, the ship's crew's quarters and the main deck level. Each of the alarms was investigated

by crew members and in each case it was determined that there was no fire in these areas, only smoke, which had actuated the sensors.

After the first ten minutes or so of the fire, Dickerson Tide and Owen Tide II were observed heading for Casey Chouest. Dickerson Tide had notified the Thevenard Island base of the situation and Thevenard Island passed the information to PGS in Perth and to Tidewater in Melbourne. When contacted directly by Casey Chouest on VHF, Thevenard Island offered to dispatch the vessel Total Endeavour, equipped with fire-fighting monitors, to assist - an offer which was accepted by the U.S. Master on board Casey Chouest.

At 0810, the fire tug Total Endeavour was alerted and instructed to proceed to the casualty and by 0825 the vessel was underway to the Snark 3D prospect area.

As the doors leading into the seismic compressor space were closed by personnel in BA sets, the smoke, which had been billowing out of the mushroom vents on the main deck and from the funnel, began to slacken and become lighter in colour. The two Masters and the Chief Engineer, who had been monitoring the situation and considering the use of the fixed CO₂ installation to flood the engine room and seismic compressor space, decided at this point that the fire was coming under control and use of the CO₂ flooding would not be necessary. Boundary cooling was continued on the upper deck and around the funnel.

Owen Tide II and Dickerson Tide were requested to send over extra air bottles for the BA sets in use, as the crew on Casey Chouest had started using all the spare bottles on board. Owen Tide II, in addition, was requested to take up a position ahead of Casey Chouest and to make ready a tow in case the ship's main engines failed, hence keeping some way on the vessel to prevent a tangle of the gun strings.

Dickerson Tide took up station on the starboard side of Casey Chouest.

After some time and once the smoke had virtually cleared, it was decided to vent the seismic compressor room. This was achieved, to start with, by opening the doors on the port and starboard sides. The PGS Gun Mechanic donned a proximity suit and BA set and, with a safety line attached to him, entered the compressor room with a fire hose and made his way down to the generator level. Others of the firefighting team kept spraying water over him. Once at the generator level, he used the fire hose to extinguish a fire which was still burning in the starboard aft corner of the space. After a short period, he had to return because of poor visibility in the smoke-filled space. He returned a second time, with a flashlight, to attempt to shut off the fuel valves in the compressor room. He turned off two valves on the starboard D399 engine and the air to the Wilden diaphragm pump which was rigged as a fuel booster pump. The D399 engine had stopped running by this time. On his way back he stopped at the generator level to shut off the fuel to the incinerator and to the seismic generator set, which had also stopped.

As the smoke eventually cleared, there was no sign of fire and the venting of the compressor room continued.

Total Endeavour approached Casey Chouest and was asked to stand-by on the starboard side. Aboard Casey Chouest, one of the team still boundary cooling noticed that the paint on the starboard side of the ship's hull, aft of the compressor room, was blistering, indicating that the fire had spread to the forward starboard side of the reel room. The doors to the compressor room were closed again and boundary cooling was moved to the area of blistering paint. A fire team was gathered to fight the new outbreak and they were briefed on how this was to be undertaken.

At 0945, Total Endeavour positioned itself off Casey Chouest's starboard side and, using its fire monitors, proceeded to cool the starboard side and starboard quarter of Casey Chouest, which was blackened with heat.

Owen Tide II was released at 1020, to return to Onslow to pick up PGS-OBS personnel.

At about 1030, the large hatch in the top of the reel room was approached by a firefighting team using two hoses and water was played on the hatch as it was lifted slightly. There were no flames beneath the hatch, so the hoses were then used to direct jets, through the hatch, into the starboard forward corner of the reel room. When the smoke dispersed, the hatch was closed again and a team made ready to enter the reel room from the compressor room. At about 1040, the Mate and the PGS Gun Mechanic, dressed in proximity suits and using BA sets, entered the compressor room via the door at the base of the funnel on the upper deck. After making their way through the compressor room to the reel room, they hosed down the starboard forward corner, where spare filters and other stores had been burning. Another team entered the reel room via the main hatch and a ladder which had been placed in the hatchway, and the starboard forward corner of the mezzanine deck in the reel room was again doused with hoses to extinguish the still-smouldering embers.

Total Endeavour shut down its fire monitors at 1045 and remained on stand-by. At about 1120, it was deemed that the situation had been made safe and Total Endeavour and Dickerson Tide were released. All spaces were vented of smoke.

An immediate problem was the recovery of the "gun" strings. The Caterpillar D343 generator set, which supplied electrical power to the hydraulic power packs used to run the hydraulic motors on the reel

drums, was found to be severely damaged, with no.4 unit connecting rod protruding through the side of the crankcase.

On the starboard side of the reel room, a three phase knife switch was fitted in the electrical supply to the seismic machinery installation, which could change the supply from the seismic generator (the Caterpillar D343) to a supply from the ship's main generators. Once the damage had been assessed, the supply switch was changed over and the Chief Engineer went to the engine room to close the breaker which supplies power to the change-over switch. As he closed the breaker, it arced and the ship blacked out. A dead short circuit to earth was found to have occurred in one of the phases on the port main generator. After starting the starboard main generator and connecting it, power was restored to the vessel and the ship's main supply was eventually used to power the hydraulics for recovering the gun strings. The vessel returned to Dampier under its own power for assessment of the damage and for repairs.

