Casualty Investigation Report CA 91

Loss of the Isle of Man registered Ship

Jökulfell

On 7th February 2005

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Summary

1. During the morning of Saturday 5th February 2005 the cargo vessel Jökulfell departed from Copenhagen bound for the port of Reydarfjørdy in Iceland. The visibility was good; the wind was from the west at Force 3 to 4 and the sea state was slight.

2. Two days earlier on the 3rd February in the port of Leipaya in Latvia the vessel had loaded a cargo of steel reinforcing bars, construction material, and several containers. She carried a full set of valid certificates for an international voyage and she was manned, in accordance with her Safe Manning Certificate, by a crew of 11 officers and ratings all holding valid STCW certificates.

3. Noon reports were sent daily from the ship to advise the company and the charterers of the vessel's progress, fuel consumption, weather conditions and estimated time of arrival.

4. On the 7th February the vessel was to the east of the Faeroe Islands and experiencing strong southerly winds of force 7 to 8 with 4 to 5 metre seas. She was rolling and pitching moderately and at times heavily in response to the sea conditions. During the afternoon of 7th February course was adjusted to a more northerly heading with the aim of reducing the heavy rolling. Arrival in Iceland was expected the following evening.

5. During the voyage the under-deck cargo on board was checked every watch by the on-watch AB, this procedure was increased to twice per watch from the 6th February in view of the deteriorating weather conditions.

6. At approximately 2040 hours (ship's time) on the evening of the 7th February 2005 the vessel experienced a particularly large roll to starboard from which she did not fully recover. She stayed listed about 10 degrees to starboard rolling about that position. Subsequent rolls caused her to list more and more heavily. The general alarm was sounded and crew members donned their immersion suits. Minutes later at 2053 hours as the list increased an MF DSC[1] distress alert was sent from the Jökulfell. This was received by Torshavn Radio in the Faeroe Islands and passed to Faeroes Marine Rescue Co-ordination Centre (MRCC). Aberdeen MRCC in Scotland also picked up the same distress alert from the ship.

[1]MF DSC , Medium Frequency Digital Selective Calling , a method of transmitting a semi automated distress alert on medium frequency using digital techniques that is a part of the Global Maritime Distress and Safety System that the ship was required to be equipped with.

7. The vessel continued to roll heavily about a rapidly increasing list until she reached an angle of about 90 degrees from where she eventually sank. Shortly after the DSC alert was sent the crew tried to abandon ship but were unable to launch any of the survival craft in view of the heavy list. They eventually jumped into the sea in their immersion suits.

8. The distress alert was relayed to the Faeroes Search and Rescue Services and to a Danish Naval vessel the “Vædderen” which was operating in the area. It was also sent to all vessels within the vicinity of the distress.

9. As soon as they thought they were in range of the casualty the crew of the “Vædderen” launched their Lynx rescue helicopter towards the location of the distress. This helicopter located and recovered five survivors from the Jökulfell at about 2344. The bodies of four other crew members were recovered from the sea the next day but two crew members have not been located and are presumed to have gone down with the ship.

10. The Search and Rescue operation continued until 1630 hours on the 8th February.

The Marine Administration would like to acknowledge the considerable assistance and help provided by the Marine Accident Investigation Authorities in Latvia and in Estonia and by the Authorities in the Faeroe Islands. The Marine Administration would also like to acknowledge the assistance provided by Burness Corlett Three Quays in analysing the ship’s stability particulars and motions in a seaway.

This report has been circulated to interested parties and where appropriate their comments have been incorporated.

Extract from The Merchant Shipping (Accident Reporting and Investigation) Regulations 2001

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the cause with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

1. Jökulfell.

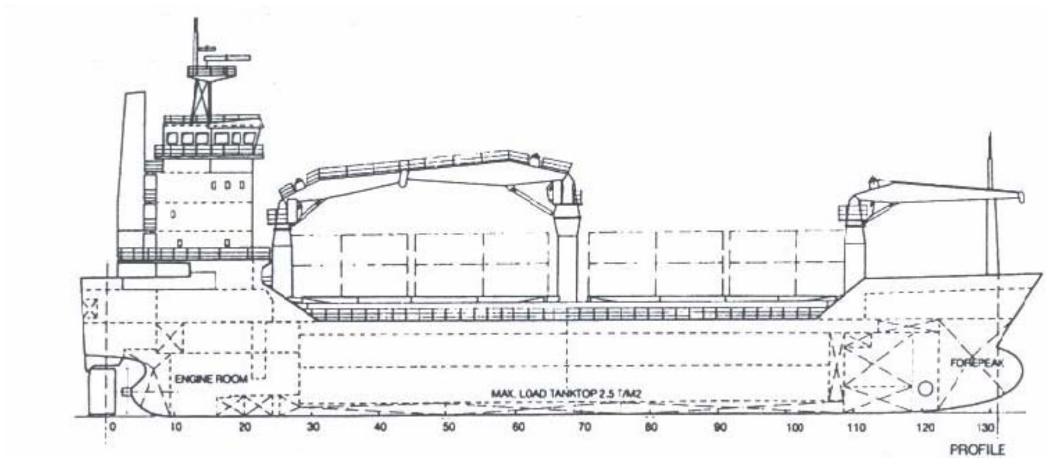
1.1. Jökulfell was a general cargo/reefer vessel built in 1988 and, at the time of her loss, engaged on a regular service between a range of Baltic Sea ports and several ports in Iceland. She was constructed with two cargo holds each with two intermediate decks (t'ween decks).

1.2. She was powered by a single main engine developing 2400 kW driving a single controllable pitch propeller and fitted with a single balanced rudder. For enhanced manoeuvring she was also equipped with a bow thruster.

1.3. Jökulfell was fitted with a GMDSS radio installation and all the deck officers were qualified to operate this equipment. She was manned in accordance with the Minimum Safe Manning Certificate issued by the Isle of Man Marine Administration. All the crew members on board were from Estonia.

The ship's essential particulars were:

Overall Length	:87.05 m
Breadth	:14.50m
Gross Tonnage	:2,469
Service Speed	:14.25 knots
Crew	:11
Main Engine	:MAK Diesel
Date of Build	:1988
Built at	:Frederikshavn, DENMARK
Ship Manager	:TESMA Estonia AS.
Time Charterer	:SAMSKIP, Iceland



Jökulfell

2. Sequence of Events

2.1. All times throughout this report use ship's time which was set to GMT+1 hour. Where other sources were operating on different times, their timing evidence has been converted to ship's time.

2.2. Jökulfell arrived at the port of St. Petersburg in Russia on 28th January 2005 to discharge cargo. At St. Petersburg a crew change took place and a new Chief Officer, Chief Engineer, Second Officer, and two Able Bodied Seamen (ABs) joined the ship to replace crew members going on leave. The newly joining crew were familiar with the Company and with this type of ship having nearly all previously sailed in either Jökulfell or her sister ship. When the cargo was discharged the vessel sailed to Leipaya, in Latvia to load her next cargo.

2.3. She arrived at Leipaya at 0130 hours on Wednesday 2nd February with orders to load a mixed cargo of construction equipment, steel reinforcing bars, and containers for delivery to four ports in Iceland. At Liepaja a further crew change took place with a new Master, Cook and another Able Bodied Seaman joining. The Master was familiar with this class of ships. The total number of Officers and Crew on board was eleven.

2.4. A preliminary cargo plan had been prepared by SAMSKIP, the Company in Iceland that chartered the ship. This was emailed to the ship so that the Master and officers could check the proposed loading for acceptability. The plan was checked as was the ship's calculated stability condition on completion as well as the deck load limits for this heavy cargo. All the factors were determined to be within the ship's design limits. The crew used a computer based spreadsheet incorporating data from the vessel's approved Trim & Stability Manual[2] to make the stability calculations.

[2] Every ship must carry an approved Trim & Stability Manual which contains the ship's essential hydrostatic and other data from which operators can compute the ship's stability at any time. It also contains simplified methods to assess stability.

2.5. The Master and the Chief Officer were satisfied that the proposed loading plan met the requirements for stability and calculated that the Metacentric Height (GM)[3] on sailing would be between 55 and 60 cm.

2.6. Initial cargo operations commenced at berth 46 at about 0200 hours on Wednesday 2nd February with the removal of empty containers on deck in order to give access to the cargo holds. The vessel then moved to berth 78 and at 1100 hours commenced loading 12 metre long bundles of steel reinforcing bars. Each bundle weighed about 2 tonnes and each was secured with metal banding. They were loaded in the fore and aft direction distributed between each space.

In the forward cargo hold (No. 1) on the tank top[4];	355 Tonne.
In No. 1 hold in the first t'ween deck	278 Tonne.
In No. 1 hold in the upper t'ween deck	278 Tonne
In the aft Cargo hold, No. 2, on the tank top,	368 Tonne
In No. 2 hold in the first t'ween deck	235 Tonne
In No. 2 hold in the upper t'ween deck	280 Tonne.

2.7. In total 1796 tonnes of bundled steel reinforcing rods were loaded.

2.8. The bundles of reinforcing rods were stowed fore and aft to distribute the load evenly over the deck supporting structure. They were stowed on wooden dunnage[5] placed transversely on the decks to provide protection and a friction material. Each stow of rods was between two and three bundles high in the t'ween decks and three high on the tank tops making the stow about 80 centimetres high for the tank top stows when loaded.

2.9. After loading each compartment, the reinforcing bars were secured by using 8 centimetre wide webbing straps stretched tightly across the stow. Three straps were used on each stow of the steel bars, spaced evenly over the cargo and anchored at each side of the hold to an individual securing point.

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[3] Metacentric height (referred to as GM) is a measure of stability determined as the vertical distance between the vessel's centre of gravity (G) and a position on the centreline called the metacentre (M) which is where a vertical line from the centre of buoyancy at small angles of inclination meets the ship's centreline. When M is above G a vessel is said to have positive stability, when M is below G a vessel has negative stability and will capsize. A minimum value of GM is required by International rules. $GM_{(fluid)}$ is a value of GM that is corrected for the apparent effect of free movement of liquids in tanks. This effect reduces effective GM so that $GM_{(fluid)}$ is a lower value.

[4] The "tank top refers to the lowest deck of each cargo hold. Below this is only a double bottom space utilised for water ballast.

[5] Dunnage - disposable pieces of wood used to protect the deck, provide a friction element between deck and cargo and to allow for stevedores to pass slings under the bundles at the discharge port.

