



Report of Investigation
into Electrocution of a Fitter
while Performing Electric Arc
Welding Repair on board
Hong Kong Registered Vessel
Pacific Explorer
on 20 November 2009



The Hong Kong Special Administrative Region
Marine Department
Marine Accident Investigation Section



Purpose of Investigation

This incident is investigated, and published in accordance with the IMO Resolution MSC 255(84), the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code).

The purpose of this investigation conducted by the Marine Accident Investigation and Shipping Security Policy Branch (MAISSPB) of Marine Department is to determine the circumstances and the causes of the incident with the aim of improving the safety of life at sea and avoiding similar incident in future.

The conclusions drawn in this report aim to identify the different factors contributing to the incident. They are not intended to apportion blame or liability towards any particular organization or individual except so far as necessary to achieve the said purpose.

The MAISSPB has no involvement in any prosecution or disciplinary action that may be taken by the Marine Department resulting from this incident.

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1. Summary

- 1.1 At about 1450 to 1517 on 20 November 2009, a fatal accident happened on board the Hong Kong registered general cargo vessel *Pacific Explorer* in which a fitter was electrocuted while performing electric arc welding repair on the fire main on the deck.
- 1.2 After the vessel had departed the port of Jakarta for Beneta Bay in Indonesia on 19 November, two fitters started to carry out repair work on the deck fire main. While the repair work was not finished on 19 November, they continued the work on 20 November.
- 1.3 On 20 November, one of the fitters finished his part of welding in the morning and was assigned other repair work. The other fitter was working alone under occasional supervision by the Chief Officer. The fitter, who had difficulty in making a good weld to the underneath of the pipeline, was still working on it in the afternoon until around 1450 to 1517.
- 1.4 At 1517, he was sighted lying unconsciously on his back adjacent to the work place. The ship's position was approximately 06° 44'S 114° 00'E. Despite efforts by the crew to recover him, there was no sign of life in him and the rescue stopped at around 1640.
- 1.5 The vessel arrived at Benete Bay at 0742 on 21 November 2009. The deceased was confirmed dead and landed ashore at 1223 on 21 November 2009 for autopsy and subsequent repatriation back to his home country.
- 1.6 The investigation revealed that the main contributory factors to the accident were as follows:-
 - while performing electric arc welding, the body and clothing of the deceased were wetted by perspiration and seawater due to the hot and damp weather together with seawater leaking from the fire main;
 - personal safety awareness of the deceased was lowered while working under pressure and stress; and
 - the senior officers did not monitor the repair work closely and failed to take decisive action to intervene and correct the situation when unsafe practices and conditions were found to have developed before the accident.

2. Description of the vessel

2.1 Particulars of *M.V. Pacific Explorer*

Port of Registry	:	Hong Kong, China
IMO No.	:	9007362
Call sign	:	VRSR
Type	:	General cargo / multi-purpose ship
Year Built	:	4 April 1991
Gross Tonnage	:	18391
Net Tonnage	:	9521
Length Overall	:	177.04 metres
Breadth	:	27.60 metres
Moulded Depth	:	14.70 metres
Main Engine	:	1 x Mitsubishi 8UEC60L
Engine Power	:	14120 kW
Speed	:	20.6 knots
Class	:	Lloyd's Register

2.2 General description of the vessel

M.V. Pacific Explorer is an 1123 TEU geared multi-purpose containership built in Minami Nippon, Usuki, Japan in 1991. She has 5 holds forward of the accommodation with container bays (01 – 31) and container stowage space (bays 33, 35 and 37) located on the poop deck. The vessel has six centerline mounted electro-hydraulic deck cranes.



