MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

HSE
Health & Safety Executive

'HAVKONG' INCIDENT

A joint report of the 'Havkong' incident at Braefoot Bay Terminal by Aberdour, Fife on 23 January 1993

HSE BOOKS

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FOREWORD

At 1850 h on Saturday, 23 January, 1993 the liquid petroleum gas tanker Havkong broke loose from her moorings at the Shell Expro jetty at Braefoot Bay Terminal, Fife during an unusually severe squall, while loading butane.

No serious injuries or damage resulted from the incident. However, it was considered appropriate to carry out a thorough investigation into the causes of the breakaway and into the subsequent emergency action taken, as the incident raised a number of important questions about the safety of ships carrying hazardous cargoes in a busy estuary, mooring arrangements at the jetty, operational procedures at Braefoot Bay Terminal and the emergency response to the incident. Because of the overlapping interests of the Health and Safety Executive (HSE), which has responsibility for enforcing on-shore safety legislation at the terminal, and the Marine Accident Investigation Branch (MAIB) of the Department of Transport whose interest lies in marine safety, an agreement was made that a joint investigation would be carried out.

The joint report reflects the close co-operation between the two departments in covering the range of issues raised by this incident.

DESCRIPTION OF INCIDENT

Summary

1 The Bermuda registered LPG tanker Havkong, berthed at the Braefoot Bay Marine Terminal in the River Forth in fine weather on January 23 1993. The forecast was for increasing westerly winds later in the day.

2 The ship moored alongside in compliance with the terminal's Jetty Regulations including those related to moorings (as shown in Appendix 4). However the winch and fairlead positions aboard Havkong were such that, despite deploying lines in excess of those required, the final mooring pattern geometry resulted in only two lines contributing restraint against westerly winds (as shown in Appendix 5).

3 During the early evening a further forecast was received which indicated the onset of very strong westerly winds during the night, much stronger than originally forecast. The Master arranged to deploy further moorings in expectation of this. At this time Havkong had loaded approximately 6000 tonnes of a nominated 15 000 tonne cargo of butane.

4 At 1850 h, and before the additional lines could be deployed, the Braefoot Bay area was subjected to an unusually violent squall.This is a recognised meteorological phenomenon that manifests itself as a very sudden increase in wind speed usually accompanied by heavy precipitation and a shift in wind direction. This squall was unusually strong for this area and produced a veering westerly wind with gusts in the order of 80 knots (92 mph) superimposed on a mean wind speed that reached 62 knots (62 knots is within the range of Beaufort Force 11 (56 to 63 knots) technically described as 'violent storm'). The resulting additional loading on the mooring system was resisted only by the forward backsprings. The winch brakes for these were overcome and the ship began to move ahead along the berth driven by the wind.

5 As she gathered momentum the loading arms reached their envelope limits and successfully disconnected with no spillage of cargo. The remainder of the mooring lines failed one by one as the load came upon them sequentially.

6 Havkong began to swing under the influence of both the wind and the last of the moorings and drifted eastwards, broadside to the wind. She cleared a ship on the other berth, that was loading ethylene, by approximately 20 metres. About eight minutes after breaking away her engine was ready for use and the Master used it to keep the ship in the deep water channel as she drifted downwind while the Chief Officer prepared the anchors.

7 Havkong was eventually brought to anchor approximately one mile east of the berth. There a pilot boarded her to assist and tugs arrived. With tug assistance

the ship was manoeuvred out into the main channel and then to a designated anchorage.

8 Forth Ports Plc emergency plan, EMERGENCY FORTH was activated during the incident and the Coastguard mobilised an RNLI lifeboat and a helicopter.

9 The available evidence leads to a conclusion that Havkong grounded lightly, probably on two occasions, during the incident. However no damage was done to the hull and her cargo containment remained intact. There were no injuries on board and no spillage of cargo. Damage to the ship was limited to some deformed rails near the manifold and minor damage to one manifold line.

10 On shore, one Shell Expro employee sustained minor injuries when he was knocked over by the wind, but there were no other casualties. As a result of the ship's movement there was minor damage to the access gantry, loading arms and a navigation light on the jetty.

11 The incident was declared over at 2255 h when Havkong anchored in Kirkcaldy Bay.

12 The investigation has led to a number of recommendations in relation to mooring practice at Braefoot Bay Terminal, operational procedures at the terminal, the provision of tugs, the revision of navigational directions for the River Forth and emergency procedures. Certain measures have now been implemented.

Braefoot Bay Terminal

Description of the terminal

13 The Braefoot Bay Marine Terminal is situated on the north shore of the Firth of Forth and between Aberdour and Dalgety Bay approximately 2.5 miles west of the port of Burntisland. The terminal is jointly operated by two companies - Shell UK Ltd trading as Shell UK Exploration and Production (Shell Expro) and Exxon Chemical Olefins Inc, (Exxon) although each company has its own control room and delineated part of the terminal.

14 The terminal has two jetties projecting southwards into the deep water area of Mortimer's Deep which lies between the mainland at Braefoot Bay and the small island of Inchcolm. The eastern jetty is operated by Exxon and is used solely for the export of ethylene. The western jetty is operated by Shell Expro and is used for the export of propane, butane and gasoline.

15 The products loaded at both jetties are produced at Shell Expro's Natural Gas Liquids (NGL) Plant and Exxon's Ethylene Plant, both located at Mossmorran, some 11 km from the terminal, and are delivered to it by pipeline.

16 Both the Mossmorran plants and the Braefoot Bay Terminal were constructed at the same time as an integrated production and shipping system. Raw NGL are delivered to the Mossmorran plant by pipeline from St Fergus where the 'FLAGS' pipeline which serves several North Sea installations lands.

Control of marine operations at Braefoot Bay Terminal

17 Under the terms of an agreement between Shell Expro and Exxon, Shell Expro controls all marine operations at both jetties and the Exxon technicians work under the Shell Expro shift supervisor on marine matters.

18 Control of marine operations at the terminal is exercised through the *Braefoot Bay Marine Terminal Jetty Regulations and Information*, a joint Shell Expro/Exxon document which gives instructions to vessels using the terminal on procedures to be followed, essential equipment, safety requirements and other matters. Although described as 'Jetty Regulations' these are not statutory regulations but company instructions and procedures formulated after consultation with Forth Ports Plc.

19 With respect to mooring arrangements, the 'Jetty Regulations' booklet requires that all vessels:

(a) *"will be required to deploy 3 headlines/sternlines, 2 breastlines, and 2 springs at each end. For vessels equipped with an all wire mooring system, 2,2,2 at each end is acceptable. Wire ropes should have rope pennants fitted complying with OCIMF standards. If weather conditions dictate, then this minimum may be increased. Mooring ropes made fast on drum ends backed up on bitts are not acceptable.*

Spring lines should be of the same material (preferably wire). Where wire springs are fitted with rope pennants, they shall comply with OCIMF standards".

Note: OCIMF= Oil Companies International Marine Forum

The booklet also notes that:

(b) *"Mooring lines used in any particular direction of service (head/stern lines, breast lines, springs) shall be of similar breaking strength, elasticity and material. Under no circumstances will a mixture of wire and synthetic ropes in the same direction of service and to the same dolphin be acceptable except moorings additional to the requirements of (a).*

(c) *If conditions as in (a) cannot be complied with, the loading arms will not be connected.*

(d) Once moored, ship's winches must be secured with the brakes hardened up. Winches must not be left on automatic tension".

20 The 'Jetty Regulations' also include instructions on when loading should be discontinued and when the ship should be disconnected from the loading arms due to high winds. The limit values vary for different types of vessel, but for Havkong at the Shell Expro jetty, it is 35 knots (two minutes 'mean' speed) for stopping loading and 40 knots for disconnection.

21 Information on wind speeds at the Shell Expro jetty is collected electronically from an anemometer sited at the jetty head. Wind speed and direction is displayed on digital wind speed indicators in the control room and jetty cabin. Wind speed is also recorded on a pen chart in the control room. A copy of the pen chart recording for the day of the incident is included in Appendix 3. Additional wind speed and direction information is collected from a remote station on Inchcolm Island off the terminal. Data from the Inchcolm site is fed by telemetry to both Braefoot Bay and Forth Navigation Service.

22 As the information on wind speeds comprises direct readings of the wind, while the 'Jetty Regulations' specify two minute mean speeds, the average is interpreted from the pen chart recorder or wind speed indicator by the supervisor.

23 There is also an alarm system at Braefoot Bay for high wind speeds. This comprises a high wind speed alarm set at 35 knots and a high wind speed alarm set at 40 knots. Both alarms comprise an audible signal and flashing light in the control room, repeated in the control cabin on the jetty head.

24 There is a facility at Mossmorran which records when alarms go off, including those at Braefoot Bay. This system was not operational on the day of the incident, as it was being upgraded.

Weather forecasts

25 The terminal uses weather forecasts from the Glasgow Weather Centre. These are supplied under contract and made specifically for Braefoot Bay Terminal. Four weather forecasts are faxed routinely to the terminal each day, at six hourly intervals. In addition, the terminal can telephone the Weather Centre and ask for updates between routine forecasts.

Description of MV Havkong

26 Havkong is a steel single screw liquefied petroleum gas tanker of 34 892 gross registered tonnage and is registered in Hamilton, Bermuda. She has four independent type 'A' prismatic tanks giving her a total cargo capacity of 54225.7 cubic metres.

Note: Type 'A' tanks are free standing independent tanks which do not rely on the ship's own structure for their structural integrity.

27 Havkong has the following main particulars:

Length overall	219.7 m
Breadth	28.5 m
Main engine	Diesel of 14650 Kw
Summer draught	11.76 m
Built	Tyseen Nordseewerke G.M.B.H West Germany in 1978.

28 Havkong was built initially as the Galconda for P&O and is one of two sister vessels. In 1987 she changed owners and was renamed Havkong coming under the management of A/S Havtor Management, PO Box 1374, Vika, N-0114, Oslo, Norway. As both Havkong and Galconda this vessel has been a regular caller at Braefoot Bay since she came into service.

29 On January 23 1993 Havkong was carrying a crew of 32 that included a British Master, a British Chief Engineer Officer, three other British Engineer Officers, and a Norwegian Chief Officer. All the other crew members were Philippinos. All the officers and crew were correctly certificated and the appropriate officers all held dangerous cargo endorsements for Liquified Petroleum Gases (LPG). There was no evidence of any language difficulties on board. The common language used by all the crew was English and the crew were proficient in this language and well drilled and competent in their duties.

30 All the ship's certificates were in date and a general inspection of the ship following the accident revealed no deficiencies.

31 Havkong is equipped with 12 hydraulic winch drums carrying wire mooring lines fitted with OCIMF rope tails. Four drums are mounted on the poop, two are on the main deck forward of the accommodation, four are on the main deck forward of amidships, and two are on the focsle. Together these winches allow Havkong to deploy 12, independently tensioned and secured, mooring wires.

32 In normal circumstances Havkong will use her wire mooring system to deploy:

(a) two wire stern lines from the poop;
(b) two wire breast lines from the poop;
(c) two wire springs from immediately forward of the accommodation;
(d) two wire springs from the main deck forward of amidships;
(e) two wire breast lines from the main deck forward;
(f) two wire head lines from the focsle.

Navigation and berthing arrangements at the terminal

33 When this terminal was first considered, detailed limitations on the navigation and routeing of LPG tankers using the terminal were set down by Forth Ports Plc, as the responsible authority. The latest requirements were set down in 1984, just before the terminal opened, as amendments to the General Directions for Navigation in the River and Firth of Forth under powers given in S3 of the Forth Ports Authority Order 1980.

34 In summary, the directions considered relevant to this enquiry are as follows:

(a) *"whenever a tanker is turning from the deep water route into the west approach to Mortimer's deep, no other vessel shall enter the section of the deep water route between No 15 buoy and Hound Point;*

(b) *vessels shall depart eastwards;*

(c) *vessels more than 145 m long shall only approach the terminal through the western channel of Mortimer's Deep and will berth port side to on the flood tide; (in practice all vessels using the Shell jetty including the Havkong.)*

(d) *vessels departing shall do so through the Eastern channel of Mortimer's deep except in emergencies;*

(e) *pilotage is compulsory;*

(f) *vessels shall not berth at or sail from the Braefoot Bay jetties if the mean wind speed exceeds 27 knots or if visibility is less than half a nautical mile at the jetties;"*

In addition to the foregoing published directions there is a further factor that influences operations at the terminal. This factor is not published as a direction nor does it appear in the 'Jetty Regulations', nevertheless it is so well understood by the terminal staff and by charterers as to give it the force of a direction. It requires that:

(g) *"vessels are not allowed to berth at the terminal when they are part-laden."*

35 Directions (b) and (c) constrain vessels of the size of Havkong to a clockwise circulation, approaching empty to the south of Inchcolm, turning out of the channel to approach the berth from the west, berthing port side to, and then departing, after loading, to the eastwards.

36 One effect of (g) is that ships' captains for significant economic reasons do not have a realistic option to leave the berth if the weather worsens during loading, as they are not permitted to re-berth once they have taken any product on board.

37 The wind data used to decide whether ships may be allowed to berth or sail is taken from the remote recording station at Inchcolm Island, which supplies common wind data to both Forth Navigation Service and Braefoot Bay Terminal. This system is separate from the terminal system based on the anemometer at the end of the jetty, which is used by the terminal to take decisions on whether a ship should stop loading due to high winds once she is berthed.

Details of incident

Arrival of Havkong at terminal

38 Havkong arrived in the River Forth on January 22 1993 intending to berth directly at the Braefoot Bay Terminal to load a part cargo of 15 000 tonnes of butane. The cargo was owned by BP under a North Sea pipeline sharing agreement and the ship's charterers were BP Shipping Ltd.