2.10. A fitted ratchet device was used on each set of straps to tighten them and these ratchets remained attached so that the crew could use them at any time to take up any slack in the lashings. The lashing straps were supplied new by a local supplier on the instructions of the charterer.

2.11. The securing of the reinforcing bar cargo was done jointly by the local stevedoring company and by the ship's crew.

2.12. Loading of the reinforcing bars was completed at 1100 on Thursday 3rd February after which the ship moved to berth 46 to load various items of construction material including some large pieces of fabricated structure.

2.13. Thirty four separate items were loaded in the remaining cargo hold spaces aft of the reinforcing bars including three large pieces of fabricated construction elements which partially overlapped some of the reinforcing bars. These latter items were distributed as;

No. 1 hold, upper deck,	25 Tonne
No. 2 hold, lower deck,	50 Tonne
No. 2 hold upper deck,	29 Tonne.

2.14. The steel building construction cargo was supported in the holds on wooden pallets to keep an even height with the steel reinforcing bars. This allowed their size to be accommodated by stowing part of each piece on top of the reinforcing bars. After loading the construction material it was secured with a combination of chains, webbing straps and wooden wedges by the stevedores and by the ship's crew under the guidance of the Chief Officer.

2.15. After completing and securing the under deck cargo eleven containers were loaded on top of the hatch covers. Six were empties being returned and five were full. These containers were attached to the hatch covers with conventional twist-locks[6]. At 2100 hours loading was completed, the ship's cranes were secured, and the vessel was made ready for departure.

[6] Twistlocks – standard devices used internationally to secure containers in ships. They lock into special fittings welded to the hatch covers and the corners of the containers in turn are held by the twistlock which has a locking mechanism that prevents the container corner posts from being removed until the lock is released.

2.16. Passage planning for the voyage to Reydarfjørdy in Iceland had been completed in accordance with the Company's Safety Management System[7] and agreed and accepted by the Master.

2.17. At some time between 0100 and 0300 hours the vessel departed from berth 46 with a sailing draft of 6.2 metres aft and 5.9 metres forward. She was almost fully loaded with a mean draught of 6.05 metres against her maximum Winter North Atlantic Loadline draught of 6.073 metres and her GM at sailing was calculated by the ship's officers to be 55 centimetres. From Leipaya Jökulfell proceeded to Copenhagen to load some deck and engine room stores.

2.18. Watchkeeping was organised conventionally in a three watch system with the Master keeping the 0800/1200 and 2000/2400 watches; the Second Officer the 0000/0400 and 1200/1600 watches and the Chief Officer the 0400/0800 and 1600/2000 watches. During the hours of darkness an AB was employed as a lookout with each Officer and maintained the same watches. In daylight the watch AB undertook other tasks but could be summoned by the watchkeeper at any time.

2.19. The on-watch AB also checked the cargo holds at regular intervals and tightened any cargo securing straps as necessary; each AB was supplied with a flashlight and a walkie-talkie radio for contacting the bridge watchkeeper when he was off the bridge.

2.20. The Chief Engineer, Second Engineer, Electrician, day work AB and Cook generally worked from 0800 hours to 1700 hours, but were available to be called at any time if they were needed.

2.21. During the Baltic Sea passage to Copenhagen all the crew members were exercised in a Fire and Abandon Ship drill as most of them were newly joined that voyage. This was part of the company's required familiarisation training.

2.22. On Saturday 5th February Jökulfell arrived off Copenhagen at about 0700 hours and loaded the additional deck and engine room stores from a launch using one of her own cranes. She did not anchor in view of the short stay but simply drifted for about 30 minutes while the transfer operation was carried out. On completion she resumed her voyage to Reydarfjørdy.

2.23. Once she cleared the Skagerrak Jökulfell set a course of 309 deg (T) aiming to pass to the north of the Shetland Islands on her way towards Iceland. The weather was fine with a SW Force 3 to 4 wind.

[7] Every ship over 500 tons is required to have in place a Safety Management System in accordance with the International Safety Management Code. The systems are audited, in this case by the flag state, the Isle of Man, and the vessel's system is certificated if it meets the requirements of the Code.

2.24. On Sunday 6th February 2005 the noon report sent to the company states that the vessel's position was 58 deg 34' N / 005 deg 03'E with the wind blowing from the south east at between Force 5 and 6. During the day the duty ABs checked the cargo lashings at least twice per watch during the day. At some point during Sunday the lashings on a deck crane broke free but they were readily re-secured.

2.25. On Monday 7th February 2005 the noon report from Jökulfell indicated that the weather had deteriorated and that the wind was now blowing from the south at about Force 8 with waves and swell running to between 4 and 5 metres. The vessel was rolling and pitching heavily but maintaining her course of 309 deg (T) at about 12 knots. She was approaching a position east of the Faeroe Islands.

2.26. During his watch in the afternoon of Monday, the Second Officer became concerned that the ship was rolling too heavily, reaching about 30 degrees at times. He discussed this with the Master who agreed and at around 1400 they altered course about 20 degrees northwards from 309 deg (T) to 330 deg (T) putting the seas 20 degrees further aft. This had the desired effect and the rolling amplitude reduced.

2.27. A steering gear motor alarm went off during the Second Officer's afternoon watch on Monday and he changed over motors to allow the electrician to investigate the alarm condition. Later the electrician asked the Second Officer to change back to the original motor. No further alarms sounded. The vessel was in auto-pilot and there are no indications that she was experiencing any difficulty in steering. The cause of the alarm remains unknown.

2.28. Lashings on all the cargo were routinely checked and tightened where necessary twice during the 1200/1600 watch on Monday afternoon. The day work AB made an additional check at 1445 before he and the other crew members stopped work for the day. None of the inspections revealed anything untoward.

2.29. At 1600 hours the Second Officer handed over the watch to the Chief Officer. The vessel was still making 12 knots on a course of 330 degrees and in automatic steering The Second Officer and the 1200/1600 AB had dinner and then the Second Officer went to get some rest in his cabin. By this time Jökulfell was again rolling to around 30 degrees.

2.30. Further checks on cargo securing at 1600 and again at 1930 revealed nothing unusual. Between 2015 and 2020 hours on Monday evening the off-watch AB sent an email home before going for dinner. Although the vessel was still rolling heavily, the Cook was still preparing meals and the crew were behaving as normal. The AB fully expected to get dinner.

2.31. At about 2030 Jökulfell started to roll very heavily and an engine room alarm sounded. At this time the Chief Officer, Chief Engineer, Second Engineer, Electrician, and two ABs were in the mess room on "A" deck.

2.32. When the engine alarm sounded the Chief Engineer, Second Engineer and the Electrician went to the engine control room to investigate. The Cook saw them as they passed and asked what was happening before going back to his cabin.

2.33. Just when the three officers arrived in the engine control room Jökulfell took a particularly large roll to starboard. This time she did not return to the fully upright position but adopted a list of about 10 degrees to starboard and continued rolling about that position. She then took another large roll to starboard but this time recovered with a larger list of about 20 degrees.

2.34. The three officers in the engine control room identified the alarm as the high/low lubricating oil alarm for the main engine. Clearly lubricating oil sloshing associated with the ship's rolling had reached a point where the high/low level alarms were being activated. A desk computer and other equipment had fallen to the deck in the control room. The alarm was acknowledged by the Electrician whilst the Second Engineer tried to put the computer back on the desk.

2.35. The Chief Engineer called the bridge using the control room phone but could not hear the response. There is no evidence to explain why he wasn't able to establish clear communication. He told the others that he would go to the bridge to see the Master. The main engine was still running at this time. As the Chief Engineer left the control room the other two officers saw water entering through the exhaust ventilator.

2.36. They left the control room and met the Chief engineer again at the top of the stairs. He asked what had happened and they said that water was coming in to the control room. Both the Electrician and Second Engineer ran to their cabins for their Immersion suits. At this stage the ship clearly had a serious list to starboard and was still rolling heavily. It was apparent to the Electrician and to the Second Engineer that the ship was in serious trouble.

2.37. At about the same time two of the ABs also realised the ship was in trouble and went from the mess room to their cabins to get their Immersion suits. While doing so they saw the on-watch AB coming down from the bridge, he said he was going to check on the cargo. At this time it seems likely that the list was such that the starboard side of B deck (the boat deck) was close to the waterline. The crew were clearly of the view that cargo had shifted.

2.38. The Second Officer who had been asleep in his cabin was woken up by the sound of his computer falling onto the deck. He was immediately concerned about the vessels starboard list which seemed to him to be at about 45 degrees. Outside his cabin he heard from the Chief Officer that the cargo had shifted and at about this time the Master sounded the General Alarm. The Second Officer went back to his cabin to collect his lifejacket and immersion suit then he went with the Chief Officer to the bridge.

2.39. One AB knocked on the day work AB's cabin door and said "the ship is not coming back". He also collected and donned his suit. At this stage it was clear to everyone on board that the ship was in serious trouble and that it would be necessary to think about abandoning her.

2.40. The three ABs then made their way out of the accommodation block through the aft centreline door and headed for the port side boat deck. (B deck). The ship's motions and the increasing list were making movement about the accommodation extremely difficult at this time. The Second Engineer attempted to follow them but somehow became separated. The three ABs reached the port side boat deck and tried to release the liferaft stowed there. Because of the heavy rolling, the weight of the raft, and the large angle of heel they were unable to release it.

2.41. When the Second and Chief Officers reached the bridge Jökulfell was listing heavily to starboard, probably in the region of 45 degrees possibly more. The Master was still on the bridge and the ship's exterior deck lights had been switched on. The Second Officer asked the Master if a DSC distress alert had been sent, but received no reply, so he activated the alert himself. This alert was received by Torshavn Radio amongst others and timed at 2053. It is estimated that this was no more than about 5 minutes after the initial heavy roll to starboard. After activating the alert, the Second Officer picked up one of the ship's GMDSS walkie-talkie sets and he and the Chief Officer exited through the port side door. They planned to make their way down to the liferaft stowage position on the boat deck below.

2.42. The Master stayed in the bridge attempting to train the ship's lights into positions that would assist the crew.

2.43. The Second Engineer, having become separated from the three ABs was on the open deck at the aft end of the accommodation on B deck. He was having problems fully securing the zip on his immersion suit but eventually succeeded in securing it. It was becoming extremely difficult to move about and he slipped and fell down towards the starboard side. He attempted to grab a ladder to hold on to in order to avoid being washed away and while in this position, on the starboard side, he was able to see forwards.

