Summary

On 3 March 1994, the Australian flag tanker Australian Achiever arrived off the floating production storage offloader Griffin Venture off the north-west coast of Western Australia and drifted, during the morning, while awaiting a pilot.

Before morning tea, the Extra Second Engineer showed the Engineer Cadet, the forward domestic fresh water pump and gave him instructions on how to remove the pump to the workshop for overhaul, a task that the Cadet was to undertake after the morning tea break. The Extra Second, in preparation for removal of the pump, ensured that the pump starter isolator and selector switches were in the "off" position. As the Extra Second was quite clear in his mind that the job involved no electrical work, the fuses were not removed and no "danger" tag was attached to the starter.

During the morning tea break, the Fifth Engineer who was the duty engineer for the day, responded to an engine room alarm which indicated a fault on the vessel's 24 volt DC system, a common cause for alarms.

Shortly after the tea break, the Fifth Engineer again responded to an alarm which he took to be another 24 volt DC earth fault, but which cleared as soon as he "cancelled" the alarm. Later evidence showed that it had been an earth fault on the 440 volt system, in all probability caused by the Cadet having come into contact with a "live" terminal within the starter box for the forward fresh water pump.

At approximately 1113, some 34 minutes later, the Third Engineer came across the Cadet lying on the deck between the fresh water pumps and the calorifiers. He was not breathing and no pulse could be detected. The door to the starter box for the forward fresh water pump was open and the isolating switch was in the "on" position. The vessel's emergency team was called and resuscitation techniques were applied but without success.

A helicopter, attending the Griffin Venture, was tasked to land on the deck of Australian Achiever and to airlift the Cadet to hospital at Exmouth. Resuscitation techniques were applied throughout the flight but, shortly after arrival, the Cadet was declared dead by hospital staff.

Sources of information

The Master and officers, Australian Achiever

Australian Maritime Safety Authority

Electrical Superintendent, ASP Ship Management

Forensic Pathologist, State Health Laboratory Services of Western Australia.

Australian Achiever

Australian Achiever was built in 1983 by Swan Hunter Shipbuilders Ltd. at their Hebburn yard near Newcastle-upon-Tyne, U.K. The ship was built for the BP Thames Tanker Co.Ltd.(U.K.) and was handed over to BP Australia Ltd. in July 1983 on a long-term bareboat charter. The vessel's original name, BP Achiever, was changed to Australian Achiever in 1991.

Australian Achiever is 261.18m in length with a beam of 39.6m and a moulded depth of 23.1m. The ship has a deadweight tonnage of 127,575 tonnes at a summer draught of 17.316m and has 13 cargo tanks. It is powered by a B&W 5L90 GFCA , five cylinder, long-stroke diesel engine, generating 11,953 kW. This machinery drives a single screw and is capable of giving the vessel a loaded speed of 13.5 knots.

The ship is classed with Lloyd's Register as a 100A1 oil tanker, equipped with inert gas, crude oil washing and segregated ballast tanks, conforming to the International Convention for the Prevention of Pollution from Ships 1973, as amended by the Protocol of 1978. It is also equipped to operate with unmanned machinery spaces (UMS). The vessel has a complement of five engineer officers, these being the Chief, Second, Third, Fourth and Fifth. In addition to the normal ship's complement, one or two cadets are periodically carried for sea training as part of their cadetship. Originally the engineering complement included an electrician but, as in the case of most Australian vessels, with the introduction of reduced manning, the Electrician was removed in 1991. The Second, Third, Fourth and Fifth engineers share the daily duty roster on a one-in four basis.

At the time of the incident, there were on board two Second Engineers in order to provide continuity at the change over of "swings" - i.e. one had been on board as Second Engineer for several weeks and the other had recently joined prior to taking over as the Second Engineer at the next port. While the two are on board, the most recent arrival is known as the Extra Second Engineer.

Fresh water for the ship's domestic services is provided by a pressure system installed in the engine-room at the port side, aft, on the same deck level as the machinery control room.