39 However, a minor fault developed on No 1 main engine cylinder, traced to a defective or failed air start valve. Accordingly, berthing was aborted and the ship anchored off Burntisland while the fault was repaired. Berthing was rescheduled for 0800 h, January 23.

40 At 0810 h the following morning Havkong weighed anchor and proceeded normally to the berth, with a pilot on board and with three tugs in attendance from a position to the south and east of Inchcolm Island.

41 At this time the wind was south westerly at around force 4 and Havkong followed the normal pattern of berthing at the west jetty. It was already known both by terminal staff and the ship's Master that strong winds had been forecast for that night.

Mooring arrangements

42 Havkong is fitted with an all-wire mooring system as described in paragraphs 31 and 32. However, because of the position of the stern winches on board the ship in relationship to the corresponding mooring dolphin on the jetty, it was not practicable to deploy the wire sternlines. The two winches intended for these on Havkong are each mounted with the drum axis aligned transversely with the wires leading outboard via fairleads at the transom. Previous experience had shown that, because the stern of the ship projected beyond the dolphin line, making these lines lead forward, then these wires, if deployed through their normal fairleads, would lead across the hard edge between the transom and the ship's side. Such an arrangement invites damage to the wire and was considered unacceptable.

43 Instead the Master elected to deploy an all rope set of sternlines. Fairleads and bitts were available to allow four rope sternlines to be deployed from the port

quarter. Such an arrangement had been used before and is allowed under the 'Jetty Regulations'.

44 The proposed arrangements were discussed with the pilot and agreed. The Master was, however, aware that the weather forecast was poor. He asked for an update from the pilot who contacted Forth Navigation and advised him that winds of between 40 and 45 knots were forecast.

45 In the light of this forecast the Master decided that additional moorings were appropriate and Havkong was finally secured alongside at 1018 h with:

(a) Forward- two wire head lines
two wire breast lines
two wire springs
two synthetic ropes as additional lines on bitts

(b) Aft- two synthetic rope stern lines on bitts
two ATLAS ropes on drums
two wire breast lines
two wire springs

as shown in Appendix 5.

The two ATLAS ropes were rigged from their own specialised hydraulic drums and tensioned as far as possible to the same tension as the wires.

Note: ATLAS is a variety of synthetic rope which is different to the more usual synthetic rope, polypropylene.

46 The mixed material headlines, all to the same dolphin, were acceptable in terms of the 'Jetty Regulations' as the primary two wire system was deployed and the rope system was an additional restraint.

Operational procedures and developments until incident occurred

47 Once the vessel was secured watches were set and the Master's standing instructions were put into effect. These required, among other things, for the main engine to be maintained at immediate readiness and that there was a duty officer and two seamen on watch on deck.

48 'Immediate readiness' aboard Havkong meant, as is normal shipping practice, that the main engine is kept at near operating temperature by constantly circulating heated water via the normal cooling system while other pumps maintain lubricating oil circulation and pressure and an electric motor continuously and slowly turns the engine. In this condition the engine may be

started immediately without risk of thermal shock damage. It does, however, require several valves to be reset preparatory to starting.

49 The ship-shore checklist (a requirement of the Dangerous Substances in Harbour Areas Regulations 1987) was completed. This requires a joint inspection carried out by a representative of the terminal operator and a ship's representative (in this case the Chief Officer). The inspection covers safety items, cargo readiness, and moorings among others. No defects were noted. An additional more extensive safety inspection was also carried out by Shell Expro as the vessel had not been at Braefoot Bay Terminal within the last 12 months.

50 While the inspection was being conducted the loading arms were tested for correct operation of the emergency quick release system and then connected to the ship's manifold. This test was a simulated test, and was routinely carried out each time a loading arm was connected to a ship's manifold.

51 Loading of the butane cargo began at 1448 h and proceeded normally. The ship-shore checklist was revalidated at 1515 h following Shell Expro standard procedures. No deficiencies were noted.

52 During the course of the afternoon the wind was generally light at around ten knots. However shortly after 1600 h it began to increase sharply settling at around 20/25 knots with gusts of over 30 knots. The dayshift supervisor had been on duty since 0630 h and was therefore familiar with weather conditions, forecasts and the progress with loading operations. At around 1735 h he collected the current weather forecast from the control room and took a copy down to the Master of Havkong. This forecast was issued at 1715 h.

53 The forecast indicated that a deep depression was moving east across the north of Scotland bringing very strong winds. Winds of 33 knots from the south west were predicted for 1800 h with gusts to 47 knots increasing steadily and becoming west south west 55 knots with gusts to 80 knots by 0300 h, then decreasing slowly but remaining strong for some time.

54 The Master noted that this forecast indicated winds in excess of those predicted earlier and the shift supervisor advised him that there was a likelihood that it would become necessary to stop loading and possibly disconnect the loading arms, in accordance with the 'Jetty Regulations' procedures for high winds.

55 In view of the stronger winds forecast for the night the Master decided to deploy additional moorings. The shift supervisor was asked if employees from the terminal could be made available to assist and he agreed to make arrangements for this, as it would be quicker than calling in the outside contractor normally used for mooring. The shift supervisor decided that this could be carried out after the shift hand over which was imminent. The Master also cancelled shore leave (at this time only two men were ashore).

56 Following this conversation the shift supervisor went across to the vessel which was berthed at the eastern jetty loading ethylene.

57 This vessel was the Teviot, a smaller gas tanker of 7260 gross registered tonnage. She had berthed at 2315 h the previous evening to load a full cargo of 4550 tonnes of ethylene. She was a regular caller at this terminal and on this occasion was berthed port side to with her stern towards Havkong.

58 Teviot was due to complete loading at 1815 h. It is normal practice for the shift supervisor from Shell Expro, as the person in control of marine operations for both jetties, to attend when cargo is finishing.

59 Teviot actually completed loading cargo at 1830 h. While aboard the shift supervisor also delivered to the Master a copy of the latest forecast as he had done aboard Havkong. Shortly afterwards Teviot's proposed departure of 2100 h was cancelled and rescheduled for the following morning.

60 During this period the incoming night shift supervisor, who had arrived at 1820 h to take over the night shift, called on his hand-held portable radio from the control room. From Teviot the day shift supervisor advised him that he would join him in five minutes and suggested that he look at the forecast.

61 Following the supervisor's departure from Havkong the Master and Chief Officer discussed additional moorings. They decided that the most effective course of action would be to bring up two additional synthetic ropes from the rope store and deploy these leading astern from the main deck just forward of the accommodation.

62 The Bosun and some crew members began this task and at about 1840 h had one rope ready in position to send ashore. As the agreed help from Shell Expro had not yet arrived the Bosun and another crew member decided to carry on themselves.

63 While the crew were carrying out this task the Master went back up to his office having satisfied himself that the ship was secure and all the moorings presently out were correctly tensioned. The wind at this time was on the starboard quarter and increasing. From this direction it was tending to push the ship on to the berth as well as to drive her forwards along the berth. The Chief Officer went to the cargo control room to ascertain the terminal's intentions in the increasing wind. Both the Chief Officer and the Master expected loading to be suspended shortly.

64 Having completed loading operations on Teviot, the day shift supervisor went back to the main control room ashore. Here he handed over to the incoming night shift supervisor who had been informed on his arrival in the control room that wind speeds were increasing. This was repeated during the handover.

65 The audible wind speed alarm in the control room had been disabled, sometime in the hour before the incident happened, by pulling the logic board out of the panel.

66 The new Shell Expro supervisor took the handover at 1843 h and went through to his control room. There he saw the windspeed recording at 30 to 40 knots with gusts to 50 knots with the mean speed rising rapidly. He told the control room operator to call both the ship and Mossmorran control room and tell both to get ready to stop loading. The time was then approximately 1845 h.

67 Before the operator could call the ship he received a call from the jetty operator to say that the ship was moving forwards and almost immediately the alarms for ESD1 and ESD2 came up on the control panel. (ESD = Emergency Shutdown.) These alarms indicate that the loading arms are outwith their safe operating limits, that the valves have closed (ESD1) and the arms have automatically disconnected (ESD2).

68 On board Havkong the Chief Officer had just called the Master and informed him that a loading shutdown was imminent. Immediately the Master put down the phone it rang again, this time the Chief Officer reported that the loading arms had disconnected and the ship was moving.

69 On deck the Bosun, who had just stepped onto the gangway to set the additional moorings from the shore side, jumped back onto the deck as the ship began to move.

Actions on board ship following the incident

70 Having been informed by the Chief Officer that the ship was moving, her Master went directly to the bridge, from where he called the Chief Engineer and requested immediate manoeuvring on the main engine. He then alerted the crew to the emergency.

71 The forward force on the ship generated by the squall overloaded the brakes holding the two forward backsprings which then released allowing Havkong to begin moving forwards. This movement slackened the stern lines and aft breast lines which then failed sequentially as the shock load of the moving ship came upon them. Most of the lines rendered under load and remained attached to the jetty, some broke and one jumped off the jetty hook, probably due to jerking caused as the brake rendered.

72 During this period the Master called Forth Navigation on VHF to report the situation. The message was timed at 1855 h.

73 Havkong continued to swing with her bow moving inside the line of the jetty and towards Teviot moored on the east jetty. As the load came sequentially onto the

forward lines their brakes were overcome and the lines paid out. On the forecastle the two wires paid out and as their bitter ends detached, the starboard one caught the brake mechanism of the drum and wrenched it off. One of the ropes broke which left the vessel attached only by one rope headline, under considerable strain. This headline was, however, serving to hold the vessels head up, swinging her further towards Teviot. The Chief Officer saw the danger and cast this rope off at some personal risk. A navigation light mounted on a stanchion at the east end of the jetty head was damaged by one or more of Havkong's mooring lines as they let go. This unit remained electrically 'live'.

74 With this line gone the Master realised that his ship would clear Teviot, albeit closely. He instructed the Chief Officer by radio to lower the port anchor to the water in preparation for anchoring. His intention at this time was to anchor the ship south of the jetty as quickly as possible.

75 The bow of Havkong cleared Teviot by approximately 20 metres and as it did so the Chief Engineer aboard Havkong telephoned the bridge to confirm that the engine was ready for use. This call was timed at eight minutes after the initial breakaway.

76 The Master's next concern was that the stern of his ship was approaching Number 6 buoy. This is a red buoy which marks the edge of deep water at the south side of the channel. He ordered Dead Slow Ahead on the engine in order to ensure that his propeller and rudder cleared the buoy mooring.

77 The stern of Havkong cleared No 6 buoy but the bow of the ship over-ran the north buoy of the pair, No 5, and carried it with the ship. Continuous use was made of engine power and steering to maintain the ship, as nearly as possible, in the deep water channel while the Chief Officer and crew members forward lowered the port anchor and prepared the starboard anchor.

78 At 1904 h Havkong was on a heading of approximately north west and drifting directly downwind. Her position at this time was approximately 900 metres due south of Hawkcraig Point. The port anchor began to lead upwind and the bow to swing to port. The engine was worked ahead with full port rudder and the vessel came head to wind with three shackles on the port anchor and the cable leading ahead. Further cable was slowly paid out to secure the ship while the engine was manoeuvred ahead to assist in maintaining position. Havkong did not, at any time, approach closer than 500 metres to the shore.

Note: Shackle is a measure of marine chain cable = 15 fathoms (90 feet).

79 The Master was not entirely certain of his ship's position at this time. Visibility was poor with driving rain and high winds. In the course of paying out the anchor and using the engine the vessel traversed north across the charted foul area. It is probable that by the time eight shackles of cable were paid out and the ship

was stationary her stern was lightly aground on the north side of the foul area due south of Hawkcraig Point. The divers who inspected the ship afterwards found no evidence to indicate a grounding but other available evidence suggests that she did touch lightly.

80 At Rosyth the naval tug Pointer was engaged in berthing HMS Dovey. At 1905 h the Master of Pointer received a VHF call from North Queensferry Naval Signalling Station advising him that a vessel at Braefoot Terminal was breaking adrift and requesting his assistance as soon as possible. Once HMS Dovey considered herself fully secured Pointer was released and proceeded at full speed towards the Braefoot area at 1920 h approximately.

81 At the Granton pilot station, one of the duty pilots heard the initial call from Havkong at 1855 h and went directly to the standby pilot boat. En route to the ship he overheard a further call from the ship in which her Master considered that he may have drifted through the naval de-gaussing range off Burntisland. This was erroneous. The pilot located the ship upwind and west of the de-gaussing range and boarded her at 1938 h.

82 On boarding, he found the ship on the north side of the foul area with the wind blowing from approximately 20/25° on the starboard bow and with the port anchor out to eight shackles and leading across the bow and somewhere out to starboard. Engine and rudder were being used to maintain station.

83 The tide was falling and the pilot considered that Havkong was probably aground aft. He was concerned about the risk to the ship both from her own anchor and from the debris on the sea bed in this area. He ordered Half Ahead in order to drag the anchor out and when she started to move he steered south west until the red buoys on the south side of the channel, (Nos 4, 6, and 8) were in line at which point he judged that the anchor was approximately centred in the foul area. This done he allowed the ship to fall back to her anchor where she brought up at approximately 1945 h with Hawkcraig Point bearing 006(T) x 0.43 miles.

84 Pointer arrived on scene as Havkong brought up and attempted to pass a line to the bow. Pointer is a small twin screw tug with a rated bollard pull of 17 tonnes. Her Master had difficulty manoeuvring close to the bow of Havkong in the prevailing weather while the crew of Havkong were unable to recover the messenger line speedily in view of the damaged brakes and broken ends of ropes still cluttering the focsle. Two attempts to pass a towline failed when the messenger parted while the tug attempted to hold station close to the bow.