2.44. He noted that the ship's lights were still on and he saw a container being washed off the hatch cover. He became concerned that, positioned as he was on the starboard side and unable to climb back up, he might become trapped if the ship capsized on top of him and so he jumped into the sea where the waves carried him away from the ship's starboard side.

2.45. At about the same time the Chief and Second Officers were climbing down towards the boat deck from the port bridge door. With the ship listing heavily to somewhere in the region of 45 degrees or more and still rolling heavily this was an extremely difficult exercise. In making the journey the Chief Officer slipped and fell. He was seen to hit the railings below and not move. The Second Officer called to him but received no response. He continued on his way down to the boat deck and when he reached it he found three ABs sitting on the outboard side of the railings. He used all his strength to pull himself up to where he could join them.

2.46. The four men linked themselves together in their immersion suits but were afraid to jump into the water as they believed the propeller was still turning. However shortly afterwards the lights went out and they concluded that all the engines had stopped.

2.47. They jumped into the water and tried to get away from the ship but the waves and the high wind made this extremely difficult. They were initially submerged when they jumped in and returned to the surface exhausted from where they saw the vessel still afloat but at an angle of close to 90 degrees. It is estimated that this was between 2100 and 2110, (about 10 or 12 minutes after the initiating event).

2.48. The four men eventually drifted away aft of the ship which was now in complete darkness. While underwater the Second Officer had lost his hold on the GMDSS portable radio.

2.49. As they drifted they encountered a lifebuoy, with an attached light, which was on, and which they were able to grab and hold on to. They also saw an inflated liferaft near the ship but they were afraid to try and swim that close to the ship to reach it.

2.50. At approximately 2330 (about 2½ hours after entering the sea), the four men in the water first heard and then saw a helicopter and tried to attract its attention by waving and shining the light from the lifebuoy in its direction. They were seen and shortly afterwards they were picked up.

2.51. **The Search and Rescue element.**

2.52. At 2053 hours Torshavn Radio, in the Faeroe Islands, received an MF DSC distress alert from Jökulfell originating in position Latitude 63 degrees north, Longitude 004 degrees 56 minutes west. They passed the message to Torshavn MRCC[8] and at 2057, the Faeroese guardship "Brimil" which was at sea in the area was asked to assist by the MRCC. The MRCC also tried calling Jökulfell by radio but received no response.

2.53. At 2106 a Faeroese rescue helicopter based at Vagar was asked about their current weather for flying and requested to stand by until the MRCC knew more. At this stage they knew only that an MF DSC alert had been received; there was no EPIRB transmission and no contact with the ship.

2.54. At 2117 the pilot of the helicopter called back to say that the weather was windy but good enough for them to fly. He said that they were ready but that the helicopter was still in the hangar. He considered himself to be "on stand by". A few minutes later another Faeroese guardship, the "Tjaldriđ" was also informed of the distress situation and asked to stand by to assist. Torshavn MRCC also attempted to contact Jökulfell directly by telephone but without success. However they did make contact with the charterers in Iceland and confirmed the vessel's identity and that she was expected to be in the Faeroes area that evening and due in Iceland on the evening of the 8th (the next day).

2.55. At 2130 hours "Brimil" informed the Royal Danish Navy patrol vessel "Vædderen" with which she was exercising and which was also at sea in the area that she was engaged in a search and rescue mission based on a DSC alert containing the name and position of Jökulfell. During this period VHF Channel 16 reception from the remote antenna at Fugløy was blocked due to some interference. The interference cleared at 2131. This antenna is positioned on the north east point of the Faeroe Islands, the point closest to the Jökulfell's position.

2.56. A few minutes later "Vædderen" received a general mayday relay message from MRCC Torshavn and set course towards the distress position at her maximum speed of 20 knots. At 2138 MRCC Torshavn reached a decision that the best option for rescue was the helicopter aboard "Vædderen" rather than the land based helicopter and so at 2150 the "Vædderen" was officially requested to participate via her command authorities at Island Command Faeroes (ISCOMFAROES).

[8] MRCC – Marine Rescue Co-ordination Centre, the body responsible for managing and co-ordination search and rescue assets in the event of any marine casualty in it's area of operations.

2.57. By 2142, 49 minutes after the initial distress alert, four vessels were proceeding to the search area, either directed by MRCC Torshavn or in response to the Mayday Relay message;

"Brimil" a Faeroese guardship with an estimated time of arrival of 2345;

"Tjaldrið " another Faeroese guardship with an estimated time of arrival of 0300;

"Viktor Mirinov", a Russian Fishing vessel with an estimated time of arrival of 2330, and

"Vædderen", a Danish Navy patrol vessel with an estimated time of arrival of 2340.

2.58. Jökulfell's Emergency Position Indicating Radio Beacon (EPIRB) had automatically begun transmitting at about this time and its signal was intercepted by MRCC Falmouth in the UK amongst others. This information was passed to MRCC Torshavn who received it at 2208, 1 hour and 15 minutes after the initial DSC alert.

2.59. At 2304 hours Vædderen launched her Lynx helicopter with a crew of four. As the helicopter approached the distress position they spotted a number of weak lights in the water. They also saw a liferaft and a person floating face down in the water. They dropped their rescue raft into the area.

2.60. From their height of 10 to 15 metres above the sea the helicopter crew, using their night vision binoculars, were able to see part of Jökulfell lying on her side. They estimated sea and swell conditions to be about 6 metres with winds of 45 to 50 knots (Force 9).

2.61. Shortly before 2333 the helicopter crew spotted the second officer and the three ABs and began a rescue operation. Each man in turn was successfully winched up to the helicopter with the assistance of the rescue diver.

2.62. The shore based helicopter took off at 2339 and set off for the area with an estimated time of arrival of 0024.

2.63. Having rescued the second officer and the three ABs the Vædderen's helicopter continued searching and located the Second Engineer who was lifted aboard at 0004 before the helicopter made a final fast search of the area and turned back for the Vædderen to conserve fuel and on the understanding that the shore based helicopter was en route to search further.

2.64. Vædderen's helicopter arrived back on board in conditions which were at the limit for safe operations.

2.65. At 0005 "Brimil" arrived on scene and reported several floating containers and a number of flashing lights in the sea. Over the next few hours the attending vessels and the Faeroese helicopter maintained an organised search of the area with Vædderen acting as on-scene commander. During the search a number of floating containers were spotted as well as several liferafts. Each raft was checked but they were all empty. In the early hours "Brimil" recovered the body of the Master and "Tjaldrið" recovered the bodies of the Chief Officer, the Electrician, and the Cook.

2.66. At 1630 in the afternoon of Tuesday 8th the search and rescue mission was abandoned and the participating vessels resumed their previous tasks. Vædderen arrived in Torshavn on Wednesday 9th with five survivors who all received medical attention ashore and were released from hospital the same day.

3. Comment and Analysis

3.1. In reviewing the sequence of events as it has been reconstructed from survivor recollections and direct evidence of the loading operation it is clear that several key questions need to be answered in order to understand this casualty. In particular it is essential to examine:

- What caused the heavy roll to starboard from which the vessel never recovered?
- Was there anything wrong with the cargo stowage arrangements?
- Was the management of the ship in heavy weather appropriate?
- Did the ship's emergency equipment fulfil its function?
- Was the Search and Rescue operation as effective as it could have been?

3.2. **What caused the vessel's heavy roll to starboard from which she never recovered?**

3.3. It has been possible to determine with some accuracy the ship's load and stability condition at departure from the final load port. Some assumptions have still been necessary including the assumption that fresh water tanks were full and the distribution of fuel oil in tanks. The assumptions are all, however, reasonable. The calculations have also used the true vertical centre of gravity height for the reinforcing bars as 0.4 metres above the t'ween decks and tank top based on an average actual height of each stow of 0.8 metres.

3.4. This calculated departure condition produces draughts of 6.23 metres aft and 5.93 metres forward which match the survivor's recollections very closely and validate the reconstruction.

3.5. The calculated departure condition gives:

Deadweight, (the total weight of cargo aboard),	3027 T
Displacement, (the total weight of ship and cargo),	4896.4 T
$GM_{(fluid)}$	1.072m
Draught Aft:	6.23m
Draught Forward	5.90m
Mean draught amidships.	6.06m

3.6. Allowing for fuel and water consumption between departure and the time of loss the calculated condition at loss is:

$GM_{(fluid)}$	1.067m
Draught Aft.	6.28
Draught Forward	5.80m
Mean draught amidships.	6.04m.

3.7. These figures for GM differ from the ship's calculation but by working the same computation with the centre of gravity of each stow of reinforcing bars taken as being at the half height for the space in question a result for $GM_{(fluid)}$ of 0.559 metres emerges. This is remarkably close to the figure from the survivors and it is concluded that the ship's crew did indeed use the half height figures for the centre of gravity for each cargo space from the stability manual to calculate their GM. Their spreadsheet was probably programmed with the half height figures as a default value.

3.8. The result of using the half height figures is an underestimation of GM which has the effect of creating a large safety margin in overall stability. However, it also creates a situation where the vessel actually has a higher GM than the one calculated which in turn means that the ship is more "stiff" than expected. In other words the vessel is more inclined to roll quickly and return to upright faster than might be anticipated with a lower GM figure. In general a lower GM will produce a dynamic condition in which the ship is described as "tender" and inclined to roll more slowly. A "stiff" ship due to a higher GM rolls more quickly and also tends to place more strain on cargo securing arrangements as a consequence of the faster roll period and more abrupt response.

3.9. A vessel's natural period of roll, the number of seconds that she will normally take to complete a roll when disturbed, varies with GM. A small GM produces a longer roll period; a higher GM produces a shorter roll period.

3.10. It is possible to compute the vessel's full range of stability from the data available and when this is done it can be seen that Jökulfell complied with all minimum international requirements in all respects;

Criteria	Minimum required	Jökulfell Actual	Complies
Area under GZ curve to 30 deg	0.055 m.rads	0.143 m.rads	**Yes**
Area under GZ curve to angle of downflooding	0.090 m.rads	0.237 m.rads	**Yes**
Area under GZ curve from 30 degrees angle of downflooding	0.030 m.rads	0.094 m.rads	**Yes**
Angle for Maximum GZ	>25 degrees	44.56 degrees	**Yes**
Maximum GZ	0.20 m	0.66 m	**Yes**
Initial GM (fluid)	0.150 m	1.067 m	**Yes**

3.11. It is therefore concluded that Jökulfell had adequate stability at the time of her loss and exceeded all the minimum international parameters for stability that were applicable to her.

3.12. Clearly from the evidence she experienced an exceptional roll to starboard. There are two possible explanations. Either she broached in the following seas or she entered a situation of synchronicity with the waves resulting in a very large and unexpected roll.

