THE COMMONWEALTH OF THE BAHAMAS

Report of the investigation into the sinking of the "MOL Comfort" in the Indian Ocean

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It should be noted that the Bahamas Merchant Shipping Act, Para 170 (2) requires officers of a ship involved in an accident to answer an Inspector's questions fully and truly. If the contents of a report were subsequently submitted as evidence in court proceedings relating to an accident this could offend the principle that individuals cannot be required to give evidence against themselves. The Bahamas Maritime Authority makes this report available to any interested individuals, organizations, agencies or States on the strict understanding that it will not be used as evidence in any legal proceedings anywhere in the world

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1 SUMMARY

1.1 The 8000 TEU-type container ship MOL Comfort departed Singapore 11th June 2013 on voyage 005W21 bound for Jeddah, Saudi Arabia as the first port of call on its west-bound rotation. It was carrying 4,382 container units (7,041 TEU) with a crew of 26.

1.2 The ship was provided with weather-routing information indicating rough weather in the Arabian Sea on the 17th June. Voyage planning was performed to meet the required arrival time at Jeddah of 0000 on 20th June based on an average speed of 18 knots. The exception to this average was to be in the Internationally Recognised Transit Corridor (IRTC) where maximum speed was to be adopted as an anti-piracy measure.

1.3 In the early morning of the 17th June, in reported weather conditions of 38 knots (19.5 m/s) wind speed and 6m wave height, the engine speed was reduced to 79 rpm. At about 0745 hours local time, in position 12°30' N 059°58' E approximately 430 nautical miles off Salalah, Oman, the ship was hit by two large waves on the port bow. The bridge watch keepers immediately noticed that the ship was hogging in an unusual manner.

1.4 Investigations by the Chief Officer and Chief Engineer revealed water ingress into the pipe duct keel space, No.6 hold and fuel tanks and the Master concluded that the ship should be abandoned for the safety of the crew. Distress messages were sent and the ship was abandoned at about 0945 with all crew embarked in one lifeboat.

1.5 The ship Yantian Express (IMO 9229831) was approximately 24 nm away from the MOL Comfort when the first distress message was received at 0900 and it proceeded immediately to the scene. A cargo net was rigged and the lifeboat manoeuvred alongside but the rescue operation was complicated by the presence of floating and semi-submerged containers.

1.6 In attempting to climb on board a number of crew members of the MOL Comfort fell into the water and needed to be saved by the use of lifebuoys. However, all 26 crewmembers were finally retrieved on board the Yantian Express by 1136. At approximately 1148 the MOL Comfort broke into two parts which commenced drifting away from each other. The Yantian Express then left the scene and continued on its voyage east-bound. The rescued crew members of the MOL Comfort were landed at Colombo, Sri Lanka, on the 20th June.

1.7 Salvage teams were dispatched to the scene of the casualty and a tow was established to the fore end on the 26th June with the intention of retrieving the section to a suitable port.

1.8 However, attaching a tow to the after section proved extremely challenging and it eventually sank in position 14°25'50" N 066°26'18" E on the 27th June along with approximately 1700 containers and 1500 tonnes fuel.

1.9 Meanwhile the fore section was under tow towards the Gulf of Oman at slow speed until 2nd July when the tow line broke. The tow was re-established and the towing resumed but in the morning of the 6th July fire broke out in the fore section.

1.10 Despite fire-fighting efforts from the salvage vessels and an Indian Coast Guard vessel the fire continued unabated and the fore end of the MOL Comfort sank on July 10th in position 19˚56'29" N 065˚24'45" E.

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2 DETAILS OF SHIP(S) AND OTHER MATTERS

2.1 The principal details of the MOL Comfort are as follows:

2.1.1 Registered Owner: Ural Container Carriers S.A.

2.1.2 Managers: Mitsui O.S.K Ship Management (Singapore) Pte. Ltd

2.1.3 Classification society: Nippon Kaiji Kyokai (NKK)

2.1.4 Tonnage Gross/Net (Registered): 86 692 / 48 825

2.1.5 Deadweight: 90 613

2.1.6 Summer Freeboard (m): 5.859 Summer Draught (m): 14.535

2.1.7 Overall Length (m): 316.000 Lf (m): 303.180

2.1.8 Cargo Capacity Dry; 8,110 TEU 3,941 FEU Refrigerated; 630 TEU 630 FEU

2.1.9 Shipbuilder: Mitsubishi Heavy Industries, Ltd. Nagasaki Shipyard & Machinery Works

2.1.10 Hull No. 2234

2.1.11 Date of delivery: 14 Jul 2008

2.1.12 Crew on board: 11 Russian; 1 Ukrainian and 14 Filipino

2.2 At the time of the casualty the ship held all required and valid statutory certification issued following completion of its 1st Special Survey and Renewal Surveys at Tokyo, Japan on 29th May 2013.