The pressure system essentially consists of two domestic fresh water "Megator" pumps which draw water from the ship's fresh water tanks and deliver it to a pressure vessel in the top of which is an air-bladder charged with compressed air (see photograph page 4). A 440 volt electric motor drives each Megator pump through a set of V-belts.

As water is drawn off for use in bathrooms, galley, etc., the system pressure falls and a pressure switch cuts in one or other of the fresh water pumps. The selected pump then runs,

compressing the air in the bladder, until the pre-set pressure is again reached and the switch cuts out the pump. This cycle continues for as long as water is being drawn off.

The pressure vessel, the two pumps, the electrical control panels and starter boxes for the pumps, the strainers and chlorine dosing pot are all built as a unit which is mounted on a common plinth welded to the steel deck (see photograph page 4).

A switch on the front of the pump control panels, situated above the pumps, allows either the aft Megator pump, (no.1), or the forward pump, (no.2), to be selected as the duty pump. Other switches allow each pump to be controlled by the pressure switch ("Auto" position), to run continuously ("Hand" position), or to be switched off. In addition to the selector switches, a larger "on/off" isolator switch for each pump is situated at the bottom of the front cover on the pump starter (see photograph page 9).

On the right hand side of the front cover of each of the pump starter panels there is a lock at the top and bottom corner, opened by a common key. In order to open the cover and gain access to the starter and control circuits it is necessary, in addition to opening these locks, to ensure that the isolating switch is in the "off" position whereby an interlock mechanism is disengaged thus allowing the panel to swing open. This interlock is designed to make sure that the "Crabtree" isolating switch within the starter is "off" and the electrical circuits contained within the starter panel are isolated before the front cover is opened.

If, with the front cover open, it is found necessary to close the isolating switch to apply power to the circuits within the starter, in order to carry out electrical testing or fault analysis, then the spindle of the isolating switch must be rotated by 90 degrees. Rotation of the spindle is opposed by a strong spring and cannot be achieved without applying a tool of some sort to the small "T-bar" passing through the end of the spindle in order to attain sufficient leverage. As can be seen in the photograph on page 15, the positions of this T-bar, corresponding with "on" and "off", are clearly marked on the front of the "Crabtree" switch.

The vessel's electrical supply is generated at 440 volts, 60 Hz, 3-phase. This is supplied through the isolator switch and contactor to the Megator pump motor. A step-down transformer is situated within the starter box to provide 110 volts for the control circuits.

Narrative - 3 March 1994

On 3 March 1994, following a voyage from Dumai, Indonesia, carrying crude from Cinta and light crude from Sumatra , Australian Achiever arrived at the off-shore floating production storage offloader Griffin Venture off the north-west coast of Western Australia.

During the morning, the ship was drifting off the Griffin Venture awaiting the arrival of a pilot pending berthing to load more cargo. The Chief Engineer had received instructions from the bridge to have the engine ready for manoeuvring shortly after 1100.

Some days earlier, the forward domestic fresh water Megator pump had been leaking water from the shaft seal and it had been switched off at the starter panel pending repair.

The Extra Second Engineer stated that, a little before 1000, he had showed the Engineer Cadet (Cadet), the forward Megator pump and had instructed him to disconnect the pump drive belts, undo the bolts holding the pump to the pedestal and remove the pump to the workshop for overhaul. He specifically instructed him not to touch the motor starter panel. He also stated that he had checked that both the motor isolating switch and the selector switch for that pump were in the "off" position, although the main and control fuses were left in position.

The two subsequently made their way to the workshop and then to the accommodation for morning tea.

While the engineers were having their morning tea, an engine room alarm sounded and the Fifth Engineer, who was the duty engineer for that day, responded. The alarm was caused by an earth fault on the vessel's 24 volt system - a common cause of alarms on this particular vessel over the years and one which causes little immediate concern amongst the engineers. The alarm was accepted and the Fifth Engineer returned to morning tea.