85 Fire wires were still rigged on the starboard side of Havkong (as required by terminal instructions) but no attempt was made to use them. The two attempts to secure a line having failed, Pointer was asked to stand by on the starboard bow until the larger tugs Oxcar and Beamer, arrived from Leith.

86 Oxcar and Beamer arrived at 2030 h. It was decided at Forth Navigation Headquarters (Marine Emergency Centre) that Havkong should, if possible, be moved out to a more open anchorage and away from the confined position close to shore that she was in. The pilot concurred with this plan. Accordingly with three tugs available the pilot positioned them on either bow to hold Havkong head to wind by pushing while the anchor was recovered. The port anchor was recovered at 2113 h with a navigation buoy and its mooring fouled on it. This was probably No 3 buoy.

87 Low water was forecast for 2124 h. As the sand bar in the channel on the normal eastward exit route might cause problems at low water possible action was discussed; following which the pilot elected to take the ship out via this route. It was understood that this would necessitate crossing the Burntisland bar with an underkeel clearance of about 1 metre, and possibly less if the ship did not steer accurately in the strong wind and with the buoy mooring trailing from the anchor. This routeing did, however, avoid passing the jetties at Braefoot and the Teviot while towing the buoy mooring and with the wind still extremely strong and the visibility poor.

88 Assisted by the tugs Havkong turned and proceeded outwards. Crossing the bar both the Chief Engineer and the pilot reported feeling a slight contact and it is considered probable that she touched the bottom lightly. No damage was done and the ship safely reached deep water where the tugs Oxcar and Beamer were released. Pointer continued to assist while Havkong steamed to Kirkcaldy Bay where attempts were made to free the buoy mooring from the anchor. These failed and the ship proceeded to designated anchorage K-1 where she was anchored with the starboard anchor by 2255 h.

89 Once anchored a preliminary damage assessment was made. It was established that no discernible hull or cargo containment damage had occurred and all that could be found was minor damage to railings near the manifold and to the manifold line. The ship ends of the hard arm emergency release mechanisms were securely attached with the ball valves closed and no cargo leakage.

90 A diver survey in the following days found no indications of grounding or hull damage and after further investigations for damage elsewhere, which revealed none, the ship departed the River Forth.

On-shore actions when emergency occurred

Shell Expro

91 When the Havkong broke away, the nightshift supervisor left the control room to go down to the jetty, taking a Shell Expro radio set and an Exxon radio set with him. At this time Teviot was still secured to the Exxon jetty and had completed loading.

92 The dayshift supervisor (who was now technically off duty, but still on the premises) remained in the control room and telephoned Forth Navigation Service to let them know that Havkong had come off the jetty and that two tugs were required. Shell Expro have a direct telephone link with the Forth Ports Plc Emergency Control Centre, but he did not use this as he knew that this phone was only manned once an emergency had been declared.

93 He then telephoned the on-call Shell Expro supervisor. At the same time the emergency shut-down alarms had come up on the control panel at Mossmorran and the supervisor at Mossmorran had initiated the emergency call-out system. The Shell Expro manager for Mossmorran and Braefoot Bay arrived in the Braefoot Bay control room at 1900 h and at his instigation the Fire Brigade and Police were informed.

94 The Shell Expro site alarm was not activated as their procedures did not require this.

95 The emergency control centre at Braefoot Bay was manned and the Police and Fire Brigade attended.

96 Meanwhile the nightshift supervisor went down to the Shell Expro jetty with an operator and spoke to the jetty cabin operator. All three then started to go to the Exxon jetty, during which time one of the operators was knocked over by the wind and was found lying on the ground in a semi-conscious state. He was sent to hospital and was discharged immediately.

97 When the supervisor reached Teviot the question of whether the loading arms could be disconnected quickly was discussed with the Exxon technician at the jetty head. Disconnection takes between 20-30 minutes and for safety reasons the Emergency Release System (ERS) is disabled before the operation starts (see paragraph 158(e)). At the time Havkong broke loose the ERS had already been disabled. As the disconnection was at a very early stage it was decided that the best option would be to reinstate the ERS and leave the ship connected to the loading arms, with valves closed and lines drained.

98 Teviot's crew also put out extra mooring lines with the assistance of two Exxon technicians.

99 The Exxon control room operator at Braefoot Bay was informed of the incident by his supervisor at Mossmorran, who had been informed by the Shell Expro control room at Mossmorran. The Exxon control room at Braefoot Bay Terminal was not informed of the incident directly either by the Shell Expro control room at Braefoot Bay or by the Shell Expro nightshift supervisor. Teviot's Master was not informed of the incident when it occurred, his first indication being when he saw the bow of Havkong pass his office window.

100 Shell Expro staff, with the assistance of an operator, called from Mossmorran, later disentangled the loading arms at the jetty (which had become caught together) and stowed them. The damaged navigation light was also electrically isolated.

101 A woman and two children were found in the Exxon jetty cabin shortly after the incident happened. They had been visitors to Teviot and disembarked when it was realised that Havkong had broken away.

Forth Ports Plc

102 When the duty officer at Forth Navigation Service was contacted, he telephoned the Chief Harbourmaster, who was also the 'on-call' officer for emergencies. The Chief Harbourmaster decided to implement the Forth Ports Plc emergency plan 'Emergency Forth'. He also called the naval dockyard at Rosyth to seek tug assistance from there as being the closest available tug to Havkong.

103 The Coastguard was alerted by the duty officer at Forth Navigation Service. The Chief Harbourmaster also alerted the Police from his home by dialling 999 to his local police force in Perth.

104 The Forth Ports Plc safety and marine adviser, who was not officially on call but was available, was called out and went to the Forth Ports Plc Emergency Control Centre at the harbourmaster's office at Leith.

105 Forth Ports Plc was able to plot the position and route of the ship on the Forth Navigation Service radar. A video is routinely made of the radar display but on this occasion the video recorder was not operational owing to the installation of new equipment.

106 Forth Ports Plc tugs were called out as soon as the incident was reported. These tugs are based at Leith docks which is a locked harbour and the minimum time required to reach Braefoot Bay from the docks has been quoted as 50 minutes, providing the tugs are manned. They are not continuously manned except when work is scheduled through the night. On this occasion the crews had to be called out, using the 'call-out' system for emergencies.

Police

107 Fife Police were notified of the incident at 1904 h by Shell Expro at Braefoot Bay Terminal. Their initial actions after contacting the Coastguard were to gather information on the situation to determine an appropriate response. Officers were sent to the Shell Expro Emergency Control Centre at Braefoot Bay. They also alerted the Fife Regional Council Emergency Planning Officer.

108 The action taken was to alert relevant parts of the police force so that the appropriate organisation, manpower and equipment was in place to enable an evacuation of the area to be carried out if necessary. A state of readiness was maintained throughout the emergency, but no actual action was required or taken.

109 The Police were also in contact with Aberdour Community Council and gave information to them on the emergency.

Fife Regional Council

110 When they were notified of the incident by the Police, the Emergency Planning Unit set up an emergency control centre at their Glenrothes headquarters. They alerted the parts of the authority which would be required in the event that an evacuation became necessary and identified appropriate places which could be used as rest centres. No action was actually required.

Coastguard

111 The Coastguard was informed of the emergency by the Forth Navigation Service operations room at 1906 h. The message was to the effect that Havkong had broken free of her moorings at Braefoot Bay and was adrift with an unknown number of people aboard. The ship was attempting to anchor, three tugs were on their way and Emergency Forth was in operation.

112 Based on that information the Anstruther lifeboat was launched (1908 h) and a request made for the assistance of a rescue helicopter (1915 h).

113 Between 10 and 15 minutes later the Coastguard was informed by Forth Navigation, first that the ship's engines had been started, then that the ship was holding position in the channel. The estimated time of arrival of the first tug was given at that stage as 15 minutes time (about 1945 h).

114 Other actions taken by the Coastguard were to call out volunteer coastguards to go to the scene (1919 h), to put the Queensferry and Kinghorn lifeboats on readiness (1944 h and 1946 h) and to send staff to the Braefoot Bay Terminal and Forth Ports Plc Emergency Control Centre.

115 The helicopter confirmed at 1945 h that it was on its way. It was originally sent to Edinburgh Airport to be held on standby but was unable to refuel there and therefore diverted to Leuchars. En route it passed over Havkong (at 2110 h) and went down to have a look. When the helicopter pilot saw that tugs were in attendance he asked if the helicopter could be released. This was agreed, though the helicopter delayed to shine its light on the ship's anchor which was entangled in a buoy.

116 The first contact the Coastguard had with the ship was at 2020 h when the Master was asked if he wanted any of his crew taken off, but declined the offer.

117 The Anstruther lifeboat was stood down at 2128 h, before it could reach the scene of the incident. It arrived back at Anstruther at 2357 h.

Fire Brigade

118 Fife Fire Brigade was called out by Shell Expro as part of their emergency procedures. Fire engines attended at Aberdour and Fire Brigade employees went to the Shell Expro emergency control centre at Braefoot Bay. No action was required and they remained on stand-by until the emergency was declared over.

Ambulance service

119 The Ambulance service was not alerted, but was aware of the incident as an ambulance had been called out by Shell Expro to the employee who had suffered concussion.

Investigation

120 The Health and Safety Executive's (HSE) interest in this incident lies in its role in enforcing the Health and Safety at Work etc Act 1974 (HSWA) and other relevant legislation, in this case the Control of Industrial Major Accident Hazards Regulations 1984 and the Dangerous Substances in Harbour Areas Regulations 1987. HSWA is applicable within the UK baseline and therefore covers work activities on-shore and in the Firth of Forth.

121 The Marine Accident Investigation Branch (MAIB) was created to allow the investigation of accidents independently of the Marine Directorate of the Department of Transport which previously conducted all investigations. The Chief Inspector of the MAIB reports directly to the Secretary of State for Transport.

122 The MAIB's aims are to fulfil the requirements of the International Convention on the Safety of Life at Sea (SOLAS) by conducting investigations and supplying the International Maritime Organisation with information and also to contribute to safety at sea by determining the cause of accidents and recommending measures to improve safety. The MAIB does not take or initiate any enforcement action; such action, if required, remains a matter for the Marine Safety Agency (prior to April 1994 the Marine Directorate).

123 The MAIB inspectors derive authority from S 33 of the Merchant Shipping Act 1988 while the wide ranging powers of inspectors to investigate thoroughly arise from S 27 of the Merchant Shipping Act 1979.

124 The legislative background to MAIB arises from the Merchant Shipping Acts and is therefore focused on the marine and ship related elements of casualties. In this incident it was clear that the areas of interest of the MAIB and HSE were both complementary and overlapping. In order to prevent duplication of effort and co-ordinate work a meeting between HSE and MAIB was held shortly after the accident when it was agreed:

(a) MAIB would assume the major investigation role for:

(i) the mooring geometry/pattern of securing the ship including consideration of any limiting effects of the Shell Expro jetty design;

(ii) berthing arrangements of the ship, particularly the direction in which it was berthed at the jetty;

(iii) the ship's availability of engines and subsequent ship movement after its loss of moorings. Also performance of the ship generally;

(iv) tugs and pilots; and

(v) similar considerations in respect of Teviot which was moored at the Exxon jetty.

(b) HSE would assume the major investigating role for:

(i) safety during loading operations;

(ii) all shore based activities; and

(iii) emergency planning considerations including any required by the Dangerous Substances in Harbour Areas Regulations 1987.

125 This report presents the joint findings of both authorities.

126 A mechanical engineering specialist inspector from HSE's Scottish Field Consultant Group with particular expertise in braking systems also visited Havkong and examined the mooring ropes and associated equipment. He concluded that the damage seen to the ropes, winch drums and winch drum brakes was consistent with a gross overload.

Relevant legal requirements at Braefoot Bay Terminal under health and safety legislation

127 The legal situation at Braefoot Bay Terminal is complex as, although Shell Expro and Exxon work closely together, they operate as two separate companies with separately delineated parts of the terminal.

128 Both Shell Expro and Exxon are subject to The Health and Safety at Work etc Act 1974 (HSWA), which places general requirements so far as reasonably practicable on both companies for the safe operation of the terminal within their area of control. HSWA requirements are wide ranging and include, for example, safe systems of work, plant and equipment, training, supervision and emergency procedures.

129 Both companies also come within the scope of the Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH) for their activities at the terminal. However, the CIMAH Regulations have a two tier structure, depending on the quantities of dangerous chemicals held on site. Those companies with larger quantities of specified hazardous substances are designated top tier sites and have specific extra duties placed upon them, eg to prepare a safety report and to have an on-site emergency plan, which are not specifically required for companies holding smaller quantities. Exxon comes within the top tier requirements of the Regulations by virtue of their storage facilities on site, while Shell Expro does not as there are not sufficient quantities of hazardous substances in the part of the terminal within its control. Transient storage, such as that held on ships during loading, is not within the scope of CIMAH.

130 As required by the CIMAH Regulations, initial and updated safety reports for Mossmorran and the Braefoot Bay Terminal were submitted to HSE by Exxon. The reports had considered the potential for the jetty to be the origin of or becoming involved in a potential major incident and they were not invalidated by this incident.

131 Local authorities (in this case Fife region) are required by CIMAH to prepare an off-site emergency plan for all companies in their area which come within the top tier requirements of the Regulations. Although this legally requires an off-site plan for Exxon and not for Shell Expro at Braefoot Bay, in practice the region has prepared a combined off-site plan covering the whole terminal.