Figure 1 – *Pacific Explorer* at anchorage



Figure 2 - *Pacific Explorer* at berth

3. Sources of evidence

3.1 Report of investigation provided by the ship management company of the vessel.

4. Outline of events
(all times are local)

- 4.1 At 0618 on 19 November 2009, the Hong Kong registered general cargo vessel *Pacific Explorer* departed the port of Jakarta, Indonesia. At 0742, the vessel was full away on passage to Benete Bay, also in Indonesia. The voyage would take about two days.
- 4.2 Renewal of a three-metre long corroded section of the fire main on deck located on the port side in the vicinity of Bay 29 had been planned for during this voyage.
- 4.3 Fitter A and Fitter B were assigned by the Chief Officer to carry out the repair. They started to work at about 0800 on 19 November 2009.
- 4.4 Before starting the work, the Chief Officer produced a hot work permit for the Chief Engineer's signing. The Chief Engineer signed the permit without assessing the danger involved in the welding job.
- 4.5 On the morning of 19 November, Fitter A and Fitter B started the work to cut off the corroded section of the fire main and prepared the new pipe. The new pipe was fitted into position using two steel sleeves, one at each end, for connecting to the existing pipeline (see Figure 3). Two runs of weld were required for each of the four joints.

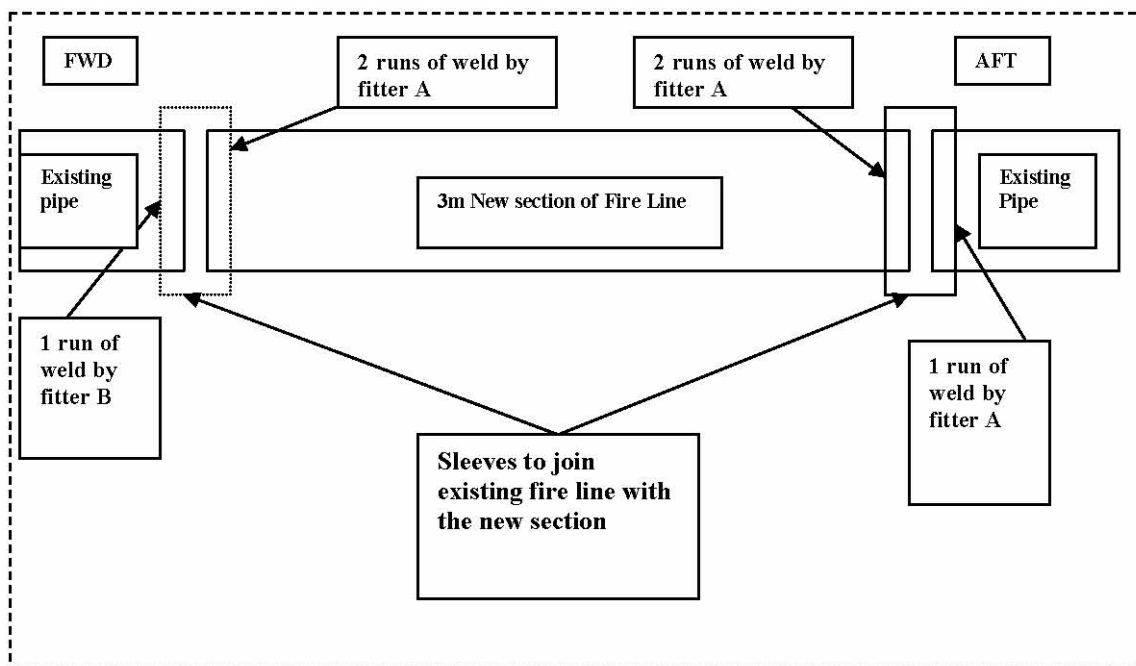


Figure 3 – Sketch showing the repair work

- 4.6 After they had finished the preparation work, the Chief Officer instructed Fitter A to start welding up the sleeves to the pipeline in the afternoon after the lunch break and told him that Fitter B would be assisting him.
- 4.7 At 1400, Fitter A used the portable welding machine for welding and at 1630, he finished welding two of the four joints (see Figure 3).
- 4.8 In order to complete the repair work by the end of the working day, the Chief Officer agreed at the suggestion of the Bosun that Fitter B should be allowed to take part in the welding using the fixed welding machine located inside No.4 mast house. At 1630, Fitter B started welding to the forward joint of the forward sleeve.
- 4.9 At about 1730, they had completed one run of weld to each joint. The Chief Officer ordered to have a hydraulic test conducted on the fire main to check for any leakage of seawater. It was found that both sleeve joints with only one run of weld were leaking, with the one done by Fitter B more seriously.
- 4.10 Considering that the leak would not affect water discharge pressure in the fire main, the Chief Officer decided to continue the work on the next day. Water in the pipeline was drained. The Chief Officer informed the Master about the situation. The Chief Engineer was not informed.
- 4.11 The Chief Engineer had been working in the engine room to repair a major leak on the main engine seawater cooling line throughout the day until 1830. He had no time to monitor the repair work on the fire main and was not aware of its status at the end of the day on 19 November. Nor did he ask the Chief Officer for details.
- 4.12 Deck fire main out-of-service labels were placed on the bridge and by the fire isolation valve in the fire station. The isolation valve was shut and the engine room crew was informed, but no out-of-service label was placed by the fire pump's starting button.
- 4.13 It was not until the Chief Officer asked the Chief Engineer to sign the hot work permit again at 0800 on the morning of 20 November that the latter learnt the fire main repair had not been completed.