The following day, while continuing to assess the fire damage, it was found that, in addition to the mechanical damage to the D343 Caterpillar engine, there was evidence of a flash-over having occurred between phases in the 3 phase cable leading from the generator. The insulation had been blown off and the conductors had melted, leaving a flash burn on the deckhead above the cable.



Side of Caterpillar D343 crankcase showing bottom of N0.4 connecting rod.



Melted polycarbonate fuel filter bowl on standard D399 compressor engine.



Circuit breaker fitted to seismic generator.

Comment and analysis

Fire fighting

Examination of the fire scene showed that the fire in the seismic compressor room started when a connecting rod on the Caterpillar D343 engine punched a hole in the side of the crankcase and oil sprayed from the hole onto the hot exhaust surfaces of the starboard Caterpillar D399 engine and ignited. The burning oil melted the forward polycarbonate fuel filter bowl on the starboard D399 engine and, with no remote fuel shut off, the oil provided a continuing source of fuel for the fire which spread through the bilges, with the trim of the vessel, to the aft starboard corner of the space.

Initially, no direct attack was made on the fire in the seismic compressor room by the vessel's personnel. The fire fighting team's first priority was to seal off all accesses to the space to allow the option of using the CO₂ smothering system. This operation required the closing of eleven openings in addition to the vents but, with access to internal spaces hindered by the amount of smoke, there was some uncertainty as to whether all the doors had been closed.

Although the fire was brought under control by closing the openings to the compressor room, thereby reducing the oxygen available to the fire, and by boundary cooling of the open deck and hull, this did not prevent a second fire starting when heat was conducted through an uninsulated bulkhead igniting combustible stores stacked against that bulkhead in the adjacent reel room. The spreading of fire by heat conduction through uninsulated bulkheads is a recognised way in which fire is able to spread on ships. Boundary cooling had not been applied in this area because there was concern that opening the reel room to apply boundary cooling on its forward bulkhead may have



D343 Caterpillar seismic generator set.



Fire damage to starboard D399 Caterpillar engine and control panel.



Starboard aft corner of seismic machinery space after the fire.



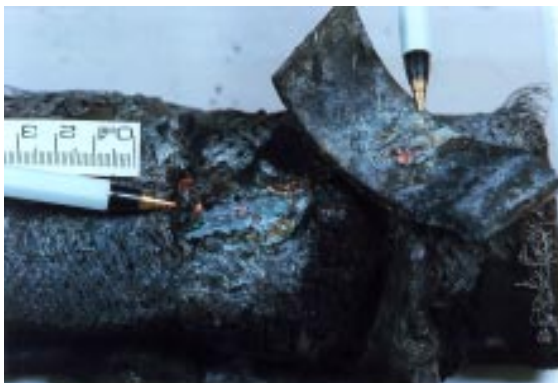
Starboard forward upper corner of reel room after the fire had spread to stored filters in cardboard boxes.



Damage to cable caused by short circuit between phases.



Aft end of same cable at seismic supply changeover switch showing poor standard of installation.



Section of damaged cable showing insulation compressed by clamp and conductors which had welded to the clamp.

admitted air to the compressor room through the two water-tight doors between the spaces. It was not known, with any certainty at the time, whether these doors were, in fact, open or closed.

A major hindrance in locating the seat of the fire and isolating and fighting it, was the spread of smoke throughout the engine room, accommodation and other spaces. This spread of smoke into the spaces forward and aft of the seismic compressor room made access to the spaces without BA impossible, and was an additional reason why boundary cooling was confined to the open deck and hull.

Given the information available to those on board at the time, the decision not to use the CO₂ smothering to extinguish the fire was reasonable. In the event, the efforts to combat the fire were effective and reflect credit to all on board Casey Chouest and those in the supporting vessels, Dickerson Tide, Owen Tide II and the Total Endeavour. However, the incident does highlight the problems caused by the spread of smoke and the limited number of compressed air bottles available on board those ships which do not carry a charging compressor, when faced with a prolonged fire fighting operation.

The seismic compressor space

The seismic compressor room contained three diesel engines, two Caterpillar D399 engines, driving large Cherco high pressure compressors which supply compressed air to the seismic “gun” strings, and a Caterpillar D343 engine driving the seismic generator to provide hydraulic power for the reels housing the gun strings.

The Caterpillar D399 engines were reported to have been overhauled in Dubai, with some subsequent repairs at another port. At the beginning of January 1996, further substantial repairs were carried out to one of the Caterpillar D399 diesel engines.