2.3 Details of Senior Officers and selected crew members

2.3.1 The Master was a 58 year old Russian National with over 19 years' command experience holding STCW certification at II/2 issued by the Russian federation in 2010. He had joined the ship at Singapore 10 days before the incident and had previously been the Master on the sister ship APL France.

2.3.2 The Chief Officer was a 48 year old Russian National with approximately 8 years' experience in that rank including over three years on container ships. He held STCW certification at II/2 issued by the

Russian Federation in 2010 which entitled him to serve in the capacity of Master. He had joined the ship in Singapore in February 2013 and had also previously worked on a sister ship the MOL Courage. He was keeping the 0400-0800 watch on the day of the incident.

2.3.3 The 0400-0800 watch keeper (lookout) supporting the Chief Officer was a Philippines National with 10 years' experience. He had joined the ship in January 2013.

2.3.4 The Second Officer was a 40 year old Russian National and had sailed in this capacity since 2010 including experience on the MOL Performance and MOL Progress. He held STCW certification at II/2 issued by the Russian Federation in 2013 which entitled him to serve in the capacity of Chief mate. He had joined the ship in Singapore, at the same time as the Master, and was keeping the 0000-0400 watch on the day of the incident.

2.3.5 The 0000-0400 watch keeper (lookout) supporting the Second Officer was a Philippines National with 8 years' experience. He had joined the ship in January 2013.

2.3.6 The Third Officer was a 25 year old Russian national who had a total of two years' experience in that rank. He held STCW certification at II/1 which entitled him to serve in the capacity of Officer in charge of a navigational watch. He joined the ship with the Chief Officer in February 2013 in Singapore and was keeping the 2000-2400 watch. Prior to joining MOL Comfort he had served on board MOL Moderna.

2.3.7 The Chief Engineer was a 55 year old Russian National with 10 years' experience in the rank. He held STCW certification at III/2 which entitled him to serve in the capacity of Chief Engineer Officer. He had joined the ship at Hamburg, Germany in January 2013 and had previously worked on sister vessels APL France and APL Poland.

2.4 The ship was provided with a crew of 26, in excess of the requirements of the Safe Manning Document, issued by the Bahamas Maritime Authority, dated 31 March 2011 valid until 25 March 2016 as follows:

Master, 4 Deck Officers, 1 Deck Cadet, 1 Bosun, 4 AB, 2 OS
Chief Engineer, 3 Engineer Officers, 1 Electrical Engineer Officer, 1 Engine Cadet, 5 Engine Room crew
Chief Cook and 2nd Cook.

2.5 The Yantian Express IMO 9229831 is a 2002-built Container Ship of 88493 GT, 7506 TEU, 320 m long. It is owned and operated by Hapag-Lloyd, Hamburg and flies the flag of Germany.

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3 NARRATIVE OF EVENTS

3.1 All times given in the narrative are local ship (MOL Comfort) time (UTC +5) and as provided by crew members during interviews held in Colombo, Sri Lanka, six days after the casualty. Since all ship-board records were lost with the ship this narrative is largely based on the recollections of crew members expressed during these interviews although the statement provided by the Master of the Yantian Express provided corroboration on event timings. However, it was concluded that the time kept on board the Yantian Express which was proceeding east-bound was -1 hour in comparison with the MOL Comfort. For the purposes of clarity in this narrative all timings given by the Master of the Yantian Express have been converted in this report to UTC +5 for consistency.

3.2 The MOL Comfort departed Singapore on its west-bound rotation of ports (Jeddah, Suez, Rotterdam, Hamburg, Southampton, Le Harve) on 11th June 2013 at 1900 hrs (Singapore time) and on the 17th June 2013 was making its way across the Indian Ocean towards Jeddah where the required arrival time was 0000 (local) on the 21st June.