- 4.14 At about 0800 on 20 November, Fitter A and Fitter B started working on the fire line. At 0915, Fitter A finished his work and the Chief Officer assigned him for another job on the poop deck. Fitter B continued the work under occasional supervision by the Chief Officer. Fitter B went for lunch at 1200.

- 4.15 During lunch break at 1330, the Chief Engineer visited the repair work and inspected the welds. He made no comment.
- 4.16 Fitter B came back to work after the lunch break. At 1450, he was called by another crewmember to join him for tea break. Fitter B acknowledged him but stayed on to work at the site.
- 4.17 At 1517, Fitter B was sighted lying unconsciously on his back adjacent to the work place. The Master raised general alarm and supervised the medical response where Cardiopulmonary Resuscitation (CPR) was administered to Fitter B for 20 minutes by various officers. With no sign of life found, the Master stopped the CPR at around 1640. The ship's position was 06° 44'S 114° 00'E when the general alarm was sounded.
- 4.18 Fitter B was taken to the ship's hospital where his boiler suit was removed and his body cleaned. He was later placed in a body bag before being placed in the cool environment of the handling space of the ship's fridge compartment.
- 4.19 The Designated Person Ashore was informed by the Master of the incident at around 1600 (Hong Kong time) on 20 November 2009. The Hong Kong Marine Department was also informed of the accident on 20 November 2009.
- 4.20 The vessel arrived at Benete Bay at 0742 on 21 November 2009. Fitter B was confirmed dead and landed ashore at 1223 on 21 November 2009 for autopsy and subsequent repatriation back to his home country.

5. Analysis of evidence

Training and experience of fitters

Fitter A

- 5.1 Fitter A held a Welder Qualification Certificate issued by the China Classification Society on 27 September 2009 valid until 26 September 2012. He was certificated to carry out manual arc welding on board ships. He had worked on board a number of vessels from November 1990 to August 2003 in the rank of motorman. Since February 2004, he had been working as a fitter on board ships, including *Pacific Explorer*.

Fitter B (the deceased)

- 5.2 Fitter B completed the Ship's Repairman Skills Training (Welding) conducted by the Northwestern Mindanao Institute of Technology from 21 July to 21 August 2008. He also completed the training in Shipboard Welding Course conducted by the SEAMAC International Training Institute, Inc. from 27 April to 2 May 2009. He held a Welder's Approval Test Certificate issued by Det Norske Veritas on 29 September 2009 valid until 29 September 2011.
- 5.3 He had worked ashore as a welder for about four years. His first appointment as a fitter on board ship was on 6 May 2009, but resigned on 19 June 2009. After that, he joined another shipping company and worked as a fitter on board *Pacific Explorer*, which he joined on 12 November 2009 in the port of Singapore. He had worked for only eight days on *Pacific Explorer* when the accident occurred. During that period, he mainly engaged in general repair work such as tack welding repairs to the jibs and No.2 hatch ram.
- 5.4 Despite having good training records and being properly certificated, Fitter B acquired only limited working experience on board ships.

Ship Manning

- 5.5 A crew of 26, mainly from China and the Philippines, manned the vessel. Crew changes had taken place recently in October and November 2009. For example: the Master and the Chief Officer joined the vessel on 16 November and 16 October respectively; the Chief Engineer joined the vessel on 12 June and was promoted to Chief Engineer on 11 November 2009; Fitter A and Fitter B joined the vessel on 1 November and 12 November respectively.