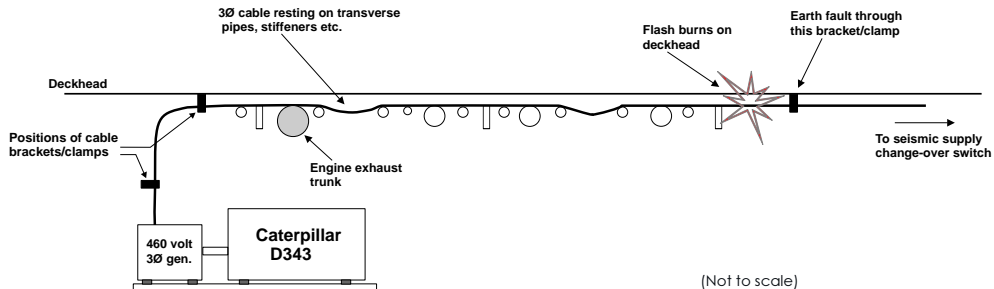
Although the fire resulted from the spray of oil from the crankcase of the seismic generator, examination of the seismic compressor room showed other important defects. The cable run from the seismic generator set had suffered a dead short circuit due to breakdown of the cable insulation. The circuit breaker fitted to the generator had failed to prevent an overload condition and subsequent damage to the engine, as the thermal and magnetic trip settings were far too high to have allowed the breaker to operate.

Further investigation identified a series of contributory factors, which combined to cause the fire. These included the fitting out and equipping of the machinery in the seismic machinery room; the maintenance, or lack of maintenance, of equipment; the accountability and responsibility of the owners and charterers and the safety servicing or survey regime, or lack thereof, under which the seismic machinery was operated.

The seismic generator set

The seismic generator, a Caterpillar D343 engine drove a 460 volt, 3 phase generator at 1800 rpm. This had been fitted as replacement for the original equipment some years ago by Teledyne Geophysical. The generator was assumed by those on board to be rated at 125 kW. No other information on the electrical end of the generator set could be found, either on the generator itself or in the documentation held on board, nor was any more known by those on board.

As much information as could be gathered was passed to Caterpillar of Australia, who on the basis of this information, advised the investigation that, although the D343/Frame 449 generator set was offered in a number of configurations, the set aboard Casey Chouest at 460 volt, 1800 rpm, 60 cycle, was most probably of 250 kW capacity and dated from some time after 1974.



M.V."Casey Chouest" - arrangement of seismic supply cable

The generator end was fitted with a 630 amp Terasaki circuit breaker, type US630CJ. It is apparent that this circuit breaker was not part of the generator set's original equipment and the one fitted at the time of the fire was a replacement, fitted in Australia, on 31 October 1995, for a similar breaker fitted some time previously.

This circuit breaker has two adjustable settings, a thermal trip for the setting of normal full load current, and a magnetic trip for the setting of fault, or short circuit protection. The thermal trip was found, after the fire, to have been set on approximately 95%, or 600 amps. The magnetic trip, for fault condition, was set on the maximum scale setting of 10. From the manufacturer's data this setting equates to a prospective fault current level of 5,000 amps (5 kA). There was no knowledge on board as to when, or by who, these trips had been set at these levels.

With a generator capacity of 250 kW, the full load current of the generator (I_{FLC}), would be approximately 390 amps (depending on the power factor, which in this instance is assumed to be the average, acceptable figure of 0.8).

The short circuit current at the terminals of the generator is calculated from I_{FLC} divided by transient reactance (x). Transient reactance is

usually between 20% and 30%, thus the short circuit current, I_{sc} (assuming $x = 25\%$) would be approximately 1560 amps (1.56 kA).

It can be seen that the thermal trip, set at 600 amps would not operate at 390 amps, the full load current of the generator. Similarly, the magnetic trip, set at 5 kA, would offer no protection against the short circuit current of the generator at 1.56 kA and, indeed, the circuit breaker was found after the fire, not to have tripped.

The interior wiring of the box on top of the generator—containing the automatic voltage regulator, current transformers and wiring to the instruments on top—was smoke damaged, however, one wire leading from the red phase terminal on the circuit breaker had been rubbing on the side panel of the box, had earthed and melted. This wire appeared to be cut and ended at a plastic cable-tie without being connected to anything.

The generator sump was empty of oil and no. 4 unit connecting rod, (from the free end) was protruding through the side of the crankcase. Subsequent examination by contractors who removed the damaged engine from the vessel, revealed that the crankshaft was not broken, but the crankpin of this unit was badly gouged after the bottom end bearing cap had come off. The bottom end bolts had necked and failed under tension. There were indications (severe blueing) that both no.3 and no.4 bottom ends had been overheating and were likely to have seized at any time. It was ascertained from evidence given by those on board the vessel that the piston rings and cylinders were in poor condition and the crankcase was pressurised to the point where the dipstick sometimes used to be blown out. The crankcase breather appeared to be in satisfactory condition.

Wiring in the seismic compressor room

The 3 phase cable from the generator set was secured by brackets (or clamps) between the deckhead and the generator, but there was then an unsupported run of about four meters where it was just draped over pipes, stringers and the exhaust trunking of the generator set itself. Half way along, one bracket was provided but the cable did not go through it.