3.3 According to information obtained from interviews with the responsible officers all the necessary stability and stress calculations were satisfactorily completed prior to departure. The reported departure drafts were 13.45m forward, 12.9m midships and 13.6m aft with the ship in a routine hogged condition and a GM of 2.5m. The ship departed with 2807 tonnes Heavy Fuel Oil, 490 tonnes Low Sulphur Fuel Oil, and 138 tonnes Low Sulphur Gas Oil. Ballast Water on departure was 6160 tonnes.

3.4 The usual and required preparations were made in the anticipation of stormy weather in the Arabian Sea. The vessel was following weather routing advice and course heading and engine revolutions were adjusted taking into account the recommendations.

3.5 On the 16th June the ship was, according to the noon report, proceeding on a course of 291° at an average sea speed of 20 knots (engine speed 85 rpm). The weather conditions were wind speed of 39 knots from 250° with a swell of 5m from 270°. The ship had experienced 18% slip over the previous 25 hours to noon on the 16th.

3.6 It was stated in interviews that in the early hours of the 17th June the wind speed was 38 knots from the south west, with an observed wave height of 6-6.5m and length of about 100m. The watch-keepers on the 0400-0800 watch described the sea conditions as rough, but not so rough as to consider rolling and pitching motions unusual.

3.7 At approximately 0700 the engine speed was reduced to 79 rpm equating to an expected speed of 17 knots. It was normal routine for the ship's carpenter to take manual soundings at 0700 every day and it was stated that nothing unusual had been reported from these soundings on the day in question.

3.8 At about 0745 on the 17th June 2013 in position 12° 30' N 059° 58' E, approximately 430 nm off Salalah, Oman, the ship was encountering wave heights of 5-6m leading to some spray on deck. Without warning the ship experienced what was variously described by crew members as a "big jerk" or "jolt" or "bang". After this the lookout on watch noticed that there was continuous spray on the bridge front and both the watch-keepers noticed something wrong with the alignment of the forward section of the vessel.

3.9 The Chief Officer reported that he had seen the bow of the vessel being hit by two large waves on the port bow. He also immediately noticed that the ship was hogging in an unusual manner.

3.10 The Chief Engineer was in the engine control room in the machinery space where he had been since 0530, as was his usual practice, and he also felt two distinct impacts on the vessel. The second impact was felt as larger than the first and the pipe duct bilge alarm sounded very shortly afterwards.

3.11 As the ship was operating in an Unmanned Machinery Space (UMS) mode the 1st, 2nd and 3rd engineers proceeded into the machinery space. It was noted that the fuel tank remote gauging system indicated that the levels in the previously empty fuel tanks 3, 6 and 7 on the port side were increasing.

3.12 The Master had arrived on the bridge almost immediately after the two unusual wave impacts. The Chief Engineer also arrived on the bridge shortly afterwards following the Master's request for him to report there. He later recalled that he had observed the ship was by that time in a significantly abnormal hogged condition. In addition the 3rd Officer, also now on the navigating bridge, recalled that he had noticed that the forward end of the ship was apparently reacting to waves independently of the after end.

3.13 When the hold bilge alarm sounded the Master sent the Chief Officer to investigate. On his arrival in the ship's office he noted that the remote sounding gauge of No.6 hold indicated flooding was taking place and he immediately started the General Service (GS) pump to pump out the water in the hold.

3.14 The Chief Officer then proceeded into the under-deck passage and reported to the Master that No. 6 hold had flooded up to the height of one container level. He also noted that the side shell plating in the area was deformed. The main engine speed was reduced to 45 rpm (manoeuvring speed) and the ship's heading altered by 5 degrees to port to reduce the impact of heavy seas and swell effects.

3.15 Level indicators in the ship's office continued to show an increase in No.6 cargo hold and the Master noted oil traces in the overboard water discharge from the GS pump. According to information gathered from interviews the gauges for fuel tanks 2 (Centre), 6 and 7 were showing an increase in level while the level in fuel oil tank 4 was falling. By this time, approximately 0830, the Master had sent a distress call and informed the ship managers of the emergency situation. The Chief Engineer reported that the pipe duct keel was flooding, there were clear signs of oil in the water and several containers had fallen off the ship.

3.16 At approximately 0900 the Master contacted vessels in the vicinity by DSC VHF and the Yantian Express, which was about 24 miles away, responded to the distress call and started to proceed to the scene. The Master called the crew to muster stations and to make preparations to abandon ship.