Familiarization training

- 5.6 During Fitter B's familiarization tour in the engine room conducted by the Second Engineer, he was shown the welding machines in the workshops and their grounding leads, as well as the portable welding machine on the poop deck. The welding machines inside No.1 and No.4 mast houses were not shown to him. Fitter B was reminded to ensure the good condition of the welding cables.
- 5.7 Fitter B was not briefed on the Safety Management System during his tour in the engine room conducted by the Second Engineer, or during another safety tour conducted by the Third Officer. Instead, Fitter B was asked to read the relevant sections of the manual himself.
- 5.8 The Safety Management System manual on board is written in English. Some essential parts have been translated into Chinese for the Chinese crew. It is not known whether Fitter B could understand the SMS manual since English was not his native language.

The weather condition

- 5.9 On 20 November 2009, the weather condition was good, with the sky partly clouded, wind North-North-West force 2 (light breeze) and no rain. Air temperature was about 31 degrees Celsius and humidity high. The sea state was calm with ripples. The vessel was sailing at 15 knots.

The repair of fire main by welding

- 5.10 The section of the fire line to be repaired by Fitter A and Fitter B runs in the fore-and-aft direction on the main deck port side adjacent to Bay 29, beside the hatch coaming and close to the deck surface (see Figures 4 and 5). A three-metre-long section of corroded pipeline was to be cut and replaced by a new pipe. Two steel sleeves were fitted to the ends of the new pipe for connecting to the existing piping and join by electric arc welding. There were a total of four welding joints - two for each sleeve - and each welding joint required two runs of weld. The welding of the joint is a combination of flat, vertical and overhead positions ("5G" horizontal fixed position). Fitter B was qualified as a 6G-graded welder (welding of a steel pipe inclined at 45 degrees from the horizontal), which is higher than 5G-grade, so he was competent to do the job.



Figure 4 – Position of fire main in relation to the hatch coaming



Figure 5 – Deck fire main after repair

- 5.11 The fire line is laid under another pipeline, close to the deck surface and runs beside the hatch coaming, resulting in a difficult position for welding by the operators. On the evening of 19 November, the fire main was hydraulically tested for leakage of seawater and then drained. When the work started again on the morning of 20 November, residue of seawater was still leaking from the piping. That made welding to the underneath of the pipeline more difficult.

The use of welding machines

- 5.12 Fitter A used the portable welding machine (see Figure 6) with its return cable clamped at the site of the welding. The open circuit voltage of the welding machine, checked after the incident, was 68.7V.