3.13. There is no evidence from survivors to suggest a broach, which is the situation that occurs when a vessel is overtaken by a large wave and in accelerating down the wave front, loses steering effect, and turns across the wave leading to a large roll angle. All through the day Jökulfell was rolling heavily but the crew were unconcerned about her.

3.14. While they found the motion tiring, none expressed any sense of concern. The cook was still preparing meals and officers and ratings were taking their dinners in the mess room. For the vessel to have been in danger of broaching it is considered that there would have been a heightened sense of danger on board, certainly a perception from the watchkeeping officers that the vessel was "on the brink". There was no sense of this and she remained in auto steering using a single steering motor and with no reported signs that she was not steering effectively. It is concluded that Jökulfell did not broach.

3.15. This investigation has instead concentrated on the possibility of synchronous rolling as an underlying cause of the initial large roll.

3.16. Synchronous rolling is a condition associated with conditions where wave excitation that causes rolling matches the vessel's natural roll period promoting large and often unexpected roll angles as the two periods act in resonance. Matched with the effect of varying righting moment as the waterplane area changes in waves there is the potential for very large roll angles.

3.17. A comprehensive analysis of the ship's loading, her hull form and the prevailing sea conditions reveals a number of important factors;

- The hull design is such that stability is greatly affected by the aft draught. Because of the shape of the aft part of the hull there is a large loss of waterplane area[9] whenever the ship pitches by the head. Overall stability is fundamentally dependent on waterplane area as a key factor. The effect of this is to introduce large cyclical variations in righting moment[10] as the ship pitches in a seaway and the broad flat stern sections are alternately submerged and lifted.

- It is almost certainly the case that the spreadsheet used for stability calculations contained only the default centre of gravity positions for each cargo space. These are the half height positions which are entirely correct for homogeneous cargoes but they will invariably give an artificially higher centre of gravity position for cargoes such as reinforcing bar which only occupy a fraction of the space's height.

- While there is no mention in the ship's trim and stability book of downflooding angles[11] the analysis shows that flooding through the engine control room vent will occur at 39.2 degrees. This equates very closely with the observed events on board. While they were in the control room at about the time that the large rolls occurred the Second Engineer and the Electrician saw water coming in through the vent. There is no mention of water in the control room when the three men first went in.

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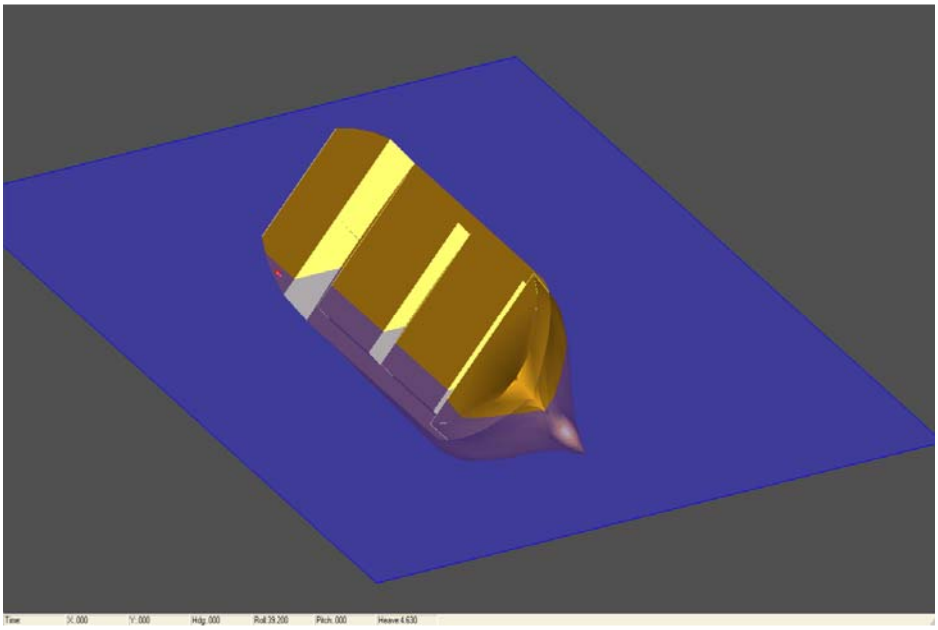
[9] Waterplane area is the area of the water surface in square metres occupied by the shape of the hull. Thus a rectangular barge has a waterplane area that is rectangular and equal to breadth times length. A ship with a long overhanging stern has a ship shaped waterplane area which can be greatly increased if the stern is depressed to bring the overhang into the water line.

[10] Righting Moment is the restoring force that brings a ship back to upright when she is inclined by an external force.

[11] Downflooding angle is the angle of heel at which, for the fully loaded ship, water can penetrate into the ship; it is a limiting factor on the minimum international stability requirements.



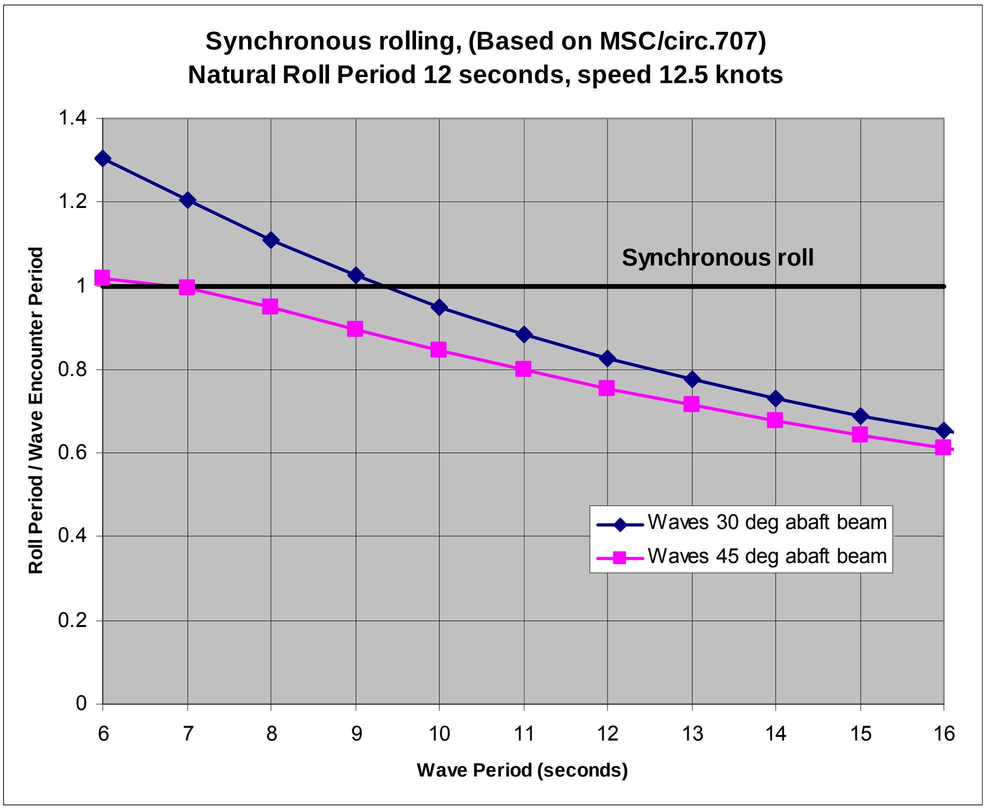
Computer simulation of Jökulfell at 39 degrees – engine room vent in waterline, viewed from ahead

- Waves with a period of about 10 seconds approaching from a position 30 degrees abaft the beam at a ship speed of 12.5 knots have the capacity to induce synchronous rolling for this ship in her condition at loss[12]. The condition could be worsened generating even larger occasional rolls if the pitching movement also introduces a coincident cyclical change in righting moment due to large waterplane area changes.

- With a GM of 0.5 metres the natural roll period for Jökulfell in her condition at loss is increased to the point that synchronous rolling is largely avoided.

3.18. It is clear that Jökulfell was rolling heavily at mid afternoon when the Second Officer and the Master altered course northwards. The course alteration had the effect of placing the waves further abaft the beam and immediately had the effect of reducing the roll amplitude. This matches the theoretical calculation that suggests the most sensitive angle for waves to induce large roll amplitudes in Jökulfell due to synchronous rolling is 30 degrees abaft the beam, with sensitivity reducing if the wave angle is changed to approach from further aft.

[12] According to IMO. Maritime Safety Committee Circular 707.

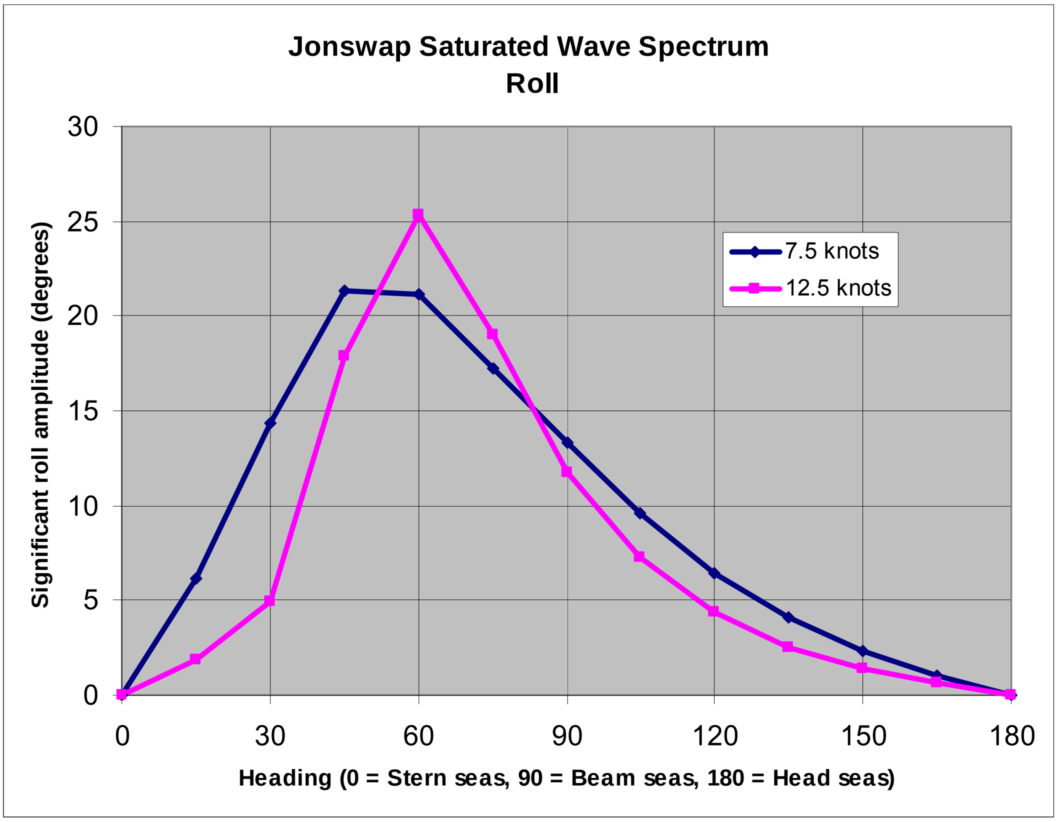


3.19. There is insufficient data available to deduce with certainty what, if any, changes in weather took place between the 1400 hours alteration of course and the time of loss. Clearly from the data in the noon report and the evidence of the rescue authorities the wind increased over the time. The surface analysis charts of the area for the time in question show a very deep depression forming to the west of Iceland at 0000 GMT on Monday 7th. The central pressure is shown as 954 mb and there was an occluded front trailing southward over the west of Iceland. Ahead of the front the wind was southerly or south-south westerly shifting rapidly towards the west at the front itself. The charts suggest this front would have passed over the position of Jökulfell sometime on Monday evening.