3.17 While abandon ship preparations were underway the Chief Officer returned to the under-deck passage and noted that a crack in the ship side shell plating was widening and showing daylight. He reported this to the Master by hand-held VHF radio but when he reported back to the Master in person at about 0945and showed him an image of a large crack on both sides of the hull in the region of No. 6 hold the Master decided issue the command to abandon ship.

3.18 The life rafts on the port side were launched but boarding was considered to be too dangerous taking into account the weather and sea conditions. The crew therefore embarked into the starboard totally-enclosed lifeboat. Some delay was experienced in the launching process due to the presence of containers in the water but eventually the boat was safely launched with the full crew of 26 on board.

3.19 The Yantian Express arrived on scene at 1018 and assumed the role of On Scene Coordinator (OSC). The Master was forced to exercise great caution in approaching the scene due to the presence of a number of containers floating in the water. Meanwhile the lifeboat approached to rendezvous with the Yantian Express but this task was made more difficult as the view from the steering position window was obscured by oil driven off the surface of the water. This required one crew member to verbally aid accurate steering while standing in a position outside the rear embarkation door.

3.20 On arriving alongside the Yantian Express, at approximately 1110 hours, the lifeboat occupants attempted to climb the cargo net rigged by the Yantian Express into the starboard pilot embarkation door. Unfortunately the rough weather conditions, reported to be Beaufort 7 with 5-6m SW waves, along with oiling of the cargo net meant that some crew members were washed into, or slipped, the sea and lifebuoys had to be deployed to save these individuals.

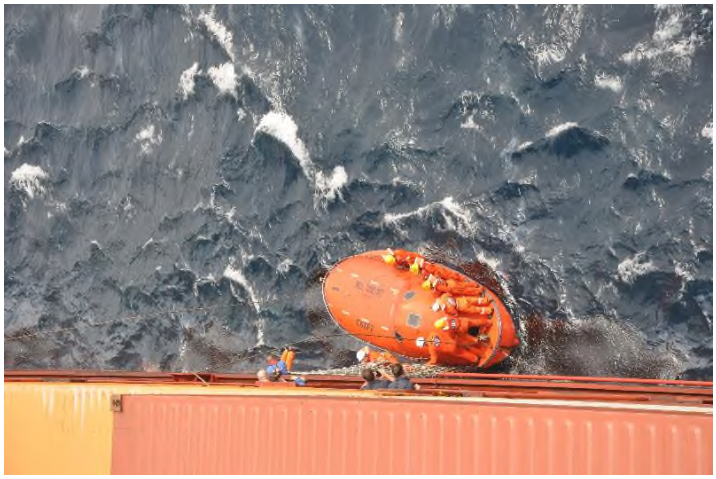

Figure 1 Lifeboat alongside Yantian Express

3.21 By 1136 all 26 members of the crew had successfully boarded the Yantian Express and it was released from OSC duties by MRCC Mumbai to resume its passage. Shortly afterwards, at 1148 hours, it was noted that the MOL Comfort had broken into two sections which were drifting away from each other.

Figure 2 After section of MOL Comfort

3.22 Having successfully embarked all 26 of the crew of the MOL Comfort on board, the Yantian Express resumed its voyage to Colombo, Sri Lanka, where all were safely landed on 20th June 2013.

3.23 Meanwhile the Owners had engaged salvors to deal with the two sections of the hull which were still in an upright and floating condition. At this stage the LRIT system was still functioning and the Bahamas Maritime Authority was monitoring the position and drift of the after section.

3.24 Four salvage boats arrived on scene on the 24th June and on 26th June had attached a tow to the fore part. Attaching a tow to the after part of the ship was proving to be extremely challenging, however, as it had assumed a position some 30° down by the "head" and containers were being lost into the water. Weather conditions were described as being very challenging with wind speeds of 30-40 knots and a 7-8m swell.

3.25 On 27th June it was reported that the fore section was under tow with escort tugs in a stable condition towards the Arabian Gulf but that the aft part was continuing to take in water, rolling heavily and losing containers overboard. The after part subsequently sank on the same day in 3000m water depth at 0748 UTC in position 14°25'50" N 066°26'18" E. Approximately 1700 containers sank along with the aft part which also contained about 1500 tonnes fuel oil.