At 1030 the engineers returned to the engine room and the Fifth Engineer commenced preparing the main engine for "stand by".

Shortly after 1030, another alarm sounded and the Fifth Engineer again responded. He accepted the alarm in some haste, and, again observing the activated alarm to be an earth fault, assumed that it was again the alarm for an earth on the 24 volt system. He did not investigate the cause or check which system was involved, and returned to preparing the main engine.

At 1100, he was in the engine control room when the Chief Engineer arrived and the two briefly discussed the preparations for manoeuvring before the Fifth returned to the main engine to check the settings on the cylinder lubricators.

During the course of these events, the Third Engineer was busy on the aft end of the control room flat overhauling one of the spare exhaust valves for the main engine. He had need of a wire sling and went around to the port side,

further aft, where he knew one was stowed close to the forward calorifier.

As he approached the calorifiers, he saw the Cadet, wearing overalls and safety boots, lying on the deck in the space between the calorifiers and the fresh water pumps (see photograph page 4). He was lying on his side, head forward and facing outboard, with his legs bent at the knees.

The Third attempted to revive him, but received no response. He found him cold to the touch and noticed that his eyes and mouth were partly open. Realising that the Cadet was unconscious, the Third quickly returned to the engine control room and advised the Chief Engineer of the situation.

Both the Chief and the Third ran back to where the Cadet was lying. The Chief felt for a pulse in the carotid artery and then, being unable to detect one, returned to the control room to advise the Master and to call for the assistance of the emergency party. The time was 1113.

On the bridge, the Master immediately broadcast an instruction for the emergency party, headed by the Third Officer, to muster and proceed to the scene. Meanwhile, the Third Engineer remained with the Cadet and continued to check for a pulse and signs of respiration, but without success.

The Chief Engineer returned from the control room and, there being no signs of any improvement in the Cadet's condition, the two of them carried him clear of the confined space between the calorifier and the fresh water pumps.

They laid the Cadet on his back and raised his neck to ensure that the airway was clear. At this point, the Third Officer arrived with other members of the emergency party, as did the Extra Second Engineer who had heard the call for the emergency party over the vessel's broadcast system. The Extra Second noticed that the door on the front of the pump starter was ajar and that the isolating lever was in the "on" position.

The Third Officer was also unable to detect a pulse or signs of breathing and noticed that there was no whitening when he depressed the skin of the Cadet's neck. He applied cardio and expired air resuscitation techniques with the assistance of the Third Engineer, the Chief Integrated Rating and two other Integrated Ratings. During this process, the Third Officer, noticing that there were no signs of injury on the Cadet, apart from what seemed to be a burn on his forefinger and a bruise above his left eyebrow, assumed that he had suffered electrocution and advised those assisting to keep clear of electrical equipment.

Resuscitation attempts were applied continuously, but signs of pulse or breathing never returned and the Master, being informed at 1118 that the attempts were unsuccessful, requested the services of the helicopter attending the Griffin Venture. As the available helicopter was too large to land on the ship's helo spot without the removal of guardrails and deck valves, he organised the crew to remove these obstacles - a task which was quickly completed.

At 1135, the helicopter arrived and landed safely on the deck of Australian Achiever with its tail rotor overhanging the ship's side on account of its length. Assistance from the Griffin Venture, in the form of the Second Mate and a stretcher party, had also arrived on board the ship. The Cadet, fitted with a Motivus Mariner automatic resuscitation unit, was placed in a Paraguard stretcher and carried to the helicopter.

The Third Officer from Australian Achiever and the Second Officer from Griffin Venture remained with the Cadet, continuing attempts to revive him, as the helicopter flew to Exmouth hospital. Shortly after arrival at the hospital, the cadet was pronounced dead by the hospital staff.

The Chief Engineer and the Third Engineer later returned to the domestic fresh water pumps and observed that the starter panel door, for the forward pump, was open and supported only by the lower hinge. The mode selector switch was in the "off" position, but the isolating lever was in the "on" position and the internal isolating switch spindle was in the "on" position. The fuses had not been disturbed and work on removing the pump had not been started.