3.20. Certainly the reports from shore stations in Faeroes of clearing weather as the search and rescue effort continued are indicative of the passage of a front shortly before. The wind shift towards the west would have had the effect of restoring the relative direction of the waves for Jökulfell back to a position closer to 30 degrees aft of the beam from their earlier position more nearly astern.

3.21. The various analyses of ship motions in the estimated sea conditions show clearly that:

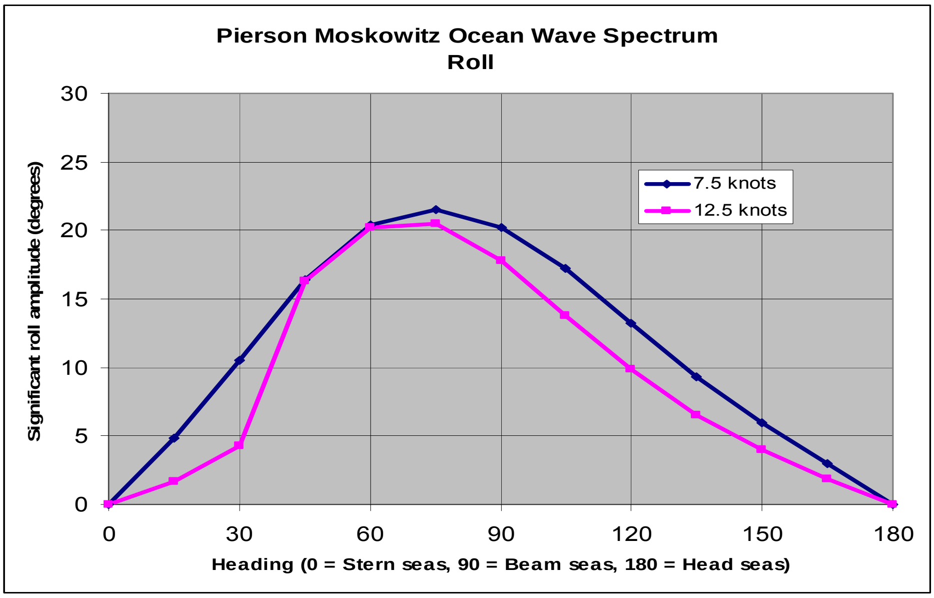
- Assuming a typical saturated wave spectrum[13] and a ship speed of 12.5 knots the graph of roll amplitude against heading (referenced to the wave direction) shows a dramatic significant roll amplitude peak of 25 degrees at a heading that puts the waves 30 degrees abaft the ship's beam (60 degrees from directly astern). A change of 15 degrees in relative heading has the effect of reducing the peak roll amplitudes by 7½ degrees. A change in heading of 30 degrees reduces the peak amplitudes by half or more.



- Assuming, by comparison, a typical Ocean Wave spectrum[14] a similar graph shows significant peak roll amplitude of 22 degrees occurring at an angle of 45 degrees abaft the beam. (see over).

[13] Jonswap with significant wave height 5.5 metres, period 9.6 seconds, Peak enhancement gamma 3.3 (standard). This is a commonly used theoretical model for wind generated waves and known to produce consistent results.

[14] Pierson Moskowitz Ocean Wave Spectrum.



3.22. It is assumed that the waves at the time were a mixture of wind generated waves and swell waves and without more accurate sea state data it is impossible to describe the actual spectra with accuracy. However the wind was increasing during the afternoon and it is clear that whatever the total spectrum, the wind generated waves would have been starting to predominate.

3.23. In studying the theoretical ship motions, the maximum likely single roll amplitude is normally taken to be 1.86 times the significant value. This, for wind waves, would give a theoretical maximum roll of 40 degrees for Jökulfell in the condition she was in at the time of her loss. This equates closely with the evidence. If an increase in this occurred due to cyclical changes in righting lever associated with waterplane area changes it is possible that occasional rolls to 50 degrees could happen. It is known that water entered the control room via the ventilator. Those in the control room did not feel that it was pouring in as might be expected were the vent submerged but clearly water was reaching the vent which strongly supports a conclusion that the ship rolled to 40 degrees or more during the initial event.

3.24. An analysis of the effects of ship speed has also been completed. A small reduction in the theoretical maximum roll amplitude is evident if speed is reduced. There is a larger effect if course is changed to either put the waves more astern or more ahead.

3.25. It is therefore, concluded that Jökulfell encountered conditions that, in combination with her course and speed and her stability, led to a phenomenon known as synchronous rolling where the wave encounter period excites the ship's natural roll period to produce extremely large roll angles. She suffered at least one extremely large roll which caused some of the cargo to shift.

3.26. It is of note that the ship's calculation of $GM_{(fluid)}$ gave a result of 0.55 metres and that, if this had been the actual $GM_{(fluid)}$, the ship would have been less susceptible to synchronous rolling in the conditions she encountered. The Master was experienced and the dangers of synchronous rolling have been known to seafarers for a long time. All masters will be aware to some degree of the relationship between the ship's natural roll period, her GM and the wave period. While it cannot now be established, it remains reasonable to conclude that an experienced Master, such as the Master of Jökulfell, would have considered that a $GM_{(fluid)}$ of about half a metre would make his ship tender enough to avoid much of the risk of approaching synchronicity in sea waves. Whether he would also have appreciated that the higher GM of over 1 metre would risk such an event must remain conjecture.

3.27. However because the ship's calculation used the half heights (as for a homogeneous cargo), as the height of the centre of gravity of each cargo parcel (which was the correct approach for the construction cargo), the ship's crew underestimated stability by a considerable margin. Normally this would serve only to give an enhanced safety margin. In this case it is possible that it led the Master into assuming that his $GM_{(fluid)}$ of about half a metre was suitable in the prevailing conditions. Such a value would have been suitable; the theoretical analysis shows that, although Jökulfell could not actually have achieved a $GM_{(fluid)}$ of 0.55 m with this cargo, such a value would have largely avoided the synchronicity risk.

3.28. The stowage of cargo

3.29. The cargo plan for this voyage had been prepared by SAMSKIP, the vessel's charterers; this plan was e-mailed to the ship for checking and verification of stability. The planning of the cargo was then checked and agreed by the master and chief officer and advised to the stevedores before loading commenced. The subsequent analysis of the ship's loading condition verifies that she was loaded in a manner that met all international requirements for stability and also met the ship's own structural limitations.

3.30. There is no evidence to suggest that the containers stowed on top of the hatch covers moved before the ship was at the point of capsize. Indeed had any of them fallen into the sea as a result of that first roll to starboard it would probably have been those on the starboard side and it would be expected that the final list would then be to port rather than to starboard as it was. Loss of containers is discounted as a causal factor.

3.31. The large pieces of construction cargo were large fabrications secured in the t'ween decks with various lashings. All of them were large pieces of construction and none were unduly heavy.

3.32. The heeling moment to produce a list of 10 degrees in this ship with a GM $_{(fluid)}$ of 1.07 metres can be calculated from:

$$\text{Heeling moment} = \Delta \times GM_{(fluid)} \times \tan \Theta$$

where Δ is Displacement, and
Θ is the angle of list.

3.33. This formula gives a required heeling moment of 863 tonne metres to produce a 10 degree list. The largest piece of the construction equipment weighed 50 tonnes and hence to produce a list of 10 degrees it would have to be shifted 17 metres sideways. This is clearly not possible. Even if all these items are shifted it remains impossible to create the observed 10 degree initial list. It is therefore concluded that any cargo shift must have involved the bundles of reinforcing bars. Only 123 tonnes of these would have to be shifted through half the breadth of a cargo hold, that is, less than 7 metres, to produce a 10 degree list. Each bundle weighed approximately 2 tonnes and hence a shift of about 60 bundles from one side of a stow to the other could easily produce a 10 degree list.

3.34. Jökulfell's cargo of 1796.22 metric tonnes of steel reinforcing bars were loaded in a forward to aft direction on all three levels in each hold. The cargo plan illustrates this as well as the distribution of the other cargo.