Figure 3 Fore section with tow vessel

3.26 The tow of the fore part continued in a west-north-westerly direction until 2nd July 2013 when the towing wire became disconnected. Efforts to re-connect the tow wire were made with the assistance of three tugs. The tow was re-established later that day by which time the fore part was in position 17°14'24" N 068°48'15" E.

3.27 In the morning of 6th July when in position 19°06'30" N 066°56'42" E it was noted that a fire had broken out in the fore part. While efforts were made to fight the fire from a tug and two rescue boats the weather remained adverse with wind speed 28 knots from the west-south-west and a 4 m swell.

3.28 Assistance was requested from the Indian Coast Guard and their patrol boat "Samudra Prahari" was reported as proceeding to the scene where it arrived on the morning of the 8th July.

Figure 4 Fore end fire-fighting by "Samudra Prahari"

3.29 Despite the assistance of the "Samudra Prahari" the fire continued unabated and the fore part of the MOL Comfort finally sank at 1900 UTC on July 10th in position 19˚56'29"N, 065˚24'45" E in over 2000m water depth along with approximately 2400 containers and 1600 tonnes of fuel oil.

3.30 The salvage team remained in the area until 12th July to monitor for floating containers and pollution but in the absence of either eventually departed the scene.

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4 ANALYSIS AND DISCUSSION

4.1 The catastrophic loss of a relatively young and well-maintained ship such as the MOL Comfort in weather conditions which the ship would have been expected to tolerate without undue concern clearly raises important issues regarding design and construction. However, in light of the detailed technical research work carried out by ClassNK, the Committee on the Safety of Large Container Ships and the International Association of Classification Societies (see 4.32-4.41) this marine safety investigation report deals with related matters.

4.2 The ship was constructed in accordance with the Rules issued by ClassNK, a full member of the International Association of Classification Societies (IACS), and all evidence provided indicates that design appraisals and survey activities were carried out to the expected standards and norms.

4.3 The total loss of the ship along with the opportunity to carry out close examination and testing of the structure in the region of the structural failure effectively prevents the establishment of the true cause(s) of the casualty.

4.4 These difficulties are exacerbated by the loss of all on board records and objective evidence which could be used in the determination of causal factors and safety improvements. While the after part of the ship remained afloat following the parting from the fore end it proved impossible to board safely and VDR records could not be obtained after sinking as no float-free capability was available[1].

4.5 Interviews were performed in Colombo, Sri Lanka on 23rd June 2013. The BMA expresses its appreciation to the Master, Chief Engineer, eight deck and engine officers and two bridge lookouts for their full participation. Further information and evidence was provided by Mitsui OSK Lines (MOL), ClassNK and the Master of the Yantian Express.

Operational matters

4.6 At the time of the casualty the MOL Comfort was manned in excess of the requirements of the Safe Manning Document issued by the BMA. The Master was highly experienced and was supported by navigating officers and bridge crew who were experienced both in the rank held and in the operation of container ships. Officers were engaged on four-month duration contracts and ratings on nine-month contracts.

[1] The Revised Performance Standards For Shipborne Voyage Data Recorders MSC.333(90), which entered into force for VDR installed after 1 July 2014, requires float-free capability.

4.7 The Master confirmed that prior to departing from the final loading port of Singapore the requisite stability calculations were performed with satisfactory results. The calculated maximum bending moment and shear force as reported to the Company were 99% and 94% respectively. There is no evidence to suggest that there was any unease regarding the departure condition of the ship.

4.8 A voyage plan was drawn up taking into account planning sheets issued for the MOL Comfort by Weathernews under its Total Fleet Management service. The Initial Voyage Plan issued on 10th June 2013 noted the anticipated heavy weather on the 17th June in the Arabian Sea due to the monsoon. Sea conditions of 5-6m swells from the south-west were predicted.

4.9 In order to meet the required arrival time at Jeddah the voyage was planned based on a continuous 83 rpm engine speed and 18 knots ship speed, except in the Internationally Recognised Transit Corridor where full sea speed was required in accordance with MOL policy. However, the planning sheet commented that maintenance of 18 knots could be "impossible" due to the very rough conditions expected in the Arabian Sea.