The Cadet's locked tool box was found at the forward outboard corner of the fresh water plant, (about 2.5 metres away) and its key, with a tag and a clip of spring steel attached to the key-ring, was lying next to the calorifier, close to where he had fallen (see photograph page 9).

Comment

In the course of the investigation, discussions were held with the Master, the Chief Engineer and the other engineer officers on the subject of the Cadet's capability and his ability to relate to others at sea. It emerged that he was considered conscientious, capable, of sober habits and mentally well-balanced. He was both well regarded and liked by those aboard Australian Achiever.

The Cadet had worked previously, under the supervision of the Extra Second Engineer, on the removal and overhaul of the air-conditioning plant sea water circulating pump and the sea water pump for circulating water through the deck seal of the inert gas system.

He had shown no uncertainty about the task assigned to him on this occasion, nor queried any aspects of electrical isolation and for these reasons the Extra Second Engineer considered he was capable of handling the task unsupervised. The job of removing the forward domestic fresh water Megator pump to the workshop for overhaul, was a straightforward one well within his capabilities. It involved removing the belt guards, disconnecting the pump suction and discharge connections, removing the bolts holding the pump to its baseplate and slipping the V-belts off the driven pulley. The pump could then be lifted clear and transported to the workshop.

The reason for the Cadet having opened the starter panel remains unclear. The pump cannot be started from any remote position and the position of the starter - immediately above and adjacent to the fresh water pump - makes it most unlikely that anyone would operate the switches. To do so would mean that the person would virtually have to stand on someone working on the pump.

It was stated that he had been told by the Extra Second Engineer not to touch the starter and the Extra Second had checked that the isolator and selector switches were both in the "off" position. It is apparent that the Cadet did open the starter panel, the most likely reasons for which must be either that he decided to remove the motor and/or control fuses to be doubly sure that the motor could not be inadvertently started while he was working on the pump, or out of curiosity about the operation of the starter and the door interlock.

The Extra Second Engineer was quite clear in his own mind that there was no electrical work involved as part of the job and, for this reason, had not carried out the usual isolating and tagging procedures required prior to commencing electrical work.

These procedures include removing fuses, attaching "Danger" tags to switches and locking isolators with padlocks. These procedures are detailed in the "Technical Manual", produced by ASP Ship Management, in paragraph 2.2 of the section "Electrical and Electronic Equipment".

Another ASP manual carried aboard the vessel, the "Safety and Emergency Procedures Manual" contains (at section 2.3) instructions for the "Tagging" and "Locking Out" of any system upon which work is to be performed and "*.....where the inadvertent activation of any apparatus or system could endanger those people working on them.*"

Section 2.3 of the vessel's "Safety and Emergency Procedures Manual" , however, goes on to state (in upper-case lettering for emphasis):-

"The following must be clearly understood :-
(a) THERE IS ALWAYS A POSSIBILITY OF PERSONAL INJURY DUE TO SOMEONE ELSE INADVERTENTLY TURNING THE POWER ON OR OPENING A SYSTEM UP WHILST A PERSON IS WORKING ON IT. IN ORDER TO AVOID THIS SITUATION ARISING, EVERY PERSON IS RESPONSIBLE FOR FASTENING A "DANGER TAG", OR PERSONAL PADLOCK, TO THE MAIN ELECTRICAL ISOLATING SWITCH, CONTROL DEVICE OR VALVE OF ANY SYSTEM HE IS TO WORK ON."

The Cadet may have been aware of these instructions which would have reinforced the engineering and general safety education instilled into him during various aspects of his training. It may also be that, in spite of the instructions given to him by the Extra Second Engineer, he considered that he should remove the fuses from the starter before commencing work.