At the end of the four metre run, just before the bracket where the cable was next supported, there had been a massive short between phases. Just beyond that, at the supporting bracket, it was found that an earth had occurred between one of the phases and the loose half of the bracket (or cable clamp). Two or three of the cable strands had welded to the bracket. The loose half of the bracket was found to be a larger radius than the fixed half, thus bearing only on the centre of the cable and compressing it badly (see page 14). The cable was distorted and its rubber sheathing under the armouring was reduced in cross-sectional thickness. This sheathing was ineffective as supplementary insulation for the three insulated conductors within the cable.

At the point where the cable had been destroyed by the short circuit between phases, the conductors were found to be heavily oxidised and coated with verdigris following a gradual breakdown of the cable insulation (see page 15). It is evident that this process had been continuing for a considerable length of time, at least some months, and this, together with the earth through the bracket, would account for persistent voltage fluctuations which had been reported by the ship's staff since they had joined the vessel and the cause of which had not been traced.

Electrical Inspectors from the ACT Building, Electrical and Plumbing Control, examined photographs of the length of cable taken from the area of the short circuit. In their opinion, the general condition of the cable in this area, and the significant degree of verdigris, indicated that the insulation had broken down over a lengthy period of time. Most probably, the fault started where the cable was squashed in the bracket, reducing the thickness of the insulation (see page 14). This eventually resulted in an earth fault which increased gradually over weeks and months, with the resultant heat build-up causing further deterioration of the insulation to a point where salt-laden moisture entered and accelerated the process of ionisation and the formation of acids. The insulation finally failed totally on 31 January 1996.

The marine standard for electrical installation in ships is Publication 92-401, 'Electrical Installation in Ships' issued by the International Electrotechnical Commission. This IEC standard, which is called up by the International Convention on the Safety of Life at Sea, 1974, states:

'With the exception of cables for portable appliances and of those installed in pipes, conduits, trunkings or special casings, cables shall be fixed by means of clips, saddles or straps of suitable flame-retardant material, and having a surface area so large and shaped that the cables remain tight without their covering being damaged.'

'the distance between supports shall be suitably chosen according to the type of cable and the probability of vibration and shall not exceed 400 mm; for a horizontal cable-run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders, the spacing between the fixing points may be up to 900 mm, provided there are supports with maximum spacing as specified above.'

‘ . . . It is strongly recommended that periodic testing and inspection be made of all equipment and cables for the purpose of detecting in the early stages the possible development of physical deterioration or changes.’

The wiring and machinery in the seismic compressor room, which was not part of the vessel’s propulsion system, was the responsibility of the operators of the seismic machinery. It did not require survey or inspection to maintain any statutory requirement relating to safety or seaworthiness.

The selection of cable for an electrical installation requires consideration of a number of factors, the most significant of which are:

- i. Measured or calculated maximum demand (in amps per phase) of the connected load
- ii. Current rating and type of insulation
- iii. Maximum ambient temperature
- iv. Maximum conductor temperature
- v. Position of cable run, (eg under the deckhead)
- vi. Vibration
- vii. Means of securing and cable bunching
- viii. Route length of the cable

Correction factors for de-rating the current carrying capacity of a particular cable may need to be applied for each of these factors.

The 3-core cable installed for the 3 phase supply from the seismic generator set had a conductor cross-sectional area of approximately 252 mm² per phase. Classification society rules, had they been applicable to the seismic machinery space, would allocate a current rating of 203 amps and 235 amps to cables with 3 or 4 cores having thermoplastic, PVC or ethylene propylene insulation and cross sectional areas of 240 and 300 mm², respectively. These figures are based on a maximum conductor temperature of 60°C and maximum ambient temperature of 45°C.¹

At an ambient temperature of 50°C, however, a correction factor of 0.82 would be applied and, in the situation in which the cable was installed, this temperature could be expected to be easily attained and probably exceeded. This would give an allowable current carrying capacity of less than 200 amps; well below the 390 amp full load current of the generator.

Information relating to the maximum load drawn by electrical circuits supplied by the generator was not available on board the vessel and it is likely that this figure would have changed over the years, since the generator was installed, as various modifications to the seismic equipment took place.

It is apparent that no effective or appropriate standard was used in the installation of the cable run from the seismic generator. No account was taken of the requirements relating to the safety of personnel or the safety of the ship.

Probable sequence of events

The evidence indicates that the sequence of events was as follows:

1. The cable bracket/clamp, of incorrect radius, distorted the cable reducing the thickness of the insulation under the

¹ Lloyd's Register of Shipping

bracket. The poor insulation resistance between the copper conductors and the earthed metal of the bracket permitted leakage current to flow from the conductor to earth.