4.10 A further planning sheet was issued by Weathernews on 16th June to update the Initial Voyage Plan. The height of the expected swell conditions was amended from 5-6m to 5-6m+. No continuous engine speed is specified on this sheet as it is based on maintaining a ship speed of 18 knots. However, the caveat regarding the achievement of 18 knots in the Arabian Sea which was contained in the planning sheet issued on the 11th June no longer featured.

4.11 The planning sheet included a list of waypoints and recommended engine speeds to maintain the required average 18 knots for the voyage. It is noted that for the day of 17th June an engine speed of 84rpm is specified to maintain the required average speed.

4.12 The noon report on the 16th June indicated an average engine speed of 85 rpm over the previous 25 hours; but according to interviewees the ship was running with an engine speed of 80 rpm during the early hours of the 17th June and the Master ordered a further reduction to 79 rpm some 45 minutes before the unusual wave strikes and the first indications of structural failure.

4.13 While the watch keepers expressed the opinion that conditions encountered on the morning of the 17th June were not unusual or excessive the reduction in engine speed is evidence of concern on the part of the Master in the face of circumstances where damage to the ship was possible. However, no interviewee suggested that the behaviour of the ship was remarkable or described it as "slamming". It is noted that the approved stability information specifies a draft at FP of 7.34m to avoid slamming impact pressure in rough weather while the departure draft forward was 13.45m.

4.14 The Company's Safety Management System Operation Procedure Manual (On Board) Chapter 6 Bridge Operation Procedure Section 7.03 deals with navigation in heavy weather. The text defines heavy weather as being Beaufort 6 and wave height of 5m and by those definitions the Master was right to take a precautionary approach to the weather developing through the 16th June. There is no evidence to suggest that the Master, or any navigator, took any action which was not fully consistent with the procedures as set out.

Abandonment and rescue

4.15 Following the initial indications of a developing problem all the evidence points to a professional and calm response by everyone on board. The fact that a lifeboat was launched in difficult circumstances and challenging sea conditions and with the added complication of floating containers in the water below the launching station without loss of life or injury is a testament to the effectiveness of training, drills and competence of everyone on board.

4.16 However, it is noted that the first choice of the crew in selecting abandonment equipment was to make use of the inflatable liferafts. This may be due to the lasting lack of confidence in the on-load release systems of lifeboats. It was only after recognising that the sea conditions made embarkation onto the liferafts extremely hazardous that the lifeboat was used.

4.17 Evidence from statements gathered indicated that the totally-enclosed lifeboat became extremely hot and many crew members experienced the discomfort of sea-sickness even though they were in the boat for only just more than one hour and fifteen minutes. In the prevailing weather conditions it was necessary to close all entry point doors rendering the boat a closed and under-ventilated box containing 26 persons.

4.18 In respect to the issue of overheating in lifeboats it is noted that the International Lifesaving Appliances Code (LSA Code) contains no provisions regarding thermal comfort. Bearing in mind the fact that the IMO has issued guidance on the wearing of immersion suits inside totally enclosed lifeboats following the experience of the crew of the MSC Napoli.

4.19 Noting that there is a ventilation provision in the LSA Code in respect of partially-enclosed lifeboats (LSA Code 4.5.2.5) the absence of specific ventilation provisions may be a weakness in the requirements for totally enclosed lifeboats.

4.20 This issue has been raised in a United Kingdom Health and Safety Executive Offshore Technology Report OTH 92 376[2] "Survivability of Occupants of Totally Enclosed Motor Propelled Survival Craft (TEMPSC)" 1993 which concluded, inter alia, that *"The thermal conditions likely to arise within TEMPSC are conducive to thermal discomfort, heat stress, dehydration and*

[2] http://www.hse.gov.uk/Research/othpdf/200-399/oth376.pdf

poor performance of the occupants. Whilst contributing to heat stress per se subjects reported that the heat exacerbated their motion sickness. The resultant thermal condition was directly related to the occupancy level. The thermal conditions likely to prevail within the TEMPSC during winter conditions whilst being less stressful than those likely to be encountered during summer will still be associated with motion sickness and heat stress." However, the report made no recommendations on design to alleviate the identified issue.

4.21 In attempting to steer the lifeboat to rendezvous with the Yantian Express a further complication was experienced due to oil obscuring the steering window. It is concluded that this oil was contained in sea spray rather than being a pre-existing condition.