Having opened the front cover of the starter panel, however, the spindle of the isolating switch would have to have been turned back into the "on" position, as, in order to open the cover, the lever which operates that switch with the door closed must be in the "off" position. The spindle cannot be turned by hand against the strong spring pressure and some form of tool must be employed to provide the necessary leverage. A test carried out after the incident showed that the spring steel clip carried on the Cadet's key ring (see photograph page 15) could have been used for this purpose by hooking the loop over one side of the T-bar on the end of the switch spindle.

The reason for the Cadet having turned the isolating switch to the "on" position is also unclear. If his purpose in opening the starter panel was to remove the fuses, then the isolator switch would have been in the "off" position when he opened the door. It is possible, but by no means certain, that, during a lapse in concentration, he turned the spindle thinking that he was turning it off. He would have had to fail to observe the "on/off" indication which is clearly marked on the switch (see photographs page 15). It must also be noted, however, that the lever on the outside of the opened door was found to also be in the "on" position. This may indicate that he had been investigating the operation of the door interlock. With the door open, he would not have been able to see that the white indicator light on the outside of the door, indicating "power on", was illuminated.

The cause of death, as determined by the W.A. pathologist, was electrocution and the evidence indicates that the cadet died following contact between his right hand and some live point within the starter panel. It is possible, although it cannot be stated with certainty, that his hand contacted some live terminal within the starter as he moved to remove the fuses (see photograph page 15). Heat and humidity in the engine room cause considerable perspiration which would have reduced the electrical resistance at the point of contact and may even have caused the initiation of an electrical arc.

Subsequent to the incident, the ASP Electrical Superintendent had "Megger"* tested the starter panel of the forward domestic fresh water pump and no electrical faults had been detected.

A search for the missing screws from the top hinge of the door on the starter panel failed to find them and it is not clear whether they were missing prior to the incident or whether the top hinge was dislodged during the incident. In either case, however, it is not considered a significant factor.

Alarms

A fault in one of the ship's systems, or the machinery, will bring up an audible and visual alarm on the alarm panel situated in the machinery control room. The duty engineer will respond by going to the machinery control room and "accepting" an alarm by means of a push-button. This acceptance will silence the audible alarm, but the visual alarm indicator for that channel will remain flashing until the "cancel" button is pressed. The flashing indicator will then change to a steady indication remaining illuminated until such time as the fault either clears itself or is corrected by action on the part of one of the engineers. It will then be automatically extinguished. In the case where the fault was brief and has corrected itself before the duty engineer presses the "cancel" button, then pressing that button will remove all indication of the fault.

The alarm panel on the engine-room console has on it separate indicating lights for something in the order of 300 alarm channels. At any time, but more especially when preparing machinery for manoeuvring, a number of these alarms will be illuminated. The alarms for earth faults on the 24 volt DC, 220 volt, and 440 volt systems are all grouped close together and the engraved lettering on the cover of each alarm light, indicating the nature of the fault, is approximately 3mm high, thus requiring some momentary concentration when "accepting" an alarm if the nature of the fault is to be appreciated.

When an alarm sounds, a printer connected to the system prints out in red the channel number of the fault together with the date and time at which the fault occurred. When the cause of the fault is corrected, the printer again prints out, in black, the

* High voltage test of insulation, using a "Megger" meter.

channel number, date and time. The time is taken from the printer's own internal clock.

The alarm print-out for 3 March showed, in red print, an alarm having occurred at 1535 in channel 212. Channel 212 is that for an earth fault in the vessel's 440 volt system. The print-out also indicated, in black print, that the alarm had been accepted and cleared at 1539. The Chief Engineer stated that resetting the clock (normally to U.T.C.) had been overlooked following a recent blackout of the vessel and a test had been conducted, following the incident, to establish the relationship between the time shown on the print-out and ship's time. The result of this test indicated that the 440 volt earth fault had occurred at 1039 (ship's time) on that morning and that it had been accepted and cleared at 1043. If a fault clears itself before the "cancel" button is pressed, then the indicating light will be extinguished when the cancelled and this is the time recorded by the printer. It is, under these circumstances, not possible to establish the time when the fault cleared itself, only the time at which it was cancelled on the console.