2. This earth may have existed for a long time and would have caused heating of the cable conductors in the section of cable adjacent to the bracket. This would have caused a breakdown of the cable insulation. The Full Load Current (thermal) trip of the circuit breaker was set too high to offer any effective protection under these circumstances.
3. The breakdown of cable insulation in this area allowed the salt-laden atmosphere, over a period of time, to reach the conductors causing ionisation, oxidation, and the formation of acids thus accelerating the process.
4. At the time of the incident, this process had reached the point where the insulation broke down completely and a flash-over occurred between the phases. The fault condition (magnetic) trip of the circuit breaker was set too high to allow it to operate at the short-circuit current produced by the generator.
5. This cable fault imposed a fault current level on the generator high enough to momentarily cause a locked rotor condition in the generator and the high inertia caused mechanical failure of the bottom end bearing in no.4 unit which, because of the poor general condition of the engine, may have been ready to seize at any time.
6. The connecting rod came through the side of the crankcase.
7. Pressurisation of the crankcase, caused by heavy blow-by, blew much of the sump oil out of the hole in the side over the 399 Caterpillar below, and to starboard of it.

8. The oil self-ignited on the turbo-charger casing of the D399 engine.
9. Burning oil in the bilge melted the polycarbonate bowl of the for'd fuel filter on the D399, allowing fuel under pressure to escape and spray over the engine and into the bilge thus adding to the fire.
10. Because of the trim of the vessel and the slight list to starboard the burning fuel in the bilge flowed to the starboard aft corner of the space underneath the space in the reel-room where large numbers of oil filter elements in cardboard cartons were stored.
11. These stores were ignited by the heat conducted through the uninsulated steel bulkhead.

Shortly after the fire, when an attempt was made to connect the ship's supply, from the port main generator, to the seismic equipment, a massive earth fault occurred following failure of the insulation at the point where the main 3 phase cable exits the generator itself through a cable gland. This blacked-out the vessel and destroyed the cable which later had to be replaced.

This further incident, although not directly connected with causes of the fire, was indicative of the poor general state of the electrical equipment on board Casey Chouest.

Maintenance and division of responsibility

Equipment

Equipment, as defined in the Navigation Act 1912 includes:

every thing or article belonging to or to be used in connection with, or necessary for the navigation and safety of, the ship and,

in particular includes boats, tackle, pumps, apparel, furniture, life saving appliances, spars, masts, rigging, sails, fog signals, lights, signals of distress, signalling lamps, pilot ladders, radio equipment, medicines, medical and surgical stores and appliances, fire prevention, detection and extinguishing appliances, inert gas systems, echo-sounding devices, mechanical pilot hoists, buckets, compasses, charts, axes, lanterns and gear and apparatus for loading or unloading, or otherwise handling, cargo.

As the seismic equipment was not used in connection with navigation, or safety, or loading and unloading, neither the seismic cable, the reels nor the generator or compressors in the seismic compressor room can be regarded as ship's equipment in terms of the Navigation Act.

When Casey Chouest was crewed by Edison Chouest masters, mates, engineers and ratings there was a clear line of responsibility to the vessel's owners for the machinery on board. The chartering firm's Party Chief would have had overall responsibility for the seismic operation and the equipment provided by the charterer.

PGS-OBS chartered the vessel and were contracted by WAPET to undertake seismic survey work. PGS-OBS and Tidewater Port Jackson entered into a manning agreement. This agreement did not specify the areas of responsibility on board, but, according to Tidewater Port Jackson, there is a long standing agreement and custom in the offshore industry that ship's engineers are responsible for the main propulsion and ancillary machinery and equipment, deck machinery and hotel services, while the seismic engineers are responsible for the machinery and equipment related directly to seismic operations.

There is, however, no written protocol nor were there any written directions regarding responsibility for the machinery in the seismic

space. This machinery included the Caterpillar D343 engine and generator, producing 250 kW at 460 volts and the two Caterpillar D399 engines operating air compressors for the seismic array. These two D399 engines were the same type as the vessel's main propulsion units, each rated at over 800 kW.

The normal practice in such operations is that the marine crew are responsible for all equipment other than the seismic machinery and related equipment, but would normally provide fresh and salt water and control air to the seismic operation. All machinery inside the seismic space was the responsibility of PGS-OBS as the charterer and seismic operator. PGS-OBS employed and carried personnel with diesel fitting experience on board Casey Chouest.

Under the arrangements for the Australian operation, the marine crew reported directly to the PGS-OBS Party Chief regarding the operation of the machinery under their care. Thus the Master or Chief Engineer channelled all reports through the Party Chief. No report was made to Tidewater Port Jackson, although invoices for repairs were channelled through the company, which provided a line of financial credit to PGS-OBS, who were new to Australia.

No instructions were carried on board relating to the maintenance policy or proper operating procedures for the D343 and D399 engines and the lack of clear direction contributed to the poor condition and subsequent failure of the D343 engine.

Split Command

Because the vessel remained under the United States flag, a US Master remained on board the vessel to represent the interests of the owner and satisfy United States legal requirements. The Australian Master was responsible for the operation of the vessel under the Navigation Act and the crew's welfare and safety. There was no

written protocol regarding the responsibilities of the two masters or who was actually in command of the ship.

However, Tidewater Port Jackson Personnel operated under a set of safety operation instructions issued by the Company.

In this incident, such uncertainty was not a source of conflict and the two men worked well and amicably together. However, in similar situations with the possibility of personality clashes, the roles should be clearly defined.