M.V. JOKULFELL **CARGOPLAN** Voyage No. 2

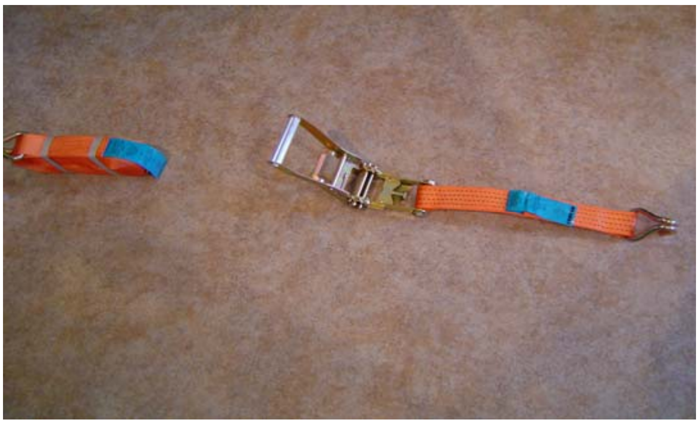
PORT OF LOADING: Liepaja 02.02.05 - 03.02.05. PORT OF DISCHARGING: Reydarfjordur, Njardvik, Grundartangi, Reikjavik

	Hold No. 2		Hold No. 1	
A	Constructions, building materials etc. - 29mt REIKJAVIK	LOT 1 12mm - 12m 26bdl.- 51,809 t 20mm - 12m 115bdl.- 228,375 t REYDARFRJORDUR - 280,184 t	Constructions - 25mt REIKJAVIK	LOT 1 20mm - 12m 70bdl.- 139,013 t 16mm - 12m 70bdl.- 139,356 t REYDARFRJORDUR - 278,369 t
B	Constructions, timber, building materials etc. REIKJAVIK - 50mt	LOT 2 12mm - 12m 60bdl.- 119,560 t NJARDVIK LOT 3 12mm - 12m 58bdl.- 115,574 t GRUNDARTANGI	LOT 1 16mm - 12m 140bdl.- 278,712 t REYDARFJORDUR - 278,712 t	
C	LOT 3 12mm - 12m 28bdl.- 55,796 t 20mm - 12m 13bdl.- 25,816 t 10mm - 12m 13bdl.- 25,988 t 25mm - 12m 5bdl.- 9,933 t 16mm - 12m 126bdl.- 250,841 t GRUNDARTANGI - 368,374 t		LOT 2 20mm - 12m 8bdl.- 15,887 t 10mm - 12m 136bdl.- 271,875 t 16mm - 12m 34bdl.- 67,687 t GRUNDARTANGI - 355,449 t	

CARGO:

Hold No.1 - 458 bdl.steel rebars bundles	:	912,53 t
Hold No.2 - 444 bdl.steel rebars bundles	:	883,692t
		1796,222 t
Hold No. 1 A ,1B, 2A - constr., build. materials, timber etc.	:	104t
Deck cargo	:	113,5t
GRAND TOTAL - Hold No.1, Hold No.2 and deck cargo	:	2013,72mt

3.35. The vessel was provided with webbing straps to secure the steel bars in each space. The lashings had a safe working load of between 4 and 8 tonnes. Other lashing equipment was provided for other cargo to be loaded, but these webbing straps alone were used for the reinforcing bars.



Ratchet tightened webbing lashing of the type used to secure the reinforcing bars cargo.

Actual stow of reinforcing bars in either No.1 or No.2 Upper T'ween Deck aboard Jökulfell before departure and before loading the construction cargo. One of the sets of webbing lashings is clearly visible.

3.36. The steel reinforcing bars were shipped in bundles held together by steel strapping. Because of their high density they only occupy a small part of the available cargo space before the limits of deck loading and ship's capacity are reached. The German Insurance Industry's web site says of the carriage of steel cargoes including steel reinforcing bars;

.".. stow and secure in such a way that no excessive loads are applied to the hull or other parts of the vessel.

Where possible, friction-enhancing materials should be laid beneath the cargo and between layers.

Fill in any gaps between individual items of cargo.

Protect cargo from chafing, scratching and similar mechanical damage>

Protect cargo from harm caused by lashings and other securing materials>

Heavy goods in particular, such as steel products, should where possible be stowed without gaps in a level layer from ship's side to ship's side"

3.37. In the case of Jökulfell the reinforcing bars were stowed such as to avoid excessive loads, with friction enhancing materials, (the dunnage), without gaps (the bundles tended to mesh quite tightly together and the regular tightening of lashings assisted in this). They were protected from chafing etc, by the dunnage, protected from harm by using webbing lashings, and stowed without gaps in a level layer from ship's side to ship's side.

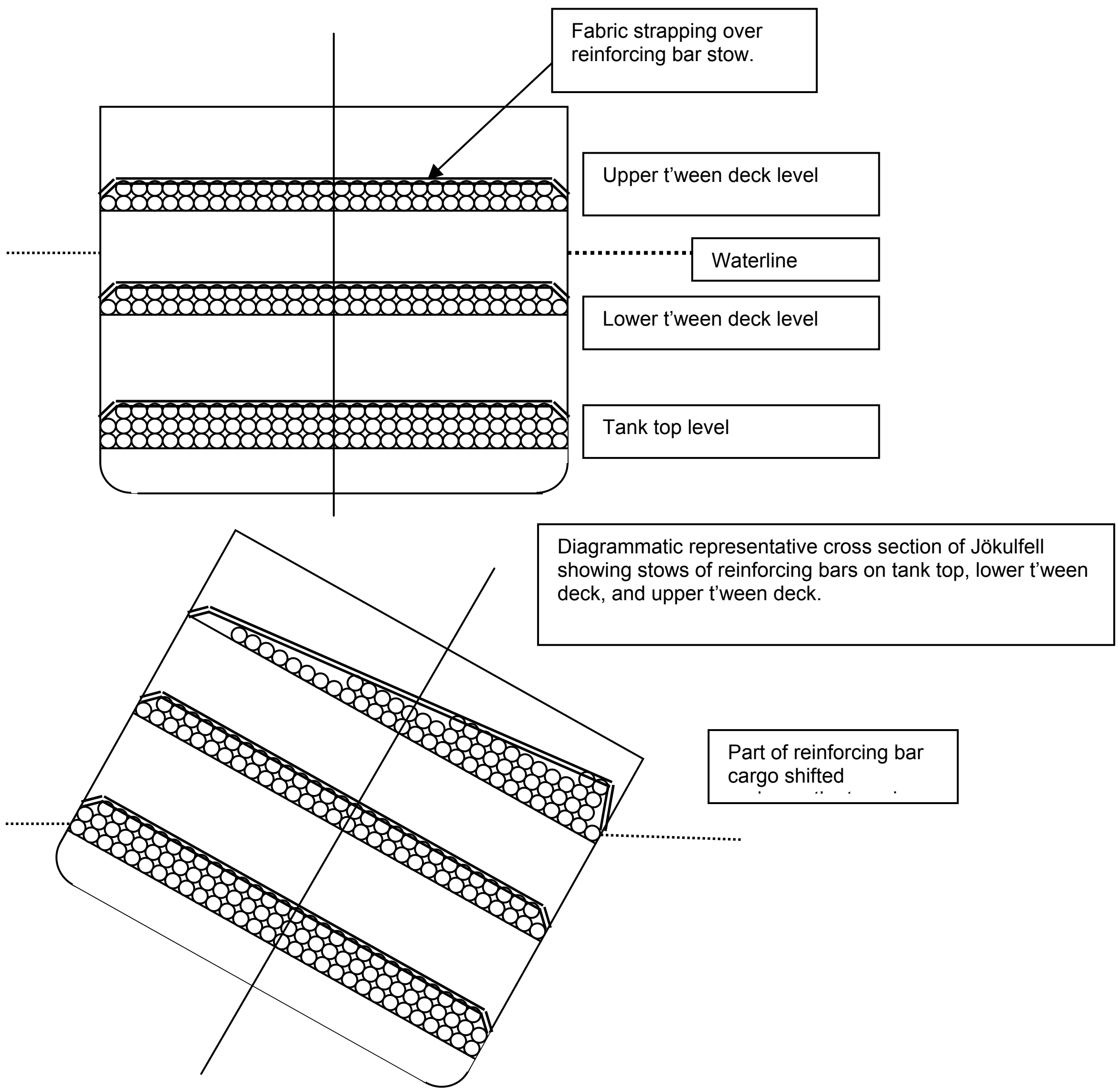
Part of Jökulfell's cargo of reinforcing bars on the quayside ready for loading.

3.38. The picture above shows a part of the cargo of reinforcing bars for Jökulfell stacked on the quayside ready for loading. It is notable that the "block" of bundles has a very steep vertical face with no lashing or support. This clearly indicates that this cargo is not easily moved. It has a strong tendency to stay locked in place. This does not remove the need for proper securing but when these bundles are stowed two or three high fully across the width of the space and against both sides it is the case that the space has to be tilted to a considerable angle to induce movement. It is also obvious, however, that once in motion; a large number of bundles will readily roll over each other.

3.39. The lashings were made across the full width of each stow. The ship's Cargo Securing Manual contains instructions, in accordance with the IMO requirements, on the securing of cargoes. On cargoes such as reinforcing bars, although they are not specifically mentioned, the manual recommends that wire lashing should be used. In this case the ship clearly used the webbing strapping provided by the charterers and not wire as recommended in the manual. The webbing strapping, however, has a breaking strain close to, or greater than, the breaking strain of the type of wire that would typically have been used for lashing. The strapping has the added characteristic of being easily tensioned and of not risking any steel to steel damage to the bars. However the webbing straps do have a tendency to stretch more than equivalent wire rope and in a long span provide less "downforce" as a result.

3.40. The characteristic of the webbing straps to elongate under load means that they can provide even less downforce in the centre of the span than might be provided by a wire lashing. Research through expert sources suggests that webbing lashings are not recommended for this cargo. While even a wire lashing will stretch to a degree in a long span it will do so less than the webbing straps and it is concluded that the webbing lashings were not in accordance with good practice for securing this cargo.

3.41. Of greater importance is the manner in which the stows of reinforcing bars were secured rather than the material used. A simple “across the deck” lashing as was used, can clearly be seen from the photograph on page 27 to provide virtually no downward force whatsoever on the centre part of the stow. The effect if the ship is heeled enough to start any bundles moving is to stress the centre of the lashing span, lifting it and allowing bundles to roll underneath the lashing and move to the low side.



Part of the Construction cargo being loaded in one of the Upper T'ween decks. Note the supporting pallets and the fact that the construction cargo is stowed over the top of the reinforcing bars stow on this deck as well as the number of lashings in place.

3.42. Some parts of the reinforcing bar stows were "overstowed" by the large pieces of construction equipment. These were placed on wooden pallets to raise them in areas where there were no reinforcing bars and allow them to be positioned in part on top of the bars. There were not enough items of construction cargo to place elements over the top of all the reinforcing bar stows. The photograph above shows a part of one of the construction items being positioned and it is clearly seen to have one end resting on top of the stow of reinforcing bars at one side.

3.43. It is extremely difficult to establish ways in which the lashing of a cargo such as reinforcing bars can be successfully achieved while meeting the other requirements for its stowage and it is also true that the cargo in Jökulfell remained firmly in place through two days of heavy rolling. Only a very large roll is likely to cause a shift, but the density of the cargo is such that a shift is also likely to have catastrophic consequences.

3.44. It is also true that with an overall lashing such as the one that was used, any shift that does occur will be uncontrolled and with the potential for a considerable weight to move through something like half the width of the ship.