132 Other regulations applicable to Braefoot Bay include the Dangerous Substances in Harbour Areas Regulations 1987 (DSHA). These Regulations place duties on all persons who handle or control dangerous substances in harbour areas, including the operator of a jetty and the statutory harbour authority (in this case Forth Ports Plc). Although the Regulations are generally enforced by HSE, certain regulations are enforced by statutory harbour authorities against persons other than themselves.

133 Under DSHA, Forth Ports Plc is required to prepare an effective emergency plan for dealing with emergencies involving dangerous substances brought into or handled in harbours or harbour areas within their statutory jurisdiction.

134 The Management of Health and Safety at Work Regulations 1992 came into force on 1 January 1993. Regulation 7 also requires employers to have procedures for serious and imminent danger and regulation 9 requires employers sharing a workplace to co-operate with each other and to co-ordinate actions.

DISCUSSION, ANALYSIS AND CONCLUSIONS

Shell UK Exploration and Production

Mooring arrangements at Braefoot Bay

135 The Shell Expro jetty at Braefoot Bay was constructed at a time when that company's fleet included two LPG tankers, Isomeria and Isocardia. These two ships are sisters and have a capacity similar to Havkong. The jetty layout and dimensions were optimised for these two ships as being representative of this size of LPG tanker. In the event both of these ships visited Braefoot Bay on very few occasions and most of the exports have been in other, broadly similar, ships.

136 Considerable research into tanker mooring at jetty and buoy berths has been conducted by the Oil Companies International Marine Forum (OCIMF).

137 Published research indicates clearly that tankers may be safely berthed virtually within their own length using a combination of breast lines, springs, and head and stern lines. OCIMF has also derived formulae for determining the environmental loads imposed on mooring systems.

138 The standard idealised design of mooring pattern advocated by OCIMF is intended to provide safe restraint for ships in winds of up to 60 knots coincident with a current of three knots. It is based on the following guidelines:

(a) mooring lines should be arranged as symmetrically as possible about the midships point of the ship;

(b) breast lines should be orientated as perpendicular as possible to the longitudinal centre line of the ship and as far aft and forward as possible;

(c) spring lines should be orientated as parallel as possible to the longitudinal centre line of the ship;

(d) the vertical angle of the mooring lines should be kept to a minimum;

(e) generally mooring lines of the same size and material should be used in all leads and if this is not possible all lines in the same service should be of the same size and material.

139 The recommended pattern shown diagrammatically in the 'Jetty Regulations' booklet (see Appendix 4) for the Braefoot Bay west jetty for a 60 000 cubic metre ship indicates a variation on the OCIMF idealised pattern but one that still follows the basic guidelines.

140 It is the normal practice at Braefoot Bay to use a ship's general arrangement plan to assess her capability to moor effectively prior to her first arrival. A library of general arrangement plans has been built up at the terminal since operations began.

141 An examination of the actual pattern achieved by Havkong, however, shows that it differs from the recommended pattern in several fundamental ways although still complying with the actual wire numbers required:

Ideal/recommended	**Havkong**
Stern lines lead perpendicular or slightly aft.	Stern lines led forward.
Forward breast lines lead partly aft.	Forward breast lines led slightly forward.
Aft breast lines lead slightly forward.	Aft breast lines led significantly forward.

142 These differences may be explained by the configuration of Havkong. They could have been overcome, but only by introducing further problems. For example, the forward breast lines and springs could have been reversed, giving a better angle for the breast lines. This arrangement would, however, have resulted in very short springs with only the rope tails external to the ship which would, in turn, have brought problems with changes in tide and loading conditions on the ship. It is recommended practice (OCIMF) that all lines are approximately the same length. A reversal of the forward springs and breast lines would have defeated this recommendation.

143 In effect only two lines, the forward springs, were effective in providing restraint against movement ahead; all other lines actually introduced a component of forwards force by virtue of their own pretension. Therefore the two forward springs carried, in addition to environmental loads, the cumulative forwards pretension load of all the other lines.

144 Using the basic formulae offered by OCIMF the longitudinal force imposed by a wind from astern may be represented by:

(a) C(26.45) tonnes for a wind of 45 knots;

(b) C(47.03) tonnes for a wind of 60 knots; and

(c) C(83.61) tonnes for a wind of 80 knots;

where 'C' is a dimensionless coefficient appropriate to the ship.

For a conventional tanker in the 250 000T range in ballast C has a value ranging between 0.8 and 1.0. It is considered that for a gas tanker of Havkong's configuration with a large accommodation block in relation to overall size plus a high freeboard and extensive top hamper a figure of 1.0 is probably on the conservative side.

145 Using a value of 1.0 for C it is apparent that the longitudinal wind force on the ship would have increased from around 26 tonnes with a 45 knot wind to around 83 tonnes with an 80 knot wind (a factor of three increase over about four minutes). All of this force was initially absorbed by the two forward springs which were already absorbing the forward loadings imposed by the forward components of all the other lines and the eastward component of the ebb tide at 2.5 to 3.0 knots.

146 It is considered that the personnel both ashore and on Havkong responsible for assessing the mooring arrangements at the jetty failed to appreciate the effect of minor variations in the mooring pattern geometry and concentrated on line numbers instead, thereby allowing Havkong to berth using a pattern which was deficient in the amount of restraint it provided in the forwards direction.

147 Immediately following the accident Shell Expro, in consultation with Forth Ports Plc, introduced a set of interim measures designed to increase safety pending the outcome of the investigation. These measures included:

(a) a prohibition on berthing if the wind forecast exceeds 45 knots for the period the vessel is expected to be alongside;

(b) a requirement for ships to deploy additional moorings in excess of the minimum required in the 'Jetty Regulations';

(c) the presence of a permanent standby tug at the terminal whenever a ship is at the berth;

(d) preparation of an individual mooring analysis for each ship intending to call at the terminal with particular recognition of the severe weather situation.

148 These interim measures were agreed to by Forth Ports Plc, the Department of Transport and HSE pending completion of the investigation and (a), (c) and (d) have been incorporated as permanent measures.

149 Measure (a) is intended to prevent any ship from being alongside when the weather forecast indicates that winds exceeding 45 knots are likely during the period when the ship is expected to be at the berth. Wind forecasts are

generally accurate but, nevertheless, not sufficiently accurate as to reliably preclude a ship on the berth being subject to winds exceeding this figure from this measure alone. It is also the case that delays can occur which necessitate a ship being alongside for longer than anticipated.

150 Interim measure (b) is less effective. Additional moorings in the majority of vessels will have to be deployed conventionally as few, if any, vessels will have the winch numbers available to deploy them as pre-tensioned winch mounted lines. Arranged in this manner the additional lines will not contribute until such time as the main system has approached failure. It is considered, however, that additional lines can be a useful back-up in some circumstances but that their use should be at the discretion of the ship's Master who retains the overall responsibility for safe mooring at a berth. It is recommended that information be included in the 'Jetty Regulations' indicating the prevalence of strong westerly winds and advising Masters to consider additional lines whenever such conditions are forecast.

151 Measures (c) and (d) are considered essential to safe operations at this jetty. The presence of a suitable tug not only provides support in the type of weather situation that affected Havkong, but also allows tug intervention rapidly in the event of an emergency at any time necessitating the ship being removed from the jetty. The fact that a numerically correct mooring system nevertheless failed due to poor geometry indicates that a proper analysis for each vessel is essential.

152 On balance it is considered that there is an upper limit to the size of vessel that can be berthed safely at Braefoot Bay but that limit is determined not purely by vessel size but by any vessel's ability to:

(a) deploy head lines from fairleads in positions such that the lines lead ahead or not more than 10° aft of the perpendicular to the ship's centreline;

(b) deploy stern lines from fairleads in positions such that the lines lead aft or not more than 10° forward of the perpendicular to the ship's centreline;

(c) have the leads of head lines and stern lines complementary in that if the lines at one end lead forwards then those at the other must lead aft and vice versa;

(d) deploy breast lines at each end from fairleads in positions such that the two sets of breast lines lead in complementary directions with the angles made by each set of breast lines with the perpendicular to the ship's centreline approximately equal;

(e) deploy two wire springs at each end;

(f) provide mooring line lengths that are all of approximately similar length.

Previous incident

153 In the course of the investigation it was determined that on 28 October 1986 a very similar incident occurred at the Shell Expro Jetty involving Havkong's sister ship known at that time as Galpara. The ship's aft lines were carried away as she was loading LPG, causing the loading arms to 'over-reach' and initiating an emergency shutdown and automatic disconnection of the loading arms. Galpara swung off the jetty more slowly than Havkong did and her crew had time to use the engine to move her back alongside, where she was re-secured.

154 Wind speeds were lighter than at the time of the Havkong incident (about 40 knots). However, the weather pattern was similar and the ship moved off during a strong westerly squall. The tracings on the wind speed recorder charts during both incidents show a similar pattern of sudden squall.

155 Shell Expro's investigation into the Galpara incident was largely concerned with the damage caused by the breakaway. Their report concluded that the main cause was the Philippino crew's failure to properly tighten the brakes on two of the winches. The investigation did not consider the efficiency of the mooring system as a contributory factor.

156 Remedial actions identified by Shell Expro were:

(i) *"checks of the ropes/procedures on completion of mooring by Braefoot Bay Jetty supervisor (initially with marine discipline accompanying);*

(ii) *inspection of the ship's moorings with the ship's officer with requests to the ship to prove the hardness of brakes and/or the integrity of mooring system;*

(iii) *hardening attitude towards 'acceptable' vessels."*

157 The Galpara incident was not reportable to HSE nor to Forth Ports Plc and the Department of Transport. An HSE inspector was told during a routine visit to Braefoot Bay Terminal several days afterwards that it had occurred. He did not see Shell Expro's internal report but was informed of their conclusions.

Instructions with regard to poor weather conditions and high winds

158 The 'Jetty Regulations' with regard to wind speed limits for stopping loading and disconnection are described earlier in this report. Several aspects of these instructions are unsatisfactory.

(a) The monitoring equipment used to measure wind speed measures direct speed and the two-minute mean speed (the criteria used in the 'Jetty

Regulations' for stopping loading) is interpreted by the operator from either a digital reader or a pen chart. From examination of the equipment it is considered that this interpretation is open to wide variation and is unlikely to give consistent and reliable results. As it is difficult to interpret and identify when the required limit has been reached, it is also difficult to monitor whether the instructions have been followed correctly;

(b) Partly due to the inadequacies of the monitoring equipment, the instructions on when to stop loading and disconnect were imprecise and open to considerable variation in interpretation;

(c) The wind speed alarm includes a loud audible alarm in the control room. This alarm can be 'acknowledged' by the operator, stopping the audible alarm, but this will repeat if the wind goes below the alarm setting, then above it again. As a result the alarms are inclined to become a 'nuisance', requiring constant acknowledgement by the operator when winds are gusting around the 35 knots and 40 knots level. It appears to have become a common practice to unofficially disable the alarm by pulling the board out of the panel. From the evidence taken, there is no indication that the disabling of the alarm had any role to play in the incident. Statements and radio transcripts confirm that the wind speed was noted and reported at frequent intervals as it increased rapidly in the 40 or so minutes before the incident occurred. In addition, a suitable and official system for over-riding the audible alarm would have been acceptable to HSE. However, this problem should have been recognised and resolved by management;

(d) Although weather forecasts are received four times a day, there was little evidence that they were used for immediate operational decisions such as stopping loading. However they were used by the scheduling office in their decision making process;

(e) The safety implications of disconnecting in high winds had not been fully considered. Disconnection is a manual task and the automatic emergency release system is disabled before disconnection, to avoid any danger to the person carrying out the disconnection from an unintentional operation of the Emergency Release System. This leaves a period of 30-40 minutes when the ship is connected to the loading system during high winds without an operational emergency release system. This has particular importance where Teviot is considered. See Appendix 2.

159 The inadequacies in Shell Expro's system for dealing with high wind speeds did not in themselves contribute to the incident. However, they led to the highly unsatisfactory situation that when the Havkong broke free from its moorings, terminal staff were caught by surprise with the ship still loading normally,

despite wind speeds above the limits specified for stopping loading and disconnecting.

Shell Expro emergency procedures

160 The Shell Expro on-site emergency plan for Braefoot Bay is a combined one, covering both their main site at Mossmorran and Braefoot Bay. The plan deals with both sites in the same way and does not specifically deal with shipping incidents. Instructions on action to take in the event of an emergency are geared towards gas leaks, fire and explosion.

161 It is considered that there was some confusion and lack of direction in the initial stages of the emergency at Braefoot Bay, reflecting the fact that marine emergencies, which had been considered at the risk assessment stage of the terminal, had not been adequately covered in the emergency procedures. For instance, there was uncertainty as to whether in this particular case the site alarm should be activated; neither Exxon nor Teviot were contacted to warn them of the situation; site security were not informed immediately; and the emergency services were not contacted until the site manager arrived on the scene about 10 minutes later. The designated initial incident controller also left the control room to see what was going on (as required by Shell Expro's emergency procedures).

162 The investigation has indicated that training for emergencies was geared towards specific incidents involving fire or product escapes. There was no system to ensure that all relevant employees were involved in emergency exercises in a role appropriate to the role they would have to perform in an emergency. Although personnel had been highly trained, the training programme did not adequately take into consideration shift patterns and consequently there was considerable variation among those interviewed in the degree to which they had been involved in exercises.