Certificates and safety certification

Casey Chouest's gross tonnage, measured under the United States National rules was 246. The vessel had subsequently been measured as 1151 gross tonnage in 1987, in accordance with the 1969 International Tonnage Convention.

However, as a vessel, the keel of which was laid before 31 December 1985, Casey Chouest is covered by the Revised Interim Scheme for Tonnage Measurement for Certain Ships, as set out in the International Maritime Organisation Resolution A494 (XII). This permits the shipowner of vessels to request their Administration to use the national gross tonnage in use before the coming into force of the International Tonnage Convention, 1969, as the basis of the application of the Safety of Life at Sea Convention, 1974.

Applying this provision, and as a vessel of less than 500 gross tonnage under its National tonnage rules, the United States Coast Guard had issued no Safety Convention certificates to Casey Chouest and hence the vessel was a non-Safety Convention ship. Further, under US law, oceanographic research vessels of less than 300 gross tonnage are not

required to be inspected and are considered as “uninspected commercial” vessels. As such, no national safety certificate is issued and vessels are only required to be surveyed for load line in accordance with the provisions of the International Load Line Convention, 1966. Such vessels are subject to only minimum safety standards.

Under the United States Code, 1994, Title 46 (Shipping):

an “oceanographic research vessel” means a vessel that the Secretary finds is being employed only in instruction in oceanography and limnology, or both, or exclusively in oceanographic or limnological research, including those studies about the sea such as seismic, gravity meter and magnetic exploration and other marine geophysical or geological surveys, atmospheric research, and biological research.”

Casey Chouest was classed as an “oceanographic research vessel” under the USCG regulations. The code states “an oceanographic research vessel shall not be deemed to be engaged in trade or commerce”; although, as in this incident, a vessel may be operating for commercial gain in the highly competitive off-shore industry.

The vessel was surveyed by the American Bureau of Shipping for load line only, until April 1992. On 23 April 1992, Casey Chouest was brought under full ABS survey, which included hull, machinery and equipment. However, in March 1995, at the owners request, the class of the vessel was suspended and ABS continued surveys only in respect of the issuing of the load line certificate.

On 9 October 1995, when it was known that PGS-OBS secured a contract for seismic work off the north-west of Western Australia, PGS-OBS made an application under the provisions of section 8A of

the Navigation Act, seeking a declaration that Casey Chouest was an offshore industry vessel to which the Act applied. In making the declaration the gross tonnage quoted was the original tonnage of 246.

A declaration was issued on 23 October and the vessel came under the provisions of the Navigation Act 1912, whenever it operated as an off-shore industry vessel as defined by the Act. Under Australian law Casey Chouest is categorised as an offshore industry vessel:

- (a) a ship (not being an offshore industry mobile unit) that is used or intended for use wholly or primarily in, or in any operations or activities associated with or incidental to, exploring, exploiting the natural resources of any or all of the following, namely
 - (i) the continental shelf of Australia
 - (ii) the seabed of the Australian coastal sea; and
 - (iii) the subsoil of that seabed.

Such vessels are not offshore supply vessels, as they are not designed to carry cargo to offshore mobile units or fixed structures, and they do not have an open working deck aft². A vessel that is to be used wholly or principally in marine or other scientific research, expeditions or survey is subject to the provisions of Marine Orders Pt 50 (Special Purpose Ships) to ensure that the vessel meets the minimum standard for safe operation.

Under Marine Orders Part 50, Casey Chouest, being built in 1981, was an “existing” ship and was required to comply with the code to the extent that AMSA considers appropriate, reasonable and practical,

² Marine Orders, Part 46

having regard to the ship, its equipment and its intended operation. The standard applied by AMSA is that of the Australian Transport Advisory Council's Uniform Shipping Laws Code, as it applies to seagoing non-passenger vessels of less than 500 gross tons, for use in all operational areas up to and including offshore operations within a limit of 200 nautical miles to seaward of the coastline.

The Navigation Act provides that an off-shore industry vessel not registered in Australia, unless the contrary intention appears, shall be deemed to be registered in Australia³. Casey Chouest, as an "Australian cargo steamship"⁴ should have carried a certificate of survey⁵. In the absence of any certificate issued by its own administration, as a minimum requirement, the operators should have applied for an appropriate Certificate of Survey or Safety Certificate, issued by the Australian Maritime Safety Authority.

The legislative trail is somewhat tortuous and involved. The requirement for the vessel to have a safety certificate escaped notice by the operators and at the Port State Inspection. The absence of such a certificate was not material to the cause of the fire.

However, there were aspects of the ship's construction and modification in relation to fire protection and the prevention of the spread of fire that are material to the incident. It seems that Casey Chouest and vessels of similar tonnage, particularly those exploiting the "grandfather clause," as it relates to the relationship between tonnage and safety construction, slip between regulatory requirements. In addition, seismic dedicated equipment (referred to as "mission related" equipment) is not subject to any safety regulation or any, even the most basic, safety audit program. In the case of Casey Chouest, the seismic machinery was as powerful as the main engines and its operation posed the same hazards and risks.