It was thus not possible to establish exactly for how long the earth fault had remained active.

As the alarm channel had cleared when the Fifth Engineer had cancelled it, he assumed it to have been another earth on the 24 volt system and did not pay it further attention. It seems most likely however, that it was a brief earth on the ship's 440 volt system caused by the actions of the Cadet.

During the investigation, it was stated by a number of the vessel's staff that many mechanical and electrical problems could be traced back to the design stages and that equipment was prone to malfunction in many areas and for a variety of reasons. Electrical earths on the 24 volt system, in particular, were not uncommon. As a result of all the problems, the engineers were said to be working under a certain amount of pressure.

Conclusions

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

1. The findings of the Coroner's inquiry were that the Cadet died by electrocution following contact between his right hand and a live terminal within the starter box for the motor on the forward domestic fresh water pump.

2. The Cadet had been given the task of removing the forward fresh water pump for overhaul, a task which was well within his mechanical abilities. It is considered likely, although it cannot be stated with certainty, that he considered the fuses should be removed prior to commencing work and he was about to do this when he accidentally touched a live terminal with his hand.

3. In order to open the front cover of the starter box to gain access to the fuses, it is necessary to turn the isolating lever to the "off" position. It seems that the Cadet, having opened the front cover, must have turned the isolating switch back into the "on" position, possibly using the spring-steel clip on his key-ring to obtain sufficient leverage.

4. The reason for the Cadet having turned the isolating switch back to the "on" position is unclear. It may have been done during a momentary lapse in concentration or he may have been investigating the function of the interlock. The isolating switch is clearly marked showing the "on" and "off" positions of the small T-bar through the end of the spindle.

5. The alarm for channel 212, recorded on the alarm print-out at a time equivalent to 1039 (ship's time), indicating an earth on the vessel's 440 volt system, was probably initiated by the contact between the Cadet and some live part of the starter for the forward domestic fresh water pump.

6. The Fifth Engineer acknowledged the alarm four minutes later at 1043. As the alarm channel cleared as soon as the "cancel" button was pushed, he was uncertain as to which alarm had been activated and assumed that it was a repeat of the earlier alarm for an earth fault on the 24 volt DC system. The Inspector considers that, as the earth fault was shown as having cleared, there was not cause for further immediate action on the part of the Fifth Engineer.

7. It is not known with certainty whether the Cadet's hand contacted a point in the starter which was at 440 volts or at the control circuit voltage of 110 volts. It is likely, in

view of the 440 volt earth alarm recorded at 1039, that it was at 440 volts. In either case, however, heat and humidity in the engine room cause considerable perspiration which would have increased the current flow through his body and, particularly in the case of 440 volts, could possibly have aided in the initiation of an electrical arc. It is not known, either, exactly how long he was in contact with the supply of current as the alarm print-out indicates only the time between the initiation of the earth fault and the time that the alarm was "cancelled" in the control room.

8. The procedures detailed in ASP Ship Management's "Safety and Emergency Procedures Manual", relating to machiney isolation, were not followed. The Extra Second Engineer stated that he had checked that both the selector switch and the isolator for the forward pump starter were in the "off" position. The job of removing the pump was not of an electrical nature and, for this reason, he had not carried out the usual precautions required before undertaking electrical work, such as removing the fuses and "tagging" the starter.

9. The reason for the Cadet having opened the door of the starter cannot be known but, in order to do so, the isolator switch had to have been turned to the "off" position. If, as is possible, he opened it to remove the fuses then under these circumstances, whether or not a safety tag had been attached to the equipment would have had no bearing on the outcome of the incident.

10. The Cadet was found lying on the deck shortly before 1113. No resuscitation techniques were applied before the Emergency Team arrived some minutes later. It was not known at that time that he was dead and, in the absence of a pulse or respiration, CPR should be applied immediately. It is acknowledged, however, that if the alarm at 1039 indicated the time he received the fatal shock, the outcome would have been no different.