Figure 6 – Portable welding machine used by Fitter A



Figure 7 – Fixed welding machine inside No.4 mast house used by Fitter B

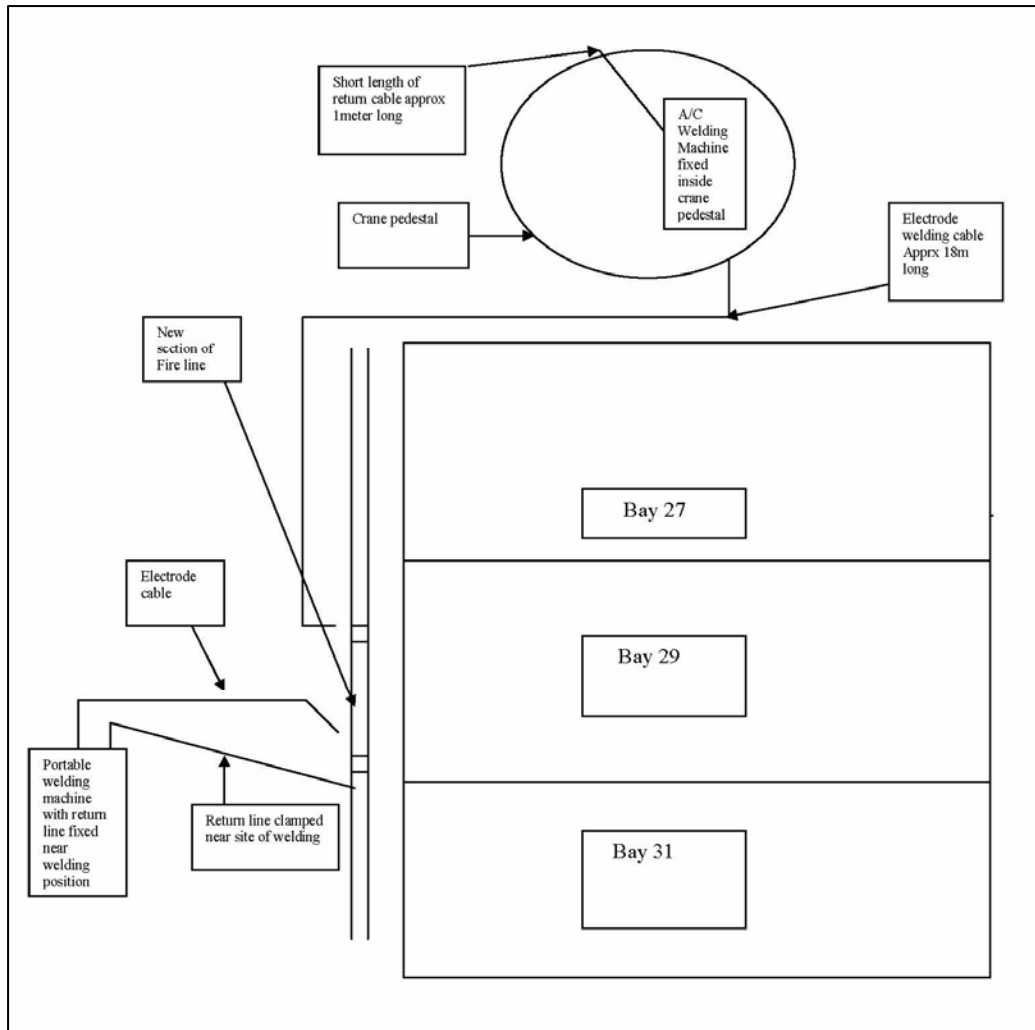


Figure 8 – Welding cable arrangement for the fixed and portable welding machines

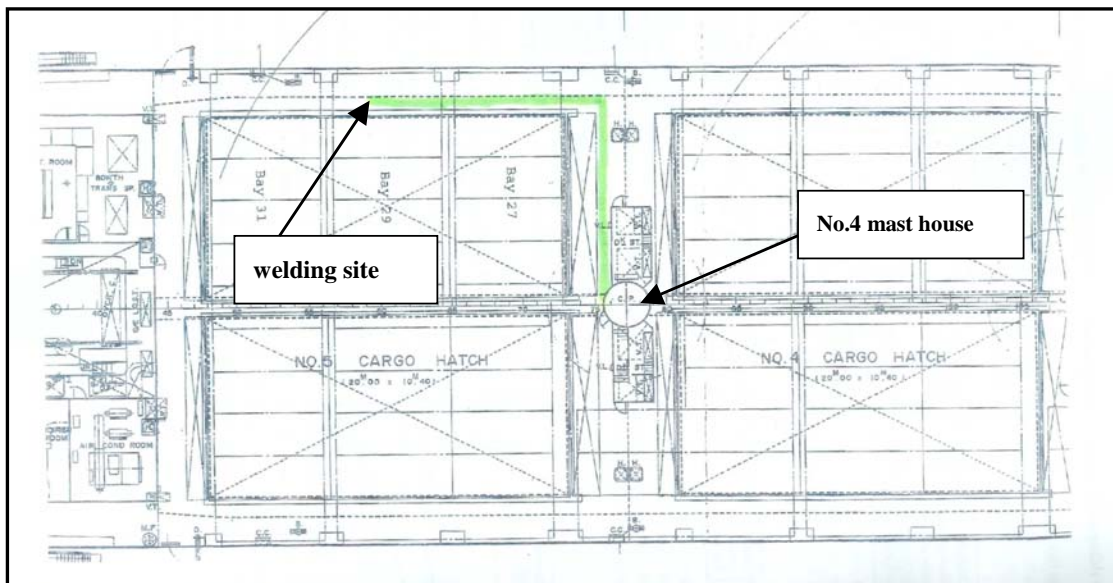


Figure 9 – The position of No.4 mast house (where the fixed welding machine was located) in relation to the welding site