Shell Expro/Exxon communications

163 Shell Expro has stated that it is responsible for marine matters at Braefoot Bay Terminal, including their own jetty and the Exxon jetty, and that the Shell Expro shift supervisor was in control of marine matters at the Exxon jetty. However, the evidence collected during the investigation has indicated a number of shortcomings:

(a) There was some uncertainty among the Exxon technicians about the role, authority and responsibilities of the Shell Expro supervisor at the Exxon jetty during marine emergencies;

(b) On this occasion it is considered there were shortcomings in the communication and exchange of information between the Shell Expro and Exxon control rooms:

(i) The Shell Expro supervisor was responsible for stopping loading at the Exxon jetty due to high winds. However, the Shell Expro and Exxon jetties have different anemometers to record wind speed and a comparison has shown that there can be considerable differences between readings. On the night of the Havkong incident Shell Expro did not ask for, and Exxon did not offer, information on the Exxon anemometer readings even though the wind speed limits set in the 'Jetty Regulations' for stopping loading Teviot were much lower than for Havkong;

(ii) Communications systems between Shell Expro and Exxon to warn of emergencies were also considered to be inadequate. No system of sharing alarms existed, therefore there was no indication either in the Exxon control room or on the jetty that the Shell Expro Emergency Shutdown system had operated. A tannoy system through which both jetties could be contacted by either control room existed, but had fallen into disuse (though it was maintained in an operational condition). In the event, the Exxon control room at the terminal was not informed directly of the emergency, although arguably the ship at their jetty was most at risk in the initial stages of the incident (see paragraph 158(e));

(iii) A final example of communication mismatch involved the woman and two children found on the Exxon jetty shortly after the incident. The Exxon control room did not know that they were on their site. They were not required to be informed of their presence by the Shell Expro security staff, who provide security for the whole terminal. The security staff knew the visitors were on the Teviot.

Monitoring arrangements by Shell

164 The shortcomings revealed by the investigation were indicative of a failure by Shell Expro management to adequately monitor the arrangements made to ensure safety at the terminal during tanker loading operations in adverse weather conditions and verify that they were both adequate and being followed by employees. This was noticeable in particular in cross-company matters between Shell Expro and Exxon.

Exxon Chemical Olefins Inc

165 Exxon is considered to have played a peripheral role in this incident, particularly as Shell Expro has confirmed that it accepted responsibility for control of marine matters at the Exxon jetty. The inquiry into the loading operation involving Teviot has concluded on the balance of probability that due to the more sheltered position of the Exxon jetty, wind speeds were not sufficiently high to require a stop to loading or disconnection of the loading arms before loading was completed.

166 However, the investigation has indicated a failure also to adequately monitor the arrangements made at the terminal which affected both companies.

Havkong

167 Havkong's Master was aware that a sister vessel had experienced difficulties at the Braefoot Bay berth in strong winds. He was also of the opinion that the jetty was not of an ideal configuration for his vessel. On receiving the initial forecast of strong winds he elected, on berthing, to deploy additional ropes over and above the minimum required in the 'Jetty Regulations'.

168 Contemporary tanker mooring practice demands that all the lines are set up on winches with substantial pretension and held on brakes. Havkong deployed all but two of her winch mounted wires on arrival. The two which could not be used were those from the poop designed as stern lines. With all the available winches in use the only additional lines which could be used were ropes either conventionally stoppered off and set up on bitts or held on the rope reels. Conventionally set up ropes can never be set up as tightly as the primary winch mounted wires and have a greater elasticity and so cannot take their share of load until the primary lines have been slackened or have rendered out.

169 With two ropes aft on reels and under tension and two ropes conventionally set up on bitts the stern line arrangement was probably the best that could be done. It did, nonetheless, suffer from the fundamental problem of differential load sharing. As the environmental load increased the load was first taken by the reel mounted lines which were stretched, possibly close to breaking point before the conventionally turned up lines began to contribute.

170 On receipt of the evening forecast the Master elected to deploy additional lines from forward of the accommodation block. These lines, if they could have been set up with an equivalent tension to the two reel mounted lines on the poop, would have enhanced the overall system performance.

171 It remains the case that responsibility for the safe mooring of a vessel lies with her Master. The Master's initial mooring proposals, agreed with the pilot, did comply with 'Jetty Regulations' but did not, in terms of an overall system, provide an adequate degree of restraint against forces from astern.

172 Nevertheless it must be concluded that, given the forecast on arrival, the decisions on mooring deployment initially and the decision to set additional lines on receipt of the later forecast were the only ones open and were appropriate in the circumstances.

173 Two other courses of action were available to the Master in the face of the increased forecast:

(a) to leave the berth for an anchorage until the weather moderated; or

(b) to call for tug assistance in advance of the strong winds.

174 Option (a) was largely precluded by the practice that part loaded vessels are not allowed to berth at this terminal. Had the Master taken this course he would not have been able to re-berth and would have had to justify the shutting out of nearly two thirds of his cargo. In any event, given the timing between receipt of the forecast and the onset of the squall which carried the ship away, it is considered that no criticism can be levelled at the Master for not following this course of action.

175 Option (b) was available and there is anecdotal evidence to suggest that it has been done before. The forecast, however, suggested that the very strong winds were not expected until later in the night. No indications were available to any of the personnel involved to suggest that a particularly strong squall was imminent. Given the time requirement for tug attendance from Leith, some 50 minutes, it is unlikely that assistance could have been provided before the squall even had a tug been called for immediately on receipt of the forecast.

176 The records from the remote station on Inchcolm Island which represent the conditions that evening show that the wind varied between a minimum of 25 knots and a maximum of 37 knots in the hour between 1720 h and 1820 h. In that hour Inchcolm recorded a peak gust of 47 knots. This was broadly in line with the forecast.

177 Between 1820 h and 1848 h the mean speed increased with the record showing values between 37 knots and 54 knots with peak gusts of 66 knots. Most of the one minute readings were in the 37 knots to 42 knots range over this period, with values increasing with time.

178 The figures recorded for the minutes after 1848 h are:

Time (h)	1 Min mean	Direction	Peak gust
1848	42	243	55
1849	49	245	62
1850	55	250	74
1851	57	252	77
1852	59	244	81
1853	62	249	79
1854	56	256	71
1855	54	252	75
1856	59	253	71
1857	58	251	74
1858	55	253	71

179 In ten minutes between 1848 h and 1858 h the wind speed increased to a peak in excess of 60 knots while gusts in excess of 75 knots were recorded. At the same time the wind veered from its previous direction of between 225 and 235 to a new direction between 245 and 255.

180 The berthing line at the Braefoot Bay West jetty lies 235/055. Before 1848 h the wind was therefore blowing from astern or from 10° on the starboard quarter of Havkong, pushing her onto the berth so that friction between her hull and the berth fenders assisted the mooring system in restraining the ship.

181 In the 10 minutes between 1848 h and 1858 h the wind direction veered to blow from between 10° and 20° on the port quarter, the shore side quarter. This had the effect of tending to blow the vessel off the berth aft. It also increased the wind loading on the mooring system as a greater amount of the ship's structure than previously was exposed to the wind while the contribution of the jetty to overall restraint was removed with the offshore component of wind force.

182 It is considered that the Master cannot be criticised in this instance for failing to seek tug assistance before the squall arrived.

183 The Master had in place a stated policy on deck watches, shore leave, and engine readiness. All the requirements of this policy were met on the night of the incident, crew were quickly available, the engine was ready for use very quickly, and the deck watch responded rapidly and correctly to the emergency.

184 Once breakaway had occurred, there was little that could be constructively done. The ship was very quickly athwart the wind with very little room ahead or astern. There were no engine orders that could have been given, prior to the first dead slow ahead order, that would have assisted in this situation. Any engine order before breakaway would have required both the bridge and the engine room to have been manned at the time. It is considered that such a degree of readiness would be unwarranted except in the most exceptional circumstances. Indeed had circumstances warranted such a level of readiness it would have been imprudent to consider loading any cargo. It is considered that no criticism can be levelled at the ship in terms of her state of readiness.

185 The Master responded correctly in the minutes following breakaway. He avoided a rushed anchor dropping that might have caused his ship to swing towards Teviot, he avoided contact between his sterngear and the navigation buoys by judicious use of the engine, and he correctly informed Forth Navigation of his situation.

186 It is considered that the Master of Havkong should be complimented for his professional conduct following the breakaway which certainly averted a potentially more damaging situation.

187 It is equally considered that the Chief Officer of Havkong should be complimented for his professional conduct and bravery in taking charge on the focsle in difficult and dangerous circumstances, in seeing the danger posed by the remaining headline and in successfully letting it go.

Forth Ports Plc

Emergency planning

188 As a statutory harbour authority, Forth Ports Plc has a duty to prepare an emergency plan which covers emergencies involving (among other matters) ships carrying hazardous cargoes in harbour areas. The plan given to HSE by Forth Ports Plc to cover this requirement is Emergency Forth. A number of shortcomings were found in this plan:

(a) The up-to-date plan given to HSE by Forth Ports Plc at the time of the Havkong investigation was identical to a copy of Emergency Forth held in HSE records. This copy was dated before the DSHA Regulations came into effect and before HSE guidance on DSHA (including the preparation of emergency plans) had been published. It therefore appears that no account had been taken of the published guidance on emergency plans and the plan had not been revised since it was first written with the exception of updating contact addresses and telephone numbers;

(b) Emergency Forth is considered to be inadequate. The range of possible emergencies had not been described and neither the scope of the plan nor the organisation and arrangements to deal with reasonably foreseeable emergencies had been defined;

(c) Emergency Forth specifically excluded Braefoot Bay Terminal and Hound Point Terminal and also appeared to exclude Leith Docks and Grangemouth Docks, on the grounds that other emergency plans existed for these sites. No emergency plans to comply with the requirements of DSHA had been prepared by Forth Ports Plc for these locations;

(d) Informal arrangements made for emergencies (eg use of the Rosyth tug) were not documented in the plan. This could have made it difficult to deal with an emergency if key personnel were absent;

(e) The Emergency Forth plan had not been practised. Although Forth Ports Plc has taken part in one exercise organised by Lothian Region, this exercise did not involve a ship carrying hazardous substances and any lessons learned from it were not used to revise the plan.

189 Issues related to Emergency Forth raised specifically by the Havkong incident were:

(a) possible time delays on officers living some distance from the emergency centre arriving following call-out;

(b) telephone communications and problems in dedicated telephone links at the start of the emergency;

(c) uncertainties concerning the exchange of information between emergency services;

(d) the significant time taken by tugs in leaving Leith Docks through the locks to respond to an incident.

190 The purpose of an emergency plan is to provide a structured approach to handling emergencies - to identify the range of foreseeable emergencies and to set up the organisation and arrangements to enable them to be handled effectively. The written document provides a framework for auditing and monitoring the plan, instruction and training of people with roles in the emergency plan and checklist for those involved in the plan. For the plan to be effective it is essential that arrangements are made for regular exercises and revision.

191 It is considered that the Emergency Forth plan did not achieve this purpose and is in need of considerable revision.

192 Despite the deficiencies in the emergency plan, Forth Ports Plc employees responded well when called out to take part in the emergency. The Police have commented that they were helpful and efficient.

Control of navigation

193 The General Directions for Navigation in as far as they control the movement of gas tankers using Braefoot Bay Terminal achieve a number of objectives. They:

(a) establish one-way east bound traffic in the vicinity of the west jetty;

(b) avoid any conflict with other traffic when an inbound vessel is turning northwards out of the main channel;

(c) avoid any conflict with other traffic whenever a loaded tanker is departing.

194 At the same time they impose limitations:

(a) vessels may only berth port side to;

(b) other traffic in the main channel is effectively precluded between Inchcolm Island and the Fairway buoy whenever a loaded tanker is departing;

(c) vessels may only depart eastwards (towards Burntisland).

195 The restriction to berthing port side to means that vessels using the west jetty are usually required to berth stern to wind after negotiating the turn around the west side of Inchcolm given the prevailing westerly wind. This is not the easiest berthing manoeuvre.

196 An approach from the east would have the advantage that berthing would more often be head to wind, noting that these vessels, particularly when empty, are more influenced by wind forces than by tidal forces in consequence of their high freeboard and complex deck structure. Several of the Forth pilots familiar with operations at Braefoot Bay support the view that an approach from the east to berth starboard side to would be safer and easier.

197 Arguments against an easterly approach are centred around the difficulties of unberthing and leaving Mortimer's Deep to the west of Inchcolm without leading marks ahead for guidance through the narrow passage between Inchcolm and the Haystack. Other arguments advanced are that with a prevailing westerly wind there is risk of a loaded ship being set down onto Inchcolm and that departing vessels will have to join the main channel from the north, approaching from behind Inchcolm, and so are unable to see the extent of traffic in the channel before joining.

198 None of these arguments is considered to be exceptionally strong, no leading marks are available ahead for the easterly departure, albeit the channel is much wider. The easterly channel is however depth limited, while that west of Inchcolm is not. Vessels departing are in a position to delay their commitment to go until conditions are optimum in terms of tide, wind, and visibility. With tug assistance and the opportunity to align the vessel with the channel while still virtually alongside the berth it is considered that the risks associated with a westerly departure are no more, and probably less, than those associated with the present easterly arrival heading, with the advantage that head to wind berthing can be achieved more frequently. It should also be noted that, although a set down onto Inchcolm due to strong westerly winds is always possible, it is slightly less likely with a loaded ship in view of the reduced freeboard when loaded and the greater momentum. Also most vessels arriving at Braefoot Bay are already purged ('gassed-up') and ready to load. In other words, although they do not have on board the combination of liquid cargo and vapour in their tanks which a loaded or part-loaded vessel will have, the tanks are nonetheless full of vapour. Additionally two tugs are in attendance for the manoeuvre around Inchcolm and would also be available if departing that way.