³ Navigation Act 1912, Section 283G

⁴ Ibid, sub-section 206T(3)

⁵ Ibid, sub-section 194(4)

Fire protection

The inspection of the seismic space and the Caterpillar D343 generator set, after it had been removed, gave the firm impression of a space fitted out with little regard to normal marine standards or appreciation of the marine environment.

Although neither the seismic compressor room, nor its machinery, wiring and ancillary equipment were subject to survey, either when installed or subsequently, some practical standard or practical, documented safety assessment should have been used in the fitting out and continuing maintenance of the space and its equipment. As it was, the fitting out of the space, at least when the original machinery was removed and the three Caterpillar engines fitted, would seem to have been ad hoc, subject to neither external scrutiny nor any industry standard, nor was it subject to any planned maintenance program.

The operators of the vessel had a responsibility to construct and equip the space safely and ensure the vessel operated within reasonable safety parameters. The machinery and its wiring posed the same potential fire risk to the ship and the people on board, as the machinery in the engine room. With the potential for fire being similar to that of the engine room, and in the absence of any other standard of safety assessment, the SOLAS Convention, while not a statutory requirement, would have provided such guidelines. Details of any approvals or standards applied during the installation were sought from the vessel's owners during the investigation, but these were not provided. Records of maintenance carried out on the machinery and cabling since installation, specifically of insulation testing, were also requested but were not available. It was stated that the equipment was "mission related" and had been maintained by various clients.

The SOLAS Convention sets out (*Chapter II-2 Regulation 2*) minimum standards for the construction of ships, in relation to fire protection, fire detection and fire extinction⁶:

1 The purpose of this chapter is to require the fullest practical degree of fire protection, fire detection and fire extinction in ships.

The Convention requirements cover machinery spaces which contain:

.2 internal combustion machinery used for purpose other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW⁷.

The two Caterpillar D399 engines were the same type and size as the vessel's main engines, which had an aggregate output of 1655 kW, while the Caterpillar D343 had an output of 250 kW. The machinery in the seismic compressor room clearly had a power output in excess of 375 kW.

The space was protected by a fire detection system and this activated and alerted those on the bridge to the fire. The space was also protected by a CO₂ smothering system and the use of this system was considered while the fire was being fought. These provisions match the requirements of SOLAS.

However, there are four important areas where the seismic compressor room did not meet SOLAS or any equivalent standard.

⁶ Safety of Life at Sea Convention, 1974, as amended, Chapter II-2, Regulation 2

⁷ Ibid, Ch II-2, Regulation 3.19.2

The fuel supply to the engines in the space could not be closed off at the fuel tank from outside the space⁸. The D399 engines had polycarbonate, rather than steel⁹, fuel filter bowls which melted in the heat of the fire allowing fuel under pressure to escape, thus feeding the fire.

In a report to PGS-OBS the Master of Casey Chouest commented on the fire hazard created by the space, noting that it had “eleven doors and accesses”. The Convention notes specifically that doors, skylights, ventilators and other openings should be kept to a minimum consistent with the needs of ventilation and the proper and safe working of the ship.

In addition, the forward bulkhead of the seismic compressor room was penetrated with a large number of cable conduits with open corner cover plates, which ran through to the accommodation space¹⁰. In the event, smoke and fumes filled the spaces forward, aft and above the seismic compressor room, and would have done so even had the doors been shut. It was extremely fortunate that the fire was detected and countered quickly and effectively.

The fire spread from the seismic compressor room to a stores area, located aft and above the level of the engines, by heat conducted through the bulkhead and deck, igniting paper filters and cardboard boxes stowed against the bulkhead. Although a machinery space, in SOLAS terms a Class A space, there was no fire retardant insulation to slow the rise in temperature on the other side of the bulkhead¹¹.

⁸ Ibid, Ch II-2, 15.2.5

⁹ Ibid, Ch II-2, 15.2.8

¹⁰ Ibid, Ch II-2, 18

¹¹ Ibid, Ch II-2, 44

The application of IMO Resolution 494 (XII), the so called “grandfather” clause, to prevent unreasonable demands upon existing ships to comply with requirements not envisaged at the time of construction, has its place. However, the seismic compressor room was modified after the vessel was built and when the SOLAS requirements were the shipping industry standard. Under such circumstances, the Inspector does not consider there is any justification in applying the original tonnage, where it would be reasonable to adopt a standard consistent with the vessel’s current gross tonnage, taking into account the number of people on board and likely areas of operation. It would not have been unreasonable to fit out the space in accordance with SOLAS or, alternatively, to have used some documented practical safety assessment approach to demonstrate that the risks were assessed and guarded against, in the interest of the safety of the people on board who may work in isolated areas of the world under harsh environmental conditions.

General safety questions

In conducting investigations the following questions of safety management, are applied:

- Were the risk factors identified or identifiable?
- Was the equipment in use fit for purpose?
- Were the systems and procedures effective to maintain safe operation?
- Were the individuals involved fit, competent and effective?
- Were emergency procedures and defences effective?
- Was there a management system to monitor performance?