4.22 While the crew of the MOL Comfort managed to abandon ship in safety the same cannot be said of the rescue onto the Yantian Express. While the Master and crew of that vessel expended every effort to make the rescue in circumstances of adverse weather and in the presence of many floating and submerged containers, and did so with consummate professionalism, it is the case that a number of individuals fell into the water during attempts to climb the rigged cargo net to safety from the lifeboat.

4.23 However, it is noted that the casualty pre-dates the entry into force of amendments to Chapter III of SOLAS which were adopted by the 91st session of the Maritime Safety Committee in 2012. The amendments, provided in Resolution MSC.338(91) introduce Regulation 17-1 which requires, inter alia, that all ships have ship-specific plans and procedures for recovery of persons from the water.

4.24 The entry into force for these regulations was 1st July 2014 and ships built before that date are required to comply by the first periodical or renewal safety equipment survey of the ship to be carried out after 1 July 2014 whichever comes first. This compliance regime means that some cargo ships may not be required implement plans and procedures until mid-2017.

Reaction by the flag State Administration

4.25 The Bahamas Maritime Authority (BMA), as the Flag State Administration, immediately took action to assess the condition of sister ships to the MOL Comfort and established that the "MOL Competence" IMO 9339662 Hull No. 2233 (Bahamas flag) was due to enter port at Southampton on the 22nd June 2013 albeit that this ship was not under the management of Mitsui O.S.K. Lines. While this ship was also built in 2008 it had not at the time completed its first Special Survey.

4.26 With the full cooperation of New Asian Shipping Co. Ltd. and with the ready assistance of the Master and crew the BMA attended on board the MOL Competence on the 23rd June to carry out inspections and surveys of the bottom structure in the mid-length section of the hull.

4.27 With the assistance of the on-board staff the following areas were examined:

Tank	Frames[3]	Defects/remarks
5 Port wing ballast	162-194	No signs of corrosion, buckling or cracks noted.
5 Stbd wing ballast	162-194	No signs of corrosion, buckling or cracks noted.
6 Port wing ballast	130-162	No signs of corrosion, buckling or cracks noted.
6 Stbd wing ballast	130-162	No signs of corrosion, buckling or cracks noted.
5 Port double bottom ballast	162-194	Bottom Shell found deformed in way of Fr.183, between side girders 3 & 9. Otherwise no signs of corrosion or cracks noted. Up to 30 cm of water was present in the tank. Complete examination of the bottom plating not possible.
5 Stbd double bottom ballast	162-194	Bottom Shell found deformed in way of Fr.183, between side girders 3 & 9. Otherwise no signs of corrosion or Cracks noted. Up to 30 cm of water was present in the tank. Complete examination of the bottom plating not possible.
6 Port double bottom ballast	130 - 162	Bottom Shell found deformed in way of Fr.151, between side girders 3 & 9. Otherwise no signs of corrosion or cracks noted Lower longitudinal stiffener on Side girder No.9 found deformed at Fr.151, deflection in the region of 20mm. Up to 30 cm of water was present in the tank. Complete examination of the bottom plating not possible.
6 Stbd double bottom ballast	130 – 162	Bottom Shell found deformed in way of Fr.151, between side girders 3 & 9. Otherwise no signs of corrosion or Cracks noted. Up to 30 cm of water was present in the tank. Complete examination of the bottom plating not possible.

4.28 Duct keel in way of Hold Nos.5 & 6 examined. Slight deformation of bottom shell in way of Fr.151 starboard noted, otherwise no sign of deformation, corrosion or cracks noted.

Under deck Passages: No sign of deformation, corrosion or cracks noted.

Main deck: No sign of deformation or cracks noted. Coating break down and

[3] Frs.151 & 167 are in way of cargo holds No.6 & 5 respectively. Fr.151 is midway along the forward bay in No.6 cargo hold in the general area where the hull fracture in MOL Comfort was observed.

light corrosion on the erection joint butt welds in the hatch coamings.