- 5.13 Fitter B used the welding machine located in No.4 mast house. The open circuit voltage of the welding machine, checked after the incident, was 67.2 volt. It had a short return line fixed to an internal stiffener of the crane house (see Figure 7).
- 5.14 Figure 8 and Figure 9 show respectively the welding cables arrangement for the fixed and portable machines, and the position of the welding machine inside No.4 mast house in relation to the welding position of Fitter B on deck.
- 5.15 The Code of Safe Working Practices for Merchant Seaman (the Code) stipulates that welding machines using Alternating Current sources must be provided with an integral voltage limiting device to ensure that the idling voltage (the voltage between electrode and work piece before an arc is struck between them) does not exceed 25 V RMS (Root Mean Square). It also requires that a “go-and-return” system utilizing two cables from the welding set should be adopted, and the welding return cable should be firmly clamped to the workplace.
- 5.16 The idling voltages of all welding machines on board were checked after the accident. They were in the range between 67.2 and 75.2 volts. After the accident, voltage reduction devices to reduce the voltage to 12 volts were supplied on board.
- 5.17 The return cable of the fixed welding machine inside No. 4 mast house did not comply with the Company’s Electric Arc Welding Precautions Guidance and the Code.

Personal protection equipment

- 5.18 Fitter B used proper boots, gloves and face visor during the welding work and all were in good condition.
- 5.19 Despite using proper personal protection equipment, Fitter B was not aware of the risk of electric shock or electrocution while working in a hot and humid environment, with seawater leaking from the fire main. His body and clothing were wetted by perspiration and seawater, and was in contact with the ship’s structure while welding in an awkward position.
- 5.20 When he was found lying on the deck adjacent to the welding site, the right side of his boiler suit was wet with sweat and seawater.
- 5.21 Fitter B did not take the precautions stipulated in the Code during electric arc welding. Examples of such precautions are: clothing and gloves should be kept as dry as possible; dry insulating mats or boards should be used when the operator may be in contact with the ship’s structure; avoid welding operation in hot or humid

conditions, etc.

Risk assessment and hot work permit system

- 5.22 Although the ship management agreed that the fire-fighting system on board ship was a critical system and any repair to the fire main would affect the fire-fighting capability, no formal risk assessment was carried out prior to the repair of the ship's fire main.
- 5.23 The ship management assessed the risk of the work by experience. They might have considered the work in question as common repair with minimal impact on ship and personal safety.
- 5.24 Without conducting a formal risk assessment, the company's guidance on Electric Arc Welding Precautions as well as the safety precautions stipulated in the Code was overlooked.
- 5.25 The hot work permit system, which eventually became the final defence to identify risks before the work started, was ineffective since the checklist might have been treated as a routine to fulfill the documentation requirements of the Safety Management System.

Stress at work

- 5.26 After Fitter A finished his part of welding work on the fire main on the morning of 20 November, Fitter B might have been under some psychological pressure while he was struggling to finish his work under the supervision of the Chief Officer and that the Bosun was waiting to paint the fire line.
- 5.27 At 1450 on 20 November, Fitter B was still working on the pipeline. Instead of joining his colleagues for tea break, he remained at the site and continued to work. At that point of time, he might have felt the pressure of time, since the repair work should be completed by the close of the working day, as would be expected by his supervisors.
- 5.28 It was probable that his personal safety awareness was lowered due to working under pressure (i.e. to finish the work as soon as possible) and stress (anxious about his performance not being accepted by the Chief Officer).

Fatigue at work

- 5.29 Fitter B had been assigned to normal day work. He did not work overtime on 19 November. He should not have suffered fatigue at work before the accident.

Effect of drugs and alcohol

- 5.30 Fitter B had only worked for eight days since joining the vessel prior to the accident. He was certified fit for duty on board before joining the vessel. He consumed alcohol but was not considered as hard drinker. There was no evidence to prove that he was affected by drugs and alcohol before the accident.