199 Possibly the most significant basis for the argument against a westerly departure lies in the fact that, if the same principles are adhered to as in the current directions, the potential delays to other traffic are increased with a longer stretch of the main channel closed during the passage of the gas tanker.

Arguments relating to the difficulties of joining the channel from behind the island can be refuted by the presence of the Vessel Traffic Service operated by Forth Navigation.

200 It should also be noted that, for a vessel berthed as at present, portside to the Shell Expro jetty, the only reasonable option for her to leave in an emergency is eastwards. Therefore, whether the emergency is on the jetty with the vessel getting clear or the emergency is on the ship which is being taken clear of the jetty, the departure route is past the Exxon jetty. Additionally, if it is low water and the vessel is fully loaded or nearly so she will only be able to proceed as far as the deep water off Hawkcraig Point until there is sufficient water to proceed across the bar.

201 A vessel berthed starboard side to having made a direct approach from the east may still choose to depart to the east if she is swung off the berth. This may be considered to involve additional risk.

202 However an examination of the survey charts for the terminal area indicates that there is room for a swinging manoeuvre off the berth. Havkong did such a swing, albeit an involuntary one. The area is, however, surrounded by visible rocks rather than by shallow water. Accordingly it looks possibly more restricted than it actually is. It is possible to construct a 400 m diameter turning circle wholly within the 20 metre depth contour off the west jetty and a 700 m diameter swinging circle wholly within the 15 m contour. Havkong is 219 metres long.

203 Although it is not possible to assert that Havkong would not have broken adrift had she been berthed starboard side to it still remains that, head to wind, she would have better resisted the forces imposed on her while the position of the manifold would have meant that the head lines would have acted more effectively in contributing to the overall restraint in the mooring system. Head to wind she would also have had access to her anchors to provide emergency restraint against the westerly wind without causing a swing which would have been the case had anchors been used in this incident.

204 It should also be noted that the shore gangway at this berth is positioned on the east side of the berth. This results, when a ship is berthed port side to, in the gangway, as the primary means of escape in emergency, as well as the sole means of access, being landed on the opposite side of the manifold to the accommodation. To reach the accommodation people using it must pass the compressor and motor rooms and the manifold, possibly the areas of greatest hazard on these ships. Were ships to be berthed starboard side to, the gangway could be landed on the accommodation side of the manifold which is inherently safer. It is normal tanker practice to position the gangway on the accommodation side of the manifold whenever possible.

205 Given that there are no arguments overwhelmingly in favour of retaining the existing port side to only berthing requirement and that there are arguments in

favour of reversing the process, it is recommended that the whole issue of routeing these vessels in the Forth and their approach to the berths is re-examined with particular regard to the possibility of a berthing approach from the east.

206 It is also recommended, considering the issues discussed above, that the present prohibition on berthing while part loaded is re-examined with a view to determining if the increase in safety it introduces is real and if the balance of safety may not be enhanced by lifting it. If this restriction were lifted it would be an option for any Master faced with an unexpectedly severe forecast to temporarily depart the berth for a safe anchorage.

207 Immediately following this incident, and by agreement with Forth Ports Plc and Shell Expro in consultation with the Department of Transport and HSE, a standby tug was provided as an interim measure to be present whenever a vessel was berthed at Braefoot Bay.

208 The 'Jetty Regulations' require all ships at this berth to deploy fire wires. At the same time, until this incident there was no tug presence at the berth and the nearest tugs were to be found either at Leith, with a call-out time of around 50 minutes or at the Hound Point Terminal with a slightly less call-out time, assuming they were not actively engaged in working with a tanker at that berth. Despite the fire wires, therefore, there would be no tug assistance available to make use of them for some 50 minutes at least. It is considered that this is an unsatisfactory arrangement for a berth dealing with hazardous products in large quantities where a ship might have to be removed from the berth as a matter of urgency in the event of a fire either on the jetty or on the ship. Similarly in bad weather, when a vessel at the berth needed tug assistance to maintain position alongside, the delay in providing tug assistance is unacceptable.

209 Accordingly it is recommended that a tug of suitable horsepower is permanently stationed at the Braefoot Bay Terminal whenever a ship is alongside. This arrangement is now in place.

210 Tug assistance in bad weather requires more than simply pushing alongside. In the case of Havkong, simply pushing on to the berth might not have prevented the ship from moving ahead. In addition to a tug presence, the role and duties of the tug must be carefully planned in advance so that it may be positioned and used to best effect in any given situation.

Emergency services

211 The emergency authorities (Police, Coastguard, Fire) involved in the incident all implemented either emergency plans or emergency procedures. These emergency procedures are not within the jurisdiction of legislation implemented by HSE (as civil emergency plans, they are within the remit of the Scottish Office Environment Department).

212 The Police, Coastguard and Fire Service have provided information to the investigation on their roles in the emergency response and any problems or difficulties experienced. The response of the emergency services to very unusual circumstances was considered competent and appropriate.

Fife Regional Council

213 Fife Regional Council, who were contacted by Fife Police were involved in the incident to a fairly minor extent, although the precautionary measures taken to alert relevant personnel that action might be required were considered to be reasonable in the circumstances.

Recommendations by Marine Accident Investigation Branch

214 The MAIB recommends that Shell Expro should restrict the use of the west jetty at Braefoot Bay Marine Terminal to vessels that can meet the following criteria in respect of moorings additional to the requirements already laid down in the 'Jetty Regulations' when the vessel is aligned with the loading arms:

(a) ability to deploy head lines from fairleads in positions such that the lines lead ahead or not more than 10° aft of the perpendicular to the ship's centre line;

(b) ability to deploy stern lines from fairleads in positions such that the lines lead aft or not more than 10° forward of the perpendicular to the ship's centre line;

(c) the leads of head lines and stern lines are complementary in that if the lines at one end lead forward then those at the other must lead aft and vice versa;

(d) ability to deploy breast lines at each end from fairleads in positions such that the two sets of breast lines lead in complementary directions with the angles between each and the perpendicular to the ship's centre line approximately equal;

(e) ability to deploy two springs, which should be wire except in the case of small vessels, at each end;

(f) all mooring lines in the same service are of approximately the same length.

215 Shell Expro and Forth Ports Plc together should prohibit berthing at the Braefoot Bay west jetty whenever the forecast indicates wind speeds of 45 knots or greater at any time during the vessel's expected stay on the berth.

216 Shell Expro should include information in the 'Jetty Regulations' advising Masters of the potential for the sudden onset of very strong winds at this berth and of the need to consider additional moorings at times.

217 Shell Expro and Forth Ports Plc should together arrange for a tug to be stationed at the Braefoot Bay Marine Terminal whenever a ship is berthed there and that suitable procedures and guidelines should be developed for using this tug in varying circumstances.

218 Shell Expro and Forth Ports Plc should make arrangements for the attendance of a pilot on board any vessel at the berth whenever it is necessary for the tug to assist. The pilot should remain on board until the tug's services are no longer required.

219 Shell Expro should develop means for analysing the actual mooring pattern geometry to be used by every vessel in order to assess the loads expected in the worst weather situation and to provide a specific optimum mooring line pattern for each vessel.

220 Forth Ports Plc should initiate a reassessment of the current directions relating to the movement of gas tankers to and from the Braefoot Bay Marine Terminal with a view to establishing:

(a) if the current restriction preventing part loaded ships from berthing needs to be maintained; and

(b) if the prescriptions for port side to berthing and no westwards departure are still the best procedures for safe operations at this berth.

221 Forth Ports Plc should set up a dedicated communication system that would allow this terminal and other terminals and ports in the River Forth, to communicate directly with Forth Navigation Service to warn of an emergency before the emergency room is manned.

222 Recommendations 214, 215, 216, 217, 218, 219 and 221 have now been implemented and the reassessment referred to in recommendation 220 is underway.

Recommendations by HSE

223 Operational procedures at Braefoot Bay Terminal should be reviewed with regard in particular to monitoring equipment and procedures for poor weather and high winds, Shell Expro/Exxon communications and emergency procedures.

224 Emergency planning as required by the Dangerous Substances in Harbour Areas Regulations be reviewed for the Forth Estuary and an effective emergency plan

or plans prepared to include all relevant harbours and the harbour area and cover the range of incidents that can reasonably be anticipated.

Remedial action

225 The following action was taken as soon as the major enquiry stage of the investigation had been completed:

226 An improvement notice (IN) was served by HSE on Shell UK Exploration and Production, requiring a review of its activities at Braefoot Bay Terminal in the light of the deficiencies identified by the investigation and preparation of a planned programme of remedial action. The IN covers issues identified both by the MAIB investigation and HSE investigation. The action required by the IN was specified in a Schedule to the Notice (see Appendix 6 for copy of Schedule). Shell Expro has reacted very positively to the notice and had fully complied with it by the expiry date of 31 May, 1993. The planned programme of remedial action identified has been implemented.

227 Compliance with the IN has required co-operation by Exxon on issues involving the overlap in management between the two sites.

228 An IN was served by HSE on Forth Ports Plc requiring an effective emergency plan to be prepared covering the range of dangerous substances brought into or handled in harbours and the harbour area within its statutory jurisdiction. The action required by the IN was specified in a Schedule to the notice (see Appendix 7 for copy of Schedule). As the IN covers the range of Forth Port Plc's activities and is not restricted to Braefoot Bay, it was considered that a substantial amount of work would be required to comply with it. Accordingly, the expiry date was agreed as 6 January 1994. Compliance with the notice was achieved by its expiry date.

229 The MAIB investigator has written to Forth Ports Plc confirming his conclusions on the restriction preventing part loaded ships berthing and the requirement to berth port side to and depart eastwards. The letter recommends that these issues are reviewed. Forth Ports Plc has not yet confirmed their conclusions on this matter and it is understood that discussions are ongoing.

APPENDIX 1

INCIDENT INVOLVING THE LPG/C HAVKONG ON 23 JANUARY 1993 SHELL UK EXPLORATION AND PRODUCTION, BRAEFOOT BAY TERMINAL

Background to HSE's involvement in the development of Braefoot Bay Terminal

1 In 1977 Shell UK Exploration and Production (Shell Expro) and Esso Chemical Inc (Essochem) (now known as Exxon Chemical Olefins Inc) applied for planning permission to construct a Natural Gas Liquids (NGL) separation plant and Ethane cracker at Mossmorran, together with associated jetty facilities at Braefoot Bay in Fife.

2 In 1979, after a public inquiry the Secretary of State for Scotland granted outline planning permission to Shell Expro and Essochem, subject to a number of planning conditions. Planning condition 24 required the applicants to arrange for a full independent hazard and operability (HAZOP) audit of the facilities before the plants were commissioned. In a letter accompanying the grant of planning permission, the Secretary of State undertook to consult HSE and local authorities before deciding whether or not the audit was adequate and the safety levels revealed, acceptable.

3 In 1979 the Major Hazards Assessment Unit (MHAU) of HSE, in consultation with the Scottish Development Department (SDD) began discussions with the developers to set the scope of the audit. In 1980/81 Shell Expro and Essochem appointed the international consulting firm of Arthur D Little Ltd (ADL) to produce audits on each of the facilities to satisfy the requirements of the planning condition.

4 Between 1980 and 1983 HSE, by discussion, review, inspection and consultation with all parties involved, monitored the progress of the audit work. These audits were submitted to the Secretary of State for Scotland and accompanied by a report from HSE dated December 1983.

5 The audits included an extensive hazard and operability study on the plant design to determine events leading to a release of hazardous material, including recommendations for certain risk reduction measures; construction procedures and management systems. The events were quantified in terms of probability and scale of release. The consequences were calculated in terms of hazard distances to levels of thermal radiation, blast over-pressures and vapour dispersion limits. Overall hazard area plots were then developed to show the probability at which given locations would be exposed to the chosen hazardous consequences. The individual risk of injury would be less than the probability levels shown for a given location.

6 HSE's report concluded that HSE was satisfied that the audit had been conducted comprehensively and also satisfied that the hazard area plots fairly and reasonably represented the potential hazards from the facilities. HSE was of the opinion that the provisions of planning condition 24 had been fully met and that the audits did not indicate any further planning requirements should be imposed.

7 No planning conditions had been made in respect of the hazards that might arise from the marine traffic, as planning law only related to developments on land. However, after careful consideration HSE concluded that in order to give full and proper advice on the safety of local populations it was essential to complement the audits, referred to above for the on-shore operations, with a risk assessment of the proposed shipping movements in the Firth of Forth and Braefoot Bay. HSE put this in the form of a request to the operating companies and the statutory harbour authority - Forth Ports Plc.

8 The Forth Ports Authority (FPA) accepted the need for a marine risk assessment and together with the terminal operators, Shell Expro and Essochem, formed a consortium which then commissioned Energy Resources Co Inc (ERCO), a firm of independent consultants with considerable experience of this kind of work to carry out a study.

9 HSE had a number of detailed discussions with the consortium and ERCO at various stages of the study starting with the formulation of the terms of reference and proceeding right through to the production of the report. The study considered all incidents involving ships plying to or from the Braefoot Bay Terminal which might have the potential to put at risk the population on shore. The broad methodology used to determine the risk was similar to that used in many studies of this type. In the most part the ERCO methodology was, in the view of HSE, satisfactory, but in certain areas HSE considered an alternative and more rigorous approach to be necessary and in these areas HSE carried out its own assessment of the risks involved. These assessments were both thorough and detailed and were put together with those parts of the ERCO study, which were agreed after careful scrutiny to enable HSE to reach its conclusions.