3.45. Looking at

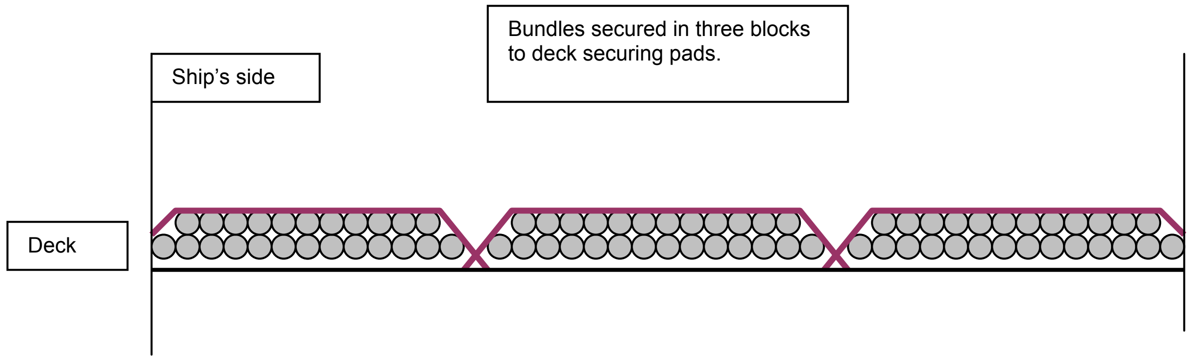
- The sequence of events involving a particularly large roll,
- Followed by a list to about 10 degrees,
- Followed by further rolls and an increasing list,
- A lashing pattern that provided no downwards force on the centre of each stow, and
- The short period of time between the initiating event and the final loss.

It is concluded that the initial large roll to starboard caused bundles of reinforcing bars in at least one of the separate stows of bars to roll under the lashings towards the low side.

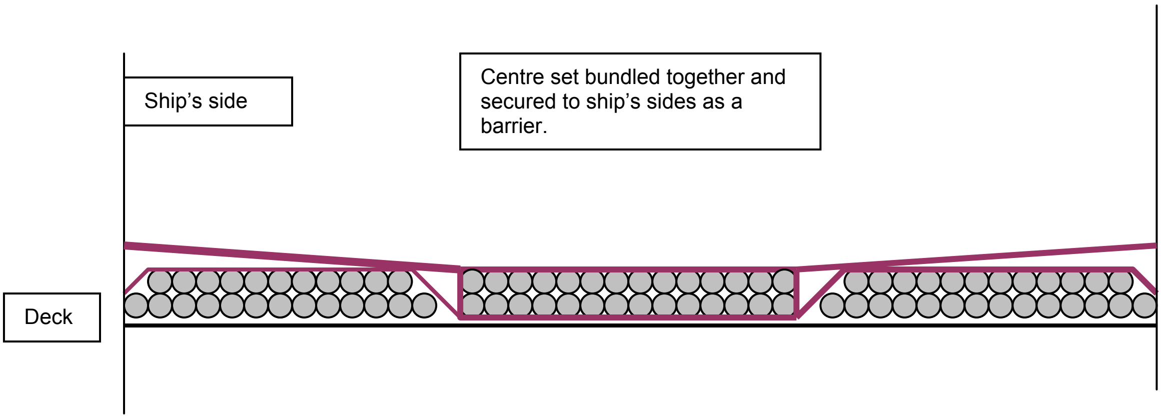
3.46. Once the ship was listed to that side further rolls, which would have been about that listed position, and hence increasingly large gradually caused more and more of the bundles in the original and in other stows to roll to the low side. At some point the total load suspended by the three webbing straps on each stow would have been enough to break the webbing and allow an uncontrolled shift to the low side. The angle of list would have rapidly increased until the ship was almost on her side at which point she would have began taking water through various openings and eventually sink.

3.47. The ship's crew had few options for lashing in terms of what was available to them. The webbing straps were provided by the charterer. Even had they ordered more wire lashings it is hard to define what type of lashings would have performed better. There are, however, some possibilities.

- Each stow of reinforcing bars could have been separated into sections with each section secured to eye pads on the deck. There were suitable eyes as can be seen from the photographs of the construction equipment with its lashings running down to the deck. The maximum movement of any bundles would then have been limited to the width of the section not the width of the hold. This would have required additional lashings and time. It could however have restricted the available movement when the ship rolled and possibly prevented this tragedy.



♦ In a similar arrangement it would have been possible during the loading to bundle a set of bundles on the centreline with straps into a single large bundle and then secure this large bundle separately to the ship's sides effectively creating a barrier on the centreline. With this arrangement any shift would have been limited to less than half the width of the hold. This would have required some additional time and additional lashings. It could have served to limit the amount able to shift in any very large roll and could have prevented this tragedy.



♦ The stows could have been held down from the deck overhead with temporary timber uprights providing a downward force on the stow to assist the support from the transverse lashings. This would, however, have been a very expensive and time consuming option and was probably impractical

♦ The separate stows of reinforcing bars could have been overstowed with other cargo. It is clear that this was planned to a limited degree. The arrangements for supporting some of the construction items so that they could extend over the reinforcing bars make this clear. Other than the construction materials, however on this occasion there was no other cargo that could have been used. The empty containers might have been ideal but there was insufficient height in each deck to place a container on top of the reinforcing bars and still close the hatch cover.

3.48. Overall, it is concluded that the only practical option without overstowing cargo would have been either to secure the reinforcing bars in each stow in blocks with each block secured to the deck individually or with a centreline bundle secured to the ship's sides. It is concluded that, had one of these methods of securing (or something very similar) been adopted instead of the overall lashing approach the likelihood of cargo shift such as occurred would have been avoided.

4. The management of the ship in heavy weather.

4.1. Jökulfell departed from Copenhagen on Saturday 5th February 2005. She was expected in her first Iceland port in the evening of Tuesday 8th February. By the evening of Sunday 6th she was to the east of the Shetland Islands, making good speed and on a direct course for Iceland. The weather was poor but not exceptional and certainly normal for this part of the North Atlantic in winter.

4.2. By Monday afternoon the weather had deteriorated and the ship was rolling very heavily, enough to raise concerns in the mind of the Second Officer. The Master altered course a little northwards which placed the seas further aft and reduced the roll amplitudes. At this point they were a little over 24 hours from their destination.

4.3. From the Master's perspective:

- ♦ The ship was performing well, steering well, and making a good speed.
- ♦ The rolling was heavy but so far there had been no effect on the cargo.
- ♦ Arrival in Iceland would be the next day.
- ♦ The bad weather was forecast to continue for at least three days.

4.4. There was a strong case for continuing onwards. The alternatives were:

- ♦ To heave to, place the weather on the bow and reduce speed, holding station until the weather moderated. Or
- ♦ To divert towards shelter.

4.5. The first option, to heave to, would have meant a turn across the weather, which is always a manoeuvre of concern, and then an indeterminate period of time making no progress while still exposed to the weather. He would also have been aware that his cargo was susceptible to salt water damage and he would have been concerned to avoid the impact of breaking seas over the hatch covers and the risks of cargo damage that might arise from any small amounts of sea water penetration that prolonged exposure to this risk might bring. He would also have been aware that the containers stowed on the hatch covers in a small ship such as Jökulfell were susceptible to loss or damage from heavy seas if he turned to put the weather ahead.

4.6. The second option, to divert towards shelter, would also have involved a turn into the weather and a significant reduction in speed. It is estimated that Jökulfell would have been unlikely to have made more than about 5 knots (possibly less) directly into the weather in these conditions.

4.7. In doing so she would have been shipping seas on deck with the risk of losing, or damaging some of the deck stowed containers and the risk of cargo damage from sea water penetration. At 5 knots she would not have arrived in the Faeroes for about 20 hours, similar to the time needed to reach Iceland. She would then have had to find a suitable place to shelter.

4.8. It is also a consideration that the Master believed his GM to be in the region of 0.5 metres which would have made the ship reasonably "tender" and less susceptible to the dangers associated with steaming with following seas.

4.9. The weather forecast issued on Monday gave continuing south-south westerly gales for the next three days. He was already experiencing these conditions and his ship appeared to be behaving well. The shortest period of exposure would have occurred by maintaining his track towards Iceland. With no significant change in the weather for three days any other action risked exposing the ship to this weather for a much longer time.

4.10. Taking all of these facts into consideration it is concluded that the decision on Monday afternoon to proceed onwards towards Iceland was a reasonable one on the available facts.

5. Performance of Lifesaving and Distress Alerting Equipment.

5.1. Ships operating in areas such as this are required to carry immersion suits for all persons on board. These are designed to enhance the wearer's ability to survive immersion in cold water while also providing a readily seen bright suit with retro-reflective patches and a light. In addition to immersion suits for all, Jökulfell also carried liferafts which could be either manually launched from their stowage racks or which would "float-free" and inflate automatically using a special release device should the ship sink with the rafts attached. To attract attention to a distress situation the ship was equipped with a GMDSS radio station capable of transmitting a DSC alert on MF or on VHF and a "float-free" EPIRB. The EPIRB is capable of transmitting an alert via an orbiting satellite constellation to MRCCs. It can be activated manually but if not activated it will, like the liferafts, automatically float off a sinking ship and activate itself.

5.2. The first EPIRB transmission from the Jökulfell's EPIRB occurred at 2159. This is approximately an hour after the Second Officer and his party left Jökulfell and last saw her on her side and largely submerged. However the rescue helicopter at 2330 was still able to see the ship so that she must have been, at least partly, on the surface until after 2330. The hydrostatic release unit that acts to release the EPIRB from its stowage is designed to operate when the head of water acting on it reaches a pre set point.

5.3. If the ship was still partly on the surface at this time then it is understandable that the EPIRB was not triggered until 2159 when either a large wave submerged the unit enough to trigger the hydrostatic release unit or its stowage position reached a depth sufficient to trigger the unit and release the EPIRB. It is concluded that the EPIRB unit and its release mechanism functioned well.

5.4. The Second Officer recalls triggering the MF DSC alert when he reached the bridge with the Chief Officer. However the shore stations in the Faeroes note that their relay transmitter was blocked on Channel 16 until 2131. This could have been caused by another VHF transmitter active in the area. It cannot be ruled out that the transmission was from Jökulfell. However a DSC alert on VHF would not be on channel 16 so this remains inexplicable. It is also unclear if any alerts had been transmitted before the Second Officer reached the bridge. The first to be received ashore was the MF DSC alert at 2053 and it is believed that this is the one he triggered. This was also received at shore stations in Scotland and aboard an RNLI[15] lifeboat at Dundee in Scotland.