Monitoring and supervision of inexperienced crew's work

- 5.31 The Master had just joined the vessel in Jakarta on 17 November. The Chief Engineer was just promoted on board the vessel 11 days before the accident. The ex-Chief Engineer told him that the newly joined Fitter B had a 6G-graded welder qualification. However, neither of them was aware of Fitter B's limited experience at sea.
- 5.32 Fitter B was recruited to work on board as a fitter with good qualification in welding. In the familiarization training on board the vessel, he was briefed and guided by the officers. However, his limited working experience on board was not highlighted by the previous Master and therefore not known to the previous or the current Chief Engineer and other officers and crew.
- 5.33 On 20 November, after Fitter A had finished the welding at 0915, he asked the Chief Officer if he should complete the job for Fitter B. His request was declined. The Chief Officer was occasionally monitoring the work of Fitter B, while the Bosun was also watching on him because he wanted to paint the new section of pipe after the work finished. The Bosun spoke to Fitter B two times on 20 November. During one of the conversations in the afternoon, Fitter B told him that he experienced difficulty in welding around the bottom of the pipe and also felt strong grounding sensations during welding. The Bosun suggested Fitter B use plywood for protection, but the latter said that would not be necessary. When the Bosun met the Chief Officer in the afternoon before coffee-time, he told him that the experience of Fitter B was limited. At 1330 on 20 November, the Chief Engineer visited the repair work and inspected the welds but made no comment. The Chief Engineer stated that he was occupied by another repair work in the engine room, and so could not spend time to monitor the fire pipe repair on the deck.

- 5.34 The ship management was not aware of the potential risks of an inexperienced new crewmember joining the vessel. Officers and crew only learnt that Fitter B was a qualified welder without knowing about his experience working on board ships. This might have led the ship officers overlooking his safety while working on board.
- 5.35 When unsafe practices and conditions were seen developing in the work performed by Fitter B, the responsible supervising officers failed to take decisive action to intervene and correct the situation.

Communication among officers on board

- 5.36 The Chief Engineer did not know that the fire main would be repaired on the morning of 19 November until he was asked by the Chief Officer to sign the hot work permit before the work started.
- 5.37 When the repair work could not be finished on 19 November, the Chief Officer only informed the Master of the repair status. The Chief Engineer had no knowledge about the status of the fire main. Nor did he find that out from the Chief Officer or the Master.
- 5.38 It was probable that the different nationalities of the crew on board had hampered effective communication among them due to language barrier and different work cultures. The Master felt that communication, especially among officers and crew of different nationalities, was at times problematic. There was reluctance for officers and crew of different nationalities to maintain close communication.

Electrocution

- 5.39 Fitter B used proper personal protective equipment, but his clothing was wetted by perspiration while working in hot and humid weather and by seawater leaking from the fire main. The wet body and clothing resulted in lower electrical resistance, enabling leakage electric current to pass through his body easily and making him more vulnerable to electric shock or electrocution.
- 5.40 The return cable of the welding machine used by Fitter B was connected to the ship's hull just beside the welding machine located inside the mast house, which was far from the place of work. The long return path of electric current through the ship's hull during welding would have a higher electrical resistance than the wet body of Fitter B. The risk of electric shock and electrocution was increased.
- 5.41 The pipeline, which ran very close to the deck surface and was restrained by hatch coaming, was leaking with seawater at the welding joints. Fitter B was having

difficulty in making a good weld to the underneath of the pipeline. The difficult position for welding would have caused Fitter B's body to come into contact with the ship structure during welding. Proper insulation to protect the operator should have been provided to avoid electric shock and electrocution.

- 5.42 While Fitter B was working under pressure and stress, he might have lowered his personal safety awareness. Had he been stopped in his work earlier or proactively sought assistance from others, the accident might have been avoided.

Autopsy

- 5.43 The Forensic Medicine Department of the Faculty of Medicine of the Udayana University in Indonesia conducted the autopsy. Advice was also sought from the Forensic Pathology Service of Hong Kong regarding the findings of the autopsy report. It concluded that fatal electrocution was a probable cause of the death of Fitter B.