In the Inspector's opinion, the risk of a fire in a machinery space is identifiable and is the subject of detailed requirements under the Safety of Life at Sea Convention, 1974. The equipment, as it relates to the engines, wiring and structural fire protection, was not fit for purpose. The systems and procedures as they related to the seismic compressor room were not effective to maintain safe operation. The ship and seismic staff responded to the emergency in an effective manner. However the fact that the machinery in the space was in poor condition, and that the fire occurred, must reflect upon the arrangement and management of the space by PGS-OBS, the continuity of maintenance of the seismic machinery as the vessel passed from charterer to charterer and the overview of Edison Chouest, the vessel's owners. Although the emergency procedures in relation to the fire were effective, the fire was able to take hold and spread because of the lack of adequate defences within the seismic compressor room. These defects were allowed to propagate in the absence of a proper audit system by those responsible for managing the operation.

Conclusions

These conclusions identify the different factors contributing to the fire on board Casey Chouest and should not be read as apportioning liability or blame to any particular organisation or individual.

The fire in the seismic compressor room and the adjacent space resulted from a number of factors that combined to initiate and spread the fire. These include:

1. The breakdown in insulation initiated by securing the electrical cable from the seismic generator with a bracket of the wrong radius.
2. An undetected earth fault at the bracket led to a progressive breakdown in cable insulation and eventually to a short circuit between phases.
3. The lack of electrical planned maintenance on board, in particular with regard to the routine testing of electrical cable insulation on board the ship.
4. A lack of appropriate supervision in fitting the circuit breaker and the incorrect trip settings (thermal and magnetic) rendering it unable to protect the cable or the generator under either full load current condition or under fault conditions.
5. The sudden load thrown on to the D343 Caterpillar diesel engine by the short circuit, on an engine in very poor condition caused the failure of no.4 bottom end bearing and the subsequent damage to the side of the crankcase.

6. The pressurisation of the crank case due to worn piston rings and cylinders, causing the sump oil to spray over the turbo charger of the adjacent Caterpillar D399 diesel engine.
7. The lack of a proper maintenance regime and standard operating instructions covering the operation of the Caterpillar D343 engine.
8. The use of polycarbonate, instead of steel, fuel filter bowls and the absence of a remote fuel shut off allowed fuel under pressure to feed the fire in the bilge.
9. Lack of bulkhead insulation allowed the heat of the fire to be conducted through the adjacent bulkhead, igniting combustible stores stowed against it.
10. The containment of the fire and associated smoke and fumes was made more difficult by the number of openings in the seismic compressor room, including the penetrations in the bulkhead to the reel room and the open conduits which ran through to the accommodation.
11. A poorly defined relationship over time between the owners and the various charterers, resulting in the ad hoc selection and fitting of machinery and cables without an overall safety oversight.
12. The lack of the adoption of a suitable standard or practical safety assessment approach, by either the vessel's owners or charterers, when designing, constructing and equipping the seismic compressor room.
13. The lack of any required standard, safety survey or safety overview by the flag State, to vessels engaged in international commercial activities, particularly in view of the nature of the operation and the number of people at risk.

14. The reliance upon a “grandfather” clause when applying the national tonnage to avoid having to apply appropriate standards to the detriment of the safety of personnel on board.
- 15 The absence of an appropriate inspection regime to cover vessels operating under the provisions of a "grandfather" clause.
16. The absence of a safety system to take into account appropriate standards for the fitting and maintenance of machinery or other equipment not considered to be ships' equipment.

The Inspector considers, under the circumstances, the fighting of the fire was performed efficiently, by both the ship’s staff and PGS personnel, and the decisions taken in the circumstances were sensible and in the best interests of the vessel. However, it should be noted that the risk to personnel and the ship was increased by the limited number of compressed air bottles available to the fire fighting team.

Details of vessel

Name	Casey Chouest
Flag	United States
Ship type	Seismic survey vessel
Year of build	1981
place of Build	Galliano, USA
Gross Tonnage	11.51
Net Tonnage	345
Lenght overall	50.65 m
Breadth extreme	12.19 m
Depth	4.27 m
Engine	2 Catepillar D399
Engine power	1655 kW
Crew	1 US Master 1 Australian Master 11 Australian crew 13 PGS seismic staff

Submissions

The provision of sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations require, 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 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, or parts thereof was sent to:

2 Masters & Chief Engineer from Casey Chouest.

Edison Chouest Offshore.

United States Coastguard.

Australian Maritime Safety Authority.

PGS Ocean Bottom Seismic.

Tidewater Port Jackson Marine.

Tidewater Port Jackson Marine submitted the following on the subject of split command:-

Split command

AMSA were previously advised of the situation on board of two Masters, and had also verified the role of the Australian Master. Furthermore, a copy of AMSA's letter of reply was replaced on board the vessel when manning up by the Australian crew.

A copy of the letter from AMSA was attached to the submission. This letter stated that if the ship was subject to the Navigation Act of 1912,

it would be necessary for the ship to carry an appropriately qualified Australian Master for the purpose of signing the crew on Articles and for accepting responsibility for the ship under the Act and associated legislation.