5.5. It is possible that the Master tried to transmit an alert, possibly on VHF Channel 16 rather than by activating the GMDSS automatic alert before the Second Officer arrived. It is also possible that in the circumstances the transmit button was left on. However this cannot now be established, nor can it be explained how a VHF transmission from Jökulfell continued until 2131 by which time she was clearly on her side and sinking with her antennae all but submerged.

5.6. The DSC alert was received in Faeroes, in several places in Scotland and probably in others and it quickly identified Jökulfell and her position. MRCC Faeroes were able to establish within 25 minutes that the originating ship was Jökulfell, locate the telephone numbers for her operators and the ship, and confirm that she was in the area. These points suggest that the GMDSS DSC alert mechanism worked as designed.

[15] Royal National Lifeboat Institution, a UK organisation responsible for operating life saving vessels around the UK coast.

5.7. The crew tried unsuccessfully to launch the liferafts on the port side. They were faced with an almost impossible task. The rafts are heavy and stowed in cradles secured by lashings to prevent their loss in the kind of motions the Jökulfell experienced prior to her loss.

5.8. The lashings have quick release arrangements for a manual launch. In the situation the crew found themselves in it would have been necessary to release the lashing, hold the weight of the raft and lift it over the outboard lip of the cradle against a slope of somewhere in the region of 45 degrees or more while having no foothold to brace against. However the rafts also have hydrostatic release units and it is clear that Jokulfell's rafts released from the ship, reached the surface, and inflated as designed.

5.9. The Second Officer recalls seeing an inflated raft close to the ship very shortly after he and his party jumped while the helicopter pilots also reported inflated rafts in the area. Clearly the rafts functioned as designed.

5.10. All of the crew managed to don their immersion suits. This, in itself, is an achievement that points to good training and a competent crew given the very short time scale of this accident. Between the initial large roll that shifted some cargo and the ship reaching a position where the only option left was to jump into the sea only about 10 minutes passed. Immersion suits are often difficult to don correctly without practice and cumbersome to move around in once donned.

5.11. Five crew members managed to survive for about 2½ hours in winter North Atlantic waters wearing their suits. Six others failed to survive. It is known that some of the crew members whose bodies were recovered were not wearing their suits fully zipped up and it is also known that, while the official cause of death is drowning, some of them had suffered serious injuries as well, either before leaving the ship or later while in the water amongst floating containers. It is not therefore possible to isolate the effects of having the suits not fully zipped.

5.12. It does, however, seem clear that the five crew members who survived were wearing their suits correctly and their suits certainly saved their lives. Four of them also stayed together for mutual support using a lifebuoy and this was entirely in accordance with their training. The Second Engineer managed to survive alone and again owes his life to his immersion suit.

5.13. It is concluded that the ships radio alerting systems and her life saving appliances worked as designed and that the combination of the GMDSS alert, the EPIRB that provided confirmation and the immersion suits that protected wearers in the water combined to save the lives of five of Jokulfell's crew.

6. Search and rescue.

6.1. The Search and Rescue operation was co-ordinated by MRCC Faeroes in Torshavn. This centre deals with about 1 search and rescue operation each week but rarely receives DSC alerts. Most come from VHF calls or from EPIRBs.

6.2. In the years since the introduction of the GMDSS system there has been a continuous problem with false alerts from both DSC transmitters and from EPIRBs. Many of these false alerts have been due to either crew's inexperience with this equipment, poor design of equipment, or the fact that there is no standard user interface. In recent years as experience has increased the number of false alerts has declined.

6.3. MRCC Torshavn has access to the fisheries inspection vessels Brimil and Tjaldriđ plus two helicopters, a fully equipped Bell 412 and a partially equipped Bell 212. In addition the Danish Navy stations a frigate around the Islands for about 10 months of the year and there is an agreement with them on the use of this resource for search and rescue operations. The frigate has a Lynx helicopter on board.

6.4. The first action taken at the MRCC on receipt of the alert from Jökulfell was to ask Brimil to head for the location. Then they alerted the pilot of the Bell 412 helicopter based at Vagar airport and asked him to be on stand by.

6.5. At this stage the MRCC knew only that an alert had been received. They had no other communication with the ship and were unable to establish any contact. They knew also that false DSC alerts did occur from time to time.

6.6. Just over 20 minutes after the DSC alert the pilot of the Bell 412 clarified that the weather was good enough to fly and that the helicopter was in the hangar and on stand by. It was 2120 before MRCC received confirmation that there was a ship called Jökulfell and that she was in the area. This was 27 minutes after the initial alert. At this stage they knew for certain that:

- Jökulfell was real and was in the area,
- There was some other transmission blocking VHF reception on VHF Channel 16 at the relay station closest to the distress position;
- Brimil was on the way but not due for some time.
- The weather was acceptable for helicopter operations.

6.7. MRCC were still unsure of the seriousness of the situation. They decided to send the naval frigate “Vædderen” which was off Torshavn and which is equipped with a rescue capable helicopter.

6.8. Following the loss of Jökulfell the Ministry of Fisheries and Maritime Affairs in the Faeroe Islands commissioned an independent study into decision making at the MRCC. That study highlighted a number of factors including the fact that there was confusion about what was meant by “ready” in terms of the helicopter. The agreement between the MRCC and the helicopter operator says ready in one hour. On first call just after 2100 the helicopter reported it was ready. In fact it was still in the hangar, had no crew, and was not fuelled. It was ready as it saw things – able to go in about an hour. Ready as MRCC saw it meant ready to go now with no further delay.

6.9. The confusion led to the MRCC assuming ready meant a much higher state of readiness than was actually the case. In any case a clear instruction to get ready rather than an enquiry was not sent to the helicopter until 2210. This was after receipt of the EPIRB alert which appears to have convinced the MRCC that the distress was indeed real.

6.10. The remaining uncertainty in the MRCC allied with a degree of inexperience in this type of operation led to delays in appreciating the seriousness of the situation at sea and led to a conservative approach to sending search and rescue assets. Only when the EPIRB signal was received at 2208 did they begin to despatch assets in earnest. By this time the crew were in the water in their immersion suits. Because of the basic uncertainties in the operation of the shore based helicopter it was only at this time that they began to open the hanger doors and fuel the aircraft. It was not to actually take off until 2339.

6.11. The report commissioned in the Faeroes has dealt with all of these points in considerable detail. It is clear that if the seriousness of the situation had been appreciated earlier the rescue helicopter from Faeroes, allowing about 40 minutes to fuel could have been on site about an hour before the first helicopter actually arrived. It cannot be known if this would have saved more lives from Jökulfell but it may have led to the earlier rescue of the 5 who were saved.

6.12. At the same time the information available to the MRCC was sparse, they had never received a genuine DSC alert before, they were unable to contact the originating ship, and there was no EPIRB signal or other indicator of a distress. It is considered here that it was understandable in the circumstances to delay despatch of full search and rescue assets until they had better confirmation of what was going on, which they obtained when the EPIRB signal was confirmed. Once that was received however there was sufficient confirmation of a major real incident to warrant immediate despatch of all available assets.

6.13. It is also considered that the helicopter should have been called to readiness as soon as the MRCC received the DSC alert as a matter of routine and launched as soon as it was confirmed that Jökulfell was in the area and not contactable. At this time there was sufficient information to justify despatch of a helicopter to investigate prior to sending the full range of assets.

6.14. It is understood that, as a result of the report that was commissioned in Faeroes, some changes have been made to procedures and arrangements in the Faeroes MRCC region aimed at addressing the short comings identified in the report.

7. Conclusions.

7.1. It is concluded that:

7.2. Jökulfell encountered sea conditions that, in combination with her natural period of roll, created a susceptibility to synchronous rolling and that this effect caused several large rolls to angles of 40 degrees or more at about 2040 ship's time on the 7th February 2005.

7.3. The large rolls caused some of the cargo of steel reinforcing bars to shift creating an angle of list which quickly worsened as the ship continued to roll and more cargo shifted until the ship was on her side from where she gradually flooded and sank.

7.4. The alteration of course on Monday afternoon served to reduce the rolling motions but this was gradually negated during the afternoon as the wind swung westerly again exposing the ship gradually to an increased risk.

7.5. Jökulfell met or exceeded all regulatory requirements for stability throughout her voyage.

7.6. The Master believed his GM to be in the region of 0.55 metres as a result of the method of calculation that was used. In fact the GM was in excess of 1 metre which made the ship more stiff and more susceptible to synchronous rolling.

7.7. The Master's decision to carry on towards Iceland was a reasonable one in the circumstances and bearing in mind the information available to him.

7.8. The method used for securing the reinforcing bar cargo was inadequate to resist large ship motions such as might reasonably be expected in the North Atlantic in winter.

7.9. The use of webbing lashing straps instead of wire lashings was inappropriate for this cargo and not in accordance with best practice or with the guidance in the ship's cargo Securing manual.

7.10. The ship's emergency equipment performed as intended and the immersion suits saved the lives of the five crew members who were saved.

7.11. There were unnecessary delays in despatching search and rescue assets to the scene but it is impossible to say if the delays affected the eventual outcome. Once in action the search and rescue personnel performed in an exemplary fashion in very difficult conditions.

8. Recommendations.

8.1. The Isle of Man Marine Administration should;

- Ensure that this report is circulated as widely as possible to all those who may have an involvement in shipping, or handling, steel reinforcing bar cargoes including P&I Clubs.

- Through the UK's Maritime and Coastguard Agency, explore the possibility of introducing a requirement for all ships to carry a simple set of graphs such as the one on page 21 for a range of typical GM values and which would allow masters to immediately see if they were approaching the danger zone for synchronous rolling.

8.2. The ship's charterers and managers should;

- Take immediate steps to ensure that future cargoes of reinforcing bars are secured in a manner that will prevent this kind of shift in future.

- Ensure that the instructions in their ship's Cargo Securing Manuals are amended where necessary to ensure that sound guidance on securing this cargo is included.

- Ensure that any ships chartered to carry this cargo are provided with adequate lashings for the purpose in accordance with the guidance in the cargo Securing Manual.

8.3. Classification Societies appointed to approve cargo Securing Manuals for Isle of Man flag ships should;

- Ensure that proper regard is had to the events of this casualty when approving a manual and that clear guidance is provided on effective securing methods along with warnings of the dangers of a failure to secure the cargo properly.

8.4. P&I Clubs in receipt of this report ;

- Are asked to use their normal channels of communication to highlight the risks of improperly secured reinforcing bar cargoes to all their members.