Safety management system

- 5.44 The analysis of the accident reveals that the safety management system has the following inadequacies and deficiencies:-
- ineffective in identifying potential risk of individuals working on board, particularly newly joined crewmembers who have limited experience working on board ships;
 - ineffective in ensuring communication between officers and crew in the execution of work on board;
 - ineffective in ensuring that safety procedures were followed by all crew; and
 - inadequate in promoting a safety culture among crewmembers to intervene and stop unsafe practices and working condition.

Corrective and preventive actions taken by the Company after the accident

- 5.45 The company was concerned about the fatal accident and conducted detailed investigation to avoid recurrence. It invited Lloyd's Register Human Factors Specialist to visit the company as well as *Pacific Explorer* to verify the findings of the company's investigation and see whether any further insights could be gained into the incident.
- 5.46 Among the corrective and preventive measures implemented by the company after the accident, the following are highlighted:-

- the safety familiarization form was revised to include information on sea time in rank and the total sea time of crew joining ship;
- voltage reduction devices to limit the open circuit voltage of welding machines to about 12 volts were supplied on board ships in the fleet. A new procedure regarding welding machine voltage reduction devices was also issued;
- the hot work permit form was revised to include the signature of the ship master; and
- the operational risk assessments for various shipboard operations and maintenance work were reviewed.

6. Conclusions

- 6.1 At about 1450 to 1517 on 20 November 2009, a fatal accident happened on board the Hong Kong registered general cargo vessel *Pacific Explorer* in which the fitter was electrocuted while performing electric arc welding repair on the fire main on the deck.
- 6.2 After the vessel had departed the port of Jakarta for Beneta Bay in Indonesia on 19 November, two fitters started to carry out repair work on the deck fire main. While the repair work was not finished on 19 November, they continued the work on 20 November.
- 6.3 On 20 November, one of the fitters finished his part of welding in the morning and was assigned other repair work. The other fitter was working alone under occasional supervision by the Chief Officer. The fitter, who had difficulty in making a good weld to the underneath of the pipeline, was still working on it in the afternoon until around 1450 to 1517.
- 6.4 At 1517, he was sighted lying unconsciously on his back adjacent to the work place. The ship's position was approximately 06° 44'S 114° 00'E. Despite efforts by the crew to recover him, there was no sign of life in him and the rescue stopped at around 1640.
- 6.5 The vessel arrived at Benete Bay at 0742 on 21 November 2009. The deceased was confirmed dead and landed ashore at 1223 on 21 November 2009 for autopsy and subsequent repatriation back to his home country.
- 6.6 The investigation revealed that the main contributory factors to the accident were as follows:-
- while performing electric arc welding, the body and clothing of the deceased were wetted by perspiration and seawater due to the hot and damp weather together with seawater leaking from the fire main;
 - personal safety awareness of the deceased was lowered while working under pressure and stress; and
 - the senior officers did not monitor the repair work closely and failed to take decisive action to intervene and correct the situation when unsafe practices and conditions were found to have been developed before the accident.

6.7 The investigation also revealed the following safety factors to the accident:-

- the welding return cable of the welding machine used by the deceased was not connected near the fire line under repair;
- risk assessment was not carried out before the repair work, resulting in overlooking of the relevant safety guidelines and code of safe working practices;
- the ship familiarization process for newly joined crewmembers could not identify the individual's experience so as to alert senior officers of the potential risks;
- the welding machines on board were not provided with voltage limiting devices for the safety of operators; and
- communication among senior officers and crew of different nationalities was ineffective.

7. Recommendations

- 7.1 A copy of the report should be sent to the ship management company of *Pacific Explorer* informing the findings of our investigation into this accident. The Company is required to issue circular letters to its fleet urging Masters, senior officers and crew to strictly follow safety measures when electric welding work is to be performed on board by the crew.
- 7.2 A Merchant Shipping Information Note (MSIN) should be issued to promulgate the lessons learnt from this accident.

8. Submissions

- 8.1 In the event that the conduct of any person or organization is commented in an accident investigation report, it is the policy of the Marine Department to send a copy of the draft report or parts thereof to that person or organization for its comment.
- 8.2 The draft report was sent to the ship management company of *Pacific Explorer* for comment.
- 8.3 No submission was received at the end of the consultation.