10 The risk figures derived in the study were based on the understanding that certain marine traffic controls would be introduced and strictly enforced by the Forth Ports Authority. These controls should significantly reduce the risk of collision or grounding of the ships carrying liquefied gas. Subject to that understanding HSE concluded that Aberdour, Dalgety Bay and Burntisland, the townships in closest proximity to the marine operations at Braefoot Bay, were not likely to be affected by a fire or explosion resulting from a marine accident more than about once in a million years. This was broadly similar to the conclusion reached in the ERCO study and was considered to be a reasonable representation of the risk.

11 In the very unlikely event of such an incident occurring, a certain proportion of people in the open air might be injured whereas most people indoors would not.

The average individual risk of fatality in these communities is therefore estimated to be significantly less than one in a million years. The risks to people living on the south shore of the Forth, namely in the northern part of Edinburgh are even lower. Risks of this magnitude are small in relation to many other risks of daily living and it was HSE's belief that they should not be a cause of concern among people living in the vicinity of the marine terminals at Braefoot Bay.

12 The Shell Expro and Exxon installations commenced operations in 1984/85. In the years that followed there were further developments at these sites, most significantly the Shell Expro Third NGL Module in 1992 and Exxon's Seventh Furnace Project also in 1988. The planning applications for these developments were supported by revised risk assessments for on-shore and shipping operations, carried out by Arthur D Little Ltd. Again, these studies were considered by HSE acting in an advisory role to the relevant planning authorities.

13 In 1989 Exxon Chemical Olefins Inc submitted an outline planning application for the development of their Fife Ethylene Plant (FEP), Mossmorran for increased feedstock flexibility, additional products and increased ethylene production. The application was supported with safety studies carried out by Arthur D Little: a shipping study looking at the tanker traffic from the Braefoot Bay Marine Terminal and an on-shore study dealing with the land based facilities at both Mossmorran and Braefoot Bay.

14 The shipping study included a detailed assessment of shipping traffic in the Firth of Forth, analysed from records provided by the Forth Navigation Service to assess maximum traffic flows, ship sizes, ship types and cargoes handled in the Forth ports, including naval traffic into and out of the port of Rosyth. This data was used to assess the probabilities of cargo spills and their consequences of releases of LPG, ethylene, propylene, gasoline and heavier hydrocarbons, which could lead to thermal radiation from pool fires, fireballs, vapour clouds or explosions. The risks were calculated by combining the probability of cargo spills with their consequences and the results presented as risk of fatality contours in order to give a measure of individual risk.

15 In the study four shipping patterns were considered:

(a) Shell Expro base case for expanded operations (from the third module); this pattern corresponded to the maximum feasible Shell Expro NGL plant capacity with an ethane feed to the Fife Ethylene Plant (FEP);

(b) FEP development project (FEP) base case: this pattern corresponded to the maximum Shell Expro NGL plant capacity with maximum feasible ethylene production at FEP (975 000 tonnes per annum);

(c) FEP Feed Variation 1 Case; corresponded to the maximum proposed Shell Expro NGL plant capacity with an FEP feed variation producing maximum

propylene (235 000 tonnes per annum) and maximum C 5 + products 9175 000 tonnes per annum); and

(d) FEP conservative LPG case; corresponded to the FEP base case above, but for LPG exports from Shell Expro at the maximum feasible plant capacity.

In all of these cases one half of the ethylene would be shipped by tanker from Braefoot Bay and the remaining half by pipeline to Grangemouth.

16 The study attempted to make best estimates for marine incident frequencies, spill probabilities, consequences and potential hazards where there was sufficient data to justify such estimates. In cases where the data was not sufficient to make best estimates, or in cases where assumptions allowed simplification of the calculations, assumptions were made which were believed to overstate the risks. Some of the areas where such conservative assumptions were made are as follows:

(a) The marine incident rates, based on historical statistics may not fully reflect the expected safety of marine operations under the specific traffic rules and regulations applicable for the Braefoot Bay tanker movements. Specifically no credit was taken for the Forth Navigation Services navigation rules for the Braefoot Bay tankers to reduce the frequency of collisions in transit or at the jetties, which include tug requirements for these tankers and restrictions in the movements of other vessels in the Forth during transits by the Braefoot Bay tankers. These restrictions should reduce the probability of collisions both at sea and at the jetties;

(b) It was assumed that release of LPG, ethylene and propylene from marine traffic incidents were possible although there have been no incidents world-wide where such releases have occurred to date;

(c) Most spills due to marine incidents were assumed to be large: one or two full tanks for LPG, ethylene or propylene: two full tanks for gasoline and C5 +;

(d) An assumed instantaneous spill overestimated the extent of thermal radiation and vapour dispersion hazards;

(e) Consequence calculations for over-pressure and fireball events over-estimated the quantity of material involved in the incident, which resulted in larger hazard areas;

(f) Hazard modelling for vapour cloud assumed that the cloud movement occurred over level terrain, but in reality the topography of the banks of the River Forth would act to restrict inland movement of the cloud;

(g) Concentration limits for all dispersion calculations were taken to half the lower flammable limit;

(h) For collisions in transit it was assumed that the striking vessel did not have a 'soft nose' - a feature of modern ship design which would reduce the probability of a release following a collision.

17 The on-shore and off-shore risk assessments by Arthur D Little were considered by HSE and the following advice was sent in April 1990 to the Fife Regional Council via HSE's Edinburgh Area Office:

"The Health and Safety Executive (HSE) has considered the risks to the surrounding areas from the proposed expansion of the Fife Ethylene Plant and the increased shipping traffic from the terminal at Braefoot Bay. HSE has concluded that there are no significant reasons on safety grounds to advise against the granting of planning permission for this proposed expansion."

In reaching this conclusion HSE has compared the risk of fatality criteria used in the Arthur D Little Risk Assessments for the plant expansion and the shipping study with the dangerous dose criteria described in HSE's document *Risk criteria for land-use planning in the vicinity of major industrial hazards.* While there are differences in the criteria, HSE is satisfied that at the shoreline at Aberdour, the risk levels in the shipping study are almost the same as those assessments using the HSE 'dangerous dose' approach.

18 Planning permission for the Fife Ethylene Development Project was subsequently granted by the local planning authority in June 1990.

APPENDIX 2

MV HAVKONG, BRAEFOOT BAY MARINE TERMINAL, 23 JANUARY 1993

The potential consequences

Introduction

1 Had Havkong stranded, somewhere due west of Burntisland, her speed and construction with cargo tanks located away from the outer hull in compliance with the IMO Code for the construction and Equipment of Vessels carrying Liquefied Gases in Bulk, make it unlikely that the cargo system would have been breached;

2 Had the Havkong made contact with the Teviot it is unlikely that the cargo containment, being situated inboard of the outer hull, would have been breached.

3 Nevertheless HSE has considered it would be helpful to look at the potential consequences for the theoretical releases and dispersions of LPG. These considerations are given in the discussion below. It should be noted that the weather category and wind speeds used in the calculations were based on the data available at the time of the incident. In the various studies referred to in Appendix 1 significantly lower wind speeds were used for the dispersion of unignited vapour clouds, leading to more conservative predictions of consequences, ie greater hazard ranges to the lower flammability limits.

Discussion of incident potential

4 As the rising wind veered and pushed the stern of Havkong away from the Shell Expro jetty, the ESD system operated, preventing a spill and causing minor damage to the ship's pipework. The same wind, pressing on the port quarter of Teviot at the Exxon jetty, was causing concern. Had the Chief Officer of Havkong not succeeded in releasing the remaining head line, the vessel would have continued to swing. When the head line did eventually release, the Havkong could have struck Teviot.

5 The mooring lines of Teviot, already under strain due to the gusting wind, would have been unlikely to resist the eastward movement of both vessels and probably those lines restraining such movement would have parted. The valves in the transfer line to Teviot were closed and the ESD system disabled for the jetty crew's safety during disconnection. So, if draining of the line had not been completed, the movement of the Teviot might have damaged the loading arms. If the pipework had failed, the contents of the lines might have spilled, the quantity being restricted to the amount between the closed valves.

The evaporating spill would have dispersed rapidly in the strong gale. If ignition of the gas had occurred, for example due to sparks from damaged electrical equipment such as the navigation lights on the jetty, the fire would only have been fed for a short time as the ethylene drained out of the pipework. Fire-fighting monitors were available on the jetty to contain such a fire.

6 Havkong striking Teviot would be unlikely to damage the cargo containment on either vessel. On Teviot the cargo tanks were forward of the engine room, the parting mooring lines would have lessened the force of the collision which, together with the wind would have tended to sweep Teviot off the Exxon jetty. Any damage sustained by Havkong in the encounter would have been near the bow and unlikely to have involved the part of the hull where the cargo tanks are located.

7 If Teviot had been torn from its moorings by the larger Havkong, the latter vessel being only part-loaded would, in the absence of any restraint, have tended to drift downwind more rapidly. The crews would be making concerted efforts to control the drift of their vessels, preparing to start their engines and drop one, or perhaps more, anchors to stop their progress downwind. Tugs were on their way to assist. The draughts of the part-loaded Havkong and the fully-loaded Teviot were similar. So if it came to it they would ground at the same distance from the shore. Although Havkong appears to have grounded on the northern side of the channel, at no point did she approach closer than 500 metres to the shore. The same would apply to Teviot.

8 After grounding, for a release of the cargo to have occurred, the underwater obstruction has to penetrate the outer hull in the area of the cargo tanks, then penetrate the inner hull some one and a half metres away and finally penetrate the cargo containment. This sequence, in the context of the incident under discussion is extremely unlikely to have happened. Research on gas tanker incidents worldwide, carried out for HSE as part of the work for HSC's publication *The major hazard aspects of the transport of dangerous substances*, shows that between 1975 and 1987 there was no evidence that any of the incidents, anywhere in the world, led to cargo tank penetration, except in the case of warfare. However in 1988 an LPG ship collided with an anchored ship off Istanbul. The LPG ship was loaded with liquid ammonia at the time. Some of the damage to the outer hull may have been caused by the anchor chain of the anchored vessel.

9 In the unlikely event that the cargo containment was ruptured, the refrigerated cargoes at sub-zero temperatures would come into contact with sea water. Neither of the cargoes was under pressure (except vapour pressure), so probably only the head in the ruptured tank would cause the outflow of the contents. As the refrigerated cargo mixed with the stormy sea water rapid boiling of the gas would take place. In the turbulent wind, the gas would mix with air, forming a flammable cloud which would be driven rapidly away from the ship.

As the mixing continued the cloud would dilute until it could no longer burn. Given the state of the tide, and the strength of the wind such dilution would have been reached long before the gas cloud reached the shore. Calculations have shown that the distance to the Lower Flammable Limit is less than 200 metres.

10 With an underwater leak of cargo ignition is unlikely. If the gas cloud did catch fire, due to some source on the vessel, or another approaching craft the wind would drive the flames downwind and probably away from the ship. The flames would not extend as far as the shore. Possibly, pockets of burning gas may break away from the main cloud but even these would be very unlikely to reach the shore.

11 Grounding approximately two hours before low water, the vessel would have floated off after four hours by which time tugs would have been available to control her.

12 If the crew of one of the tankers was unable to gain control of their vessel and the tugs unable to arrive in time, the ship would eventually ground off Burntisland. The wind direction would have dictated the direction of drift. If the wind direction remained the same as when Havkong's moorings parted, the tanker would probably have grounded off the entrance to Burntisland harbour. Had the wind continued to veer the tanker would have been swept out into open water in the Forth. If the wind had backed again, grounding would have occurred to the west of Burntisland. The depth of water would have limited the approach of the vessel to the shore. Whether a release of cargo occurred would depend upon the sequence of damage described above. As the laden LPG ship Inga Tholstrup demonstrated in November 1986, running aground on rocks in heavy weather in the Firth of Forth and even holing the outer hull in the area of the cargo tanks does not mean that a release is inevitable. Even with a significant release of cargo at the closest point of approach to the entrance to the harbour at Burntisland, the strength of the wind was such that a gas cloud would have been unlikely to be flammable beyond the lighthouse at the end of the breakwater.

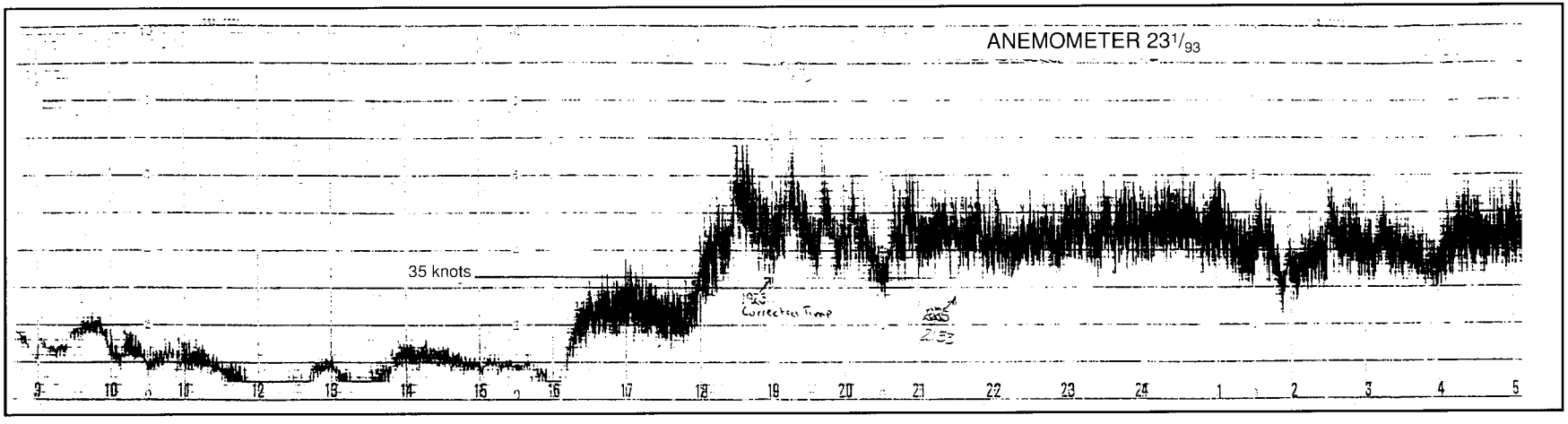
13 The potential consequences under different tidal conditions bear consideration. The maximum depth of water would have been at high water springs. This would, on one hand provide more depth of water over the seabed and more room to manoeuvre, on the other it would allow vessels drifting out of control to ground closer to the shore. Provided the tankers cleared the rocks at Craigdimas their down wind drift would still have tended to take them clear of Burntisland unless the wind backed. At Hawkcraig Point and Common Rocks, the down wind dispersion of the gas cloud over the sea would render it no longer flammable by the time it reached the shore. Clearing Common Rocks either tanker could have been driven into the bay to the west of Burntisland harbour. In the unlikely event of a release of cargo the gas cloud would not remain flammable beyond the outer harbour. As the substantial quantity of liquefied gas

came into contact with the sea water the gas would boil off vigorously and some of the sea water may freeze. As the head in the tank falls to balance that of the sea outside the hull more ice would tend to form. Naturally a fire would inhibit this but the hull damage would be likely to be below the waterline - at least until the tide receded. For an explosion to occur air would have to enter the damaged tank in sufficient quantities to create a flammable atmosphere. Given the low likelihood of damage to the ship's tanks in the first place and possible ice formation at the leak this leads to the conclusion that an explosion would be a very remote possibility.

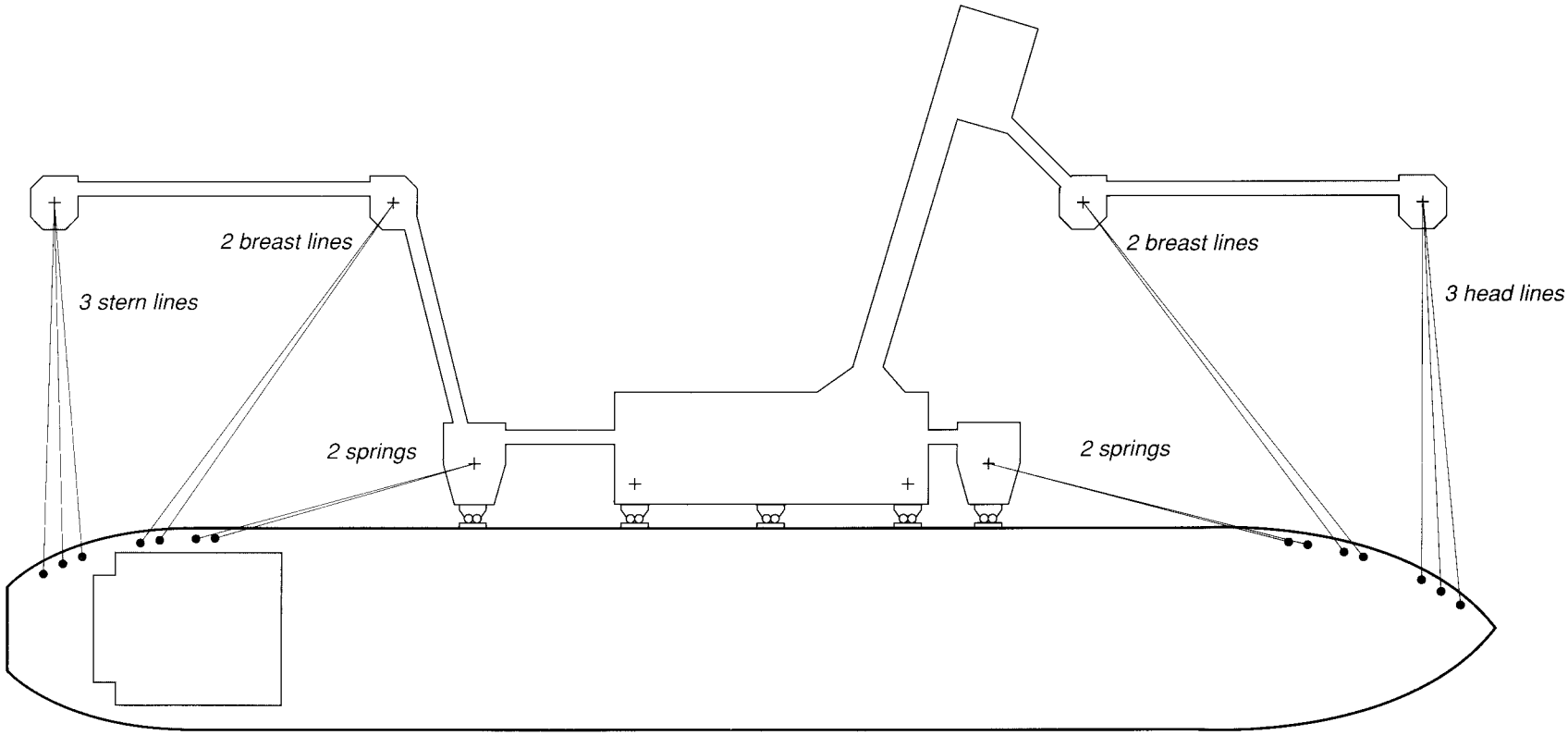
Conclusion

14 While the discussion given above makes pessimistic assumptions as to how a potential incident might proceed, in the range of events considered it is concluded that the predicted consequences would not have been significant for people onshore.

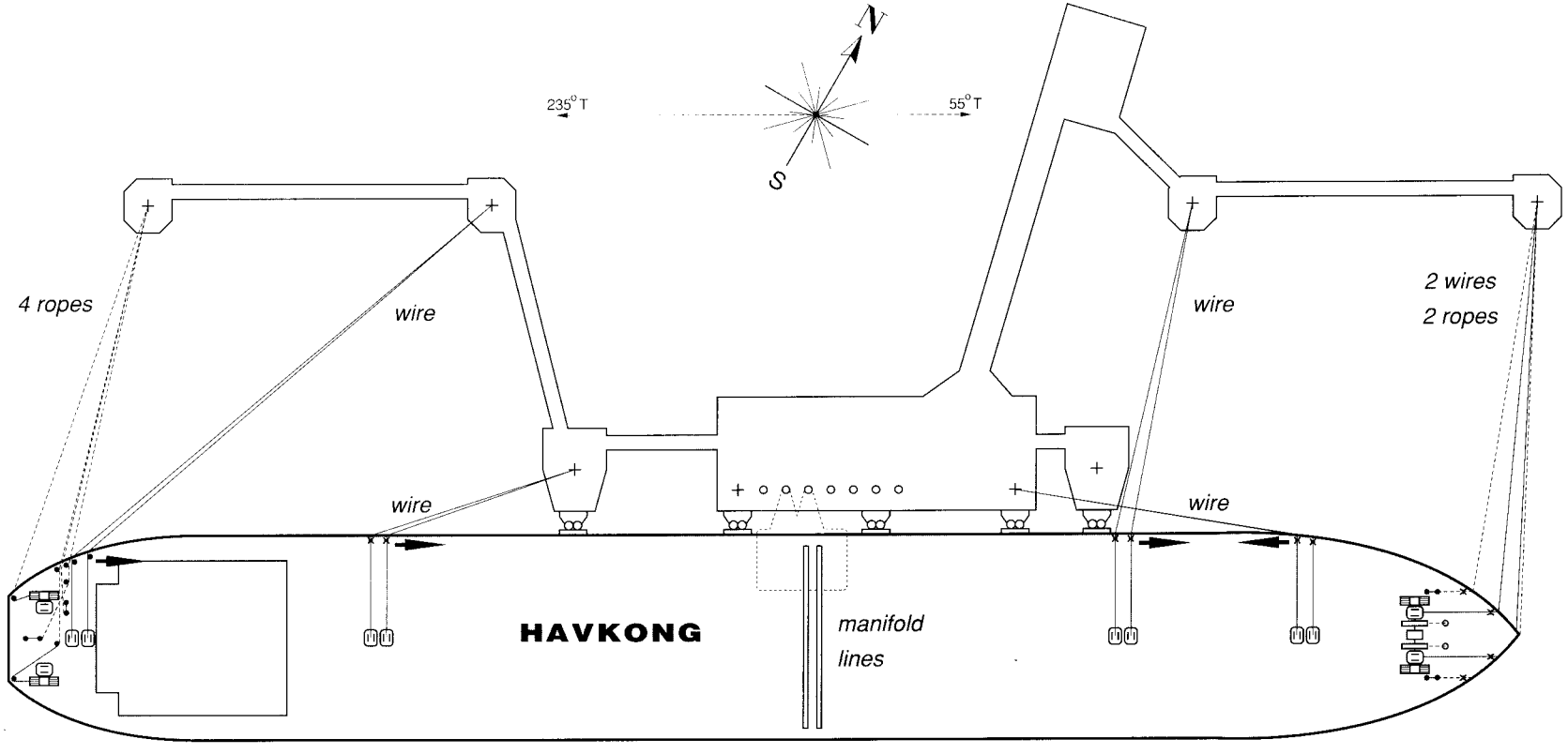
APPENDIX 3
Extract from pen chart recording of wind speed



APPENDIX 4
Typical mooring arrangement at Shell jetty for ships of Havkong's size



APPENDIX 5
Final moored arrangement for Havkong



indicates longitudinal component of force introduced by pre-tension

hydraulic wire winch

powered rope reel and 'Atlas' line

loading arm operating envelope

APPENDIX 6

Schedule to improvement notice for Shell UK Exploration and Production

1 A review should be carried out of operations and operational procedures at the Shell Expro Jetty at the Braefoot Bay Terminal and of operational procedures within the control of Shell Expro at the jetty operated by Exxon Chemical Olefins Inc at the Braefoot Bay Terminal.

2 The reviews should consider at least the following areas:

3 The adequacy of the mooring arrangements at the Shell Expro Jetty to determine:

(a) the maximum vessel parameters in terms of length, winch and fairlead position, and manifold position for safe mooring at the existing jetty;

(b) the optimum mooring line disposition for each vessel intending to use the jetty, with particular regard to severe weather conditions and any shore augmentation which might be appropriate;

(c) the means by which Shell Expro will both promulgate and thereafter enforce the maximum vessel parameters acceptable at the jetty for safe mooring.

4 The role of tugs should be considered:

(a) the provision of tug assistance and the availability, response time and particular functions of tugs in an emergency, not restricted only to severe weather conditions;

(b) the provision of pilotage assistance on board vessels at the jetty whenever tug assistance is called for severe weather should receive consideration.

5 The requirements for stopping loading and disconnection in the event of high winds in the 'Jetty Regulations' and in particular:

(a) on what basis the limits for stopping loading and disconnection due to wind speeds have been selected;

(b) whether the monitoring equipment available to Shell Expro operators is capable of providing the information required to enable them to decide whether a two-minute mean speed above the limit has been reached;

(c) the design and function of the high wind speed alarm including under what circumstances, if any, the alarm can be overridden or disconnected;

(d) whether the instructions in the 'Jetty Regulations' on when to stop loading are sufficiently precise;

(e) monitoring arrangements to ensure that requirements and procedures in the event of high winds are being followed.

6 Emergency procedures at Braefoot Bay and the management system covering training and exercises in these procedures to ensure that all employees receive the training and practice appropriate to their roles in an emergency.

7 Communications with Exxon and Shell Expro's role in the management of marine matters at the Exxon jetty to include in particular the exchange of information, especially in the event of an emergency occurring, and the position and responsibilities of the Shell Expro Marine Supervisor on the Exxon jetty.

8 A written report on the above matters should be made available to HSE by the expiry date of the improvement notice. The report should include your conclusions on the topics covered and proposals for any remedial action. A provisional timescale for remedial action should be included (which need not, however, be within the expiry date of the notice).

Notes:

(a) The above is intended as a guide and does not prevent the inclusion of other topics or options which you consider to be relevant;

(b) Any proposal which involves a significant increase in the number of ships visiting the Shell Expro Jetty may involve a re-appraisal of your previous risk assessment document which took account of the number of ships expected to visit the jetty;

(c) You may wish to include in the report the views of your company on the requirement to always berth ships so that they are facing eastward.

APPENDIX 7

Schedule to improvement notice for Forth Ports Plc

1 An emergency plan should be prepared for dealing with emergencies which involve, affect or could affect dangerous substances that are brought into or are handled in all harbour areas within the statutory jurisdiction of Forth Ports Plc.

2 Before the emergency plan is prepared the emergency services and any other body which appears to Forth Ports Plc to be appropriate should be consulted.

3 The emergency plan should include a Schedule giving details of the action which will be taken to keep the plan up-to-date.

4 By the expiry date of this improvement notice the following should be available for inspection by HSE:

(a) a written copy of the completed plan;

(b) documentary evidence that all organisations, companies and persons with duties under the emergency plan or involvement in it are aware of their role and have agreed to it.

5 Alternatively, other action may be taken which fully complies with all relevant legal requirements.

Notes:

(a) The terms 'harbour', 'harbour area', 'harbour authority' and 'dangerous substances' are defined in the Dangerous Substances in Harbour Areas Regulations 1987;

(b) More detailed guidance on the preparation of emergency plans under the Dangerous Substances in Harbour Areas Regulations 1987 is given in HS(R)27 *A guide to Dangerous Substances in Harbour Areas Regulations 1987*;

(c) Also relevant is the Approved Code of Practice *Dangerous substances in harbour areas.*