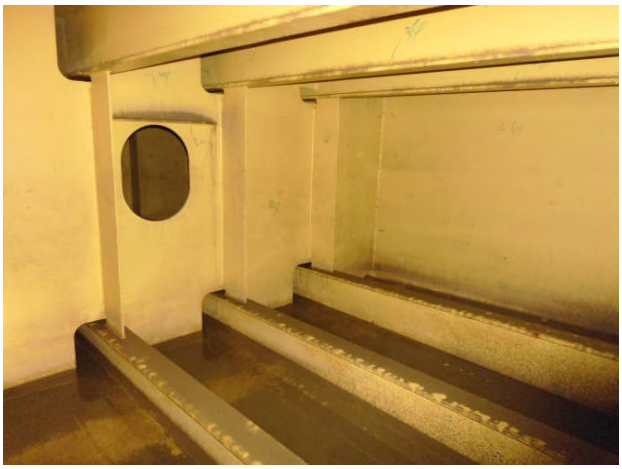

Figure 5 General view of condition – MOL Competence No.5 port double bottom

4.29 As a result of the findings of this inspection the BMA requested ClassNK to carry out surveys of all the sister ships, and the results of these surveys were reported back to the BMA on 10th July 2013 as follows:

1. "**MOL Creation**" (IMO 9321237)

Duct Keel - slight deformation (max. 22mm) on bottom plates at Fr.151 between SG3 (P) and SG3 (S)

No.6 double bottom water ballast tank (P) - slight deformation (max. 8mm) on bottom plates at Fr.151 between SG9 and BL16

No.6 double bottom water ballast tank (S) - slight deformation (max. 21mm) on bottom plates at Fr.151 between SG3 and BL17

Apart from the above, deformation which is assumed to be caused by the previous bottom touch has been found on bottom plates and the floors from Fr. 130 to Fr. 150 between BL11 and BL14 in way of No.6 and 7 double bottom water ballast tanks (P).

2. "**MOL Charisma**" (IMO 9321249)

Duct Keel - slight deformation (max. 10mm) on bottom plates at Fr.151 between SG3 (P) and SG3 (S)

No.6 double bottom water ballast tank (P) - slight deformation (max. 7mm) on bottom plates at Fr.135, 151 between BL8 and SG15

No.6 double bottom water ballast tank (S) - slight deformation (max. 4mm) on bottom plates at Fr.151 between BL5 and SG9, BL17 and BL18

No.7 double bottom water ballast tank (P) - slight deformation (max. 7mm) on bottom plates at Fr.118 between SG3 and BL6

No.7 double bottom water ballast tank(S) - slight deformation (max. 5mm) on bottom plates at Fr.118 between SG3 and BL7

3. "**MOL Celebration**" (IMO 931251)

No.5 double bottom water ballast tank (P) - slight deformation (max. 15mm) on bottom plates at Fr.183 between SG3 and SG15

No.5 double bottom water ballast tank (S) - slight deformation (max. 15mm) on bottom plates at Fr.183 between SG3 and BL17 and Fr.167 between BL14 and BL17

No.6 double bottom water ballast tank (P) - slight deformation (max. 7mm) on bottom plates at Fr.151 between BL7 and BL11

No.6 double bottom water ballast tank (S) - slight deformation (max. 5mm) on bottom plates at Fr.151 between BL4 and BL10

No.7 double bottom water ballast tank (S) - slight deformation (max. 7mm) on bottom plates at Fr.120 between SG3 and BL10

4. "**MOL Courage"** (IMO 9321263)

Duct Keel - slight deformation (max. 15mm) on bottom plates at Fr.183 between SG3 (P) and SG3 (S)

No.5 double bottom water ballast tank (P) - slight deformation (max. 10mm) on bottom plates at Fr.183 between SG9 and SG15

No.5 double bottom water ballast tank (S) - Slight deformation (max. 10mm) on bottom plates at Fr.180, 189 between BL12 and BL13

No.6 double bottom water ballast tank (P) - slight deformation (max. 10mm) on bottom plates at Fr.158 between BL12 and BL13

No.7 double bottom water ballast tank (S) - slight deformation (max. 10mm) on bottom plates at Fr.118 between BL7 and BL8

5. "**MOL Competence**"(IMO 9339662)

No.5 double bottom water ballast tank (P) - slight deformation (max. 12mm) on bottom plates at Fr.183 between SG3 and SG9

No.5 double bottom water ballast tank (S) - slight deformation (max. 7mm) on bottom plates at Fr.183 between BL5 and BL7

No.6 double bottom water ballast tank (P) - slight deformation (max. 20mm) on bottom plates at Fr.151 between SG3 and SG9. Slight deformation (max. 20mm) on stiffener attached to SG9 at Fr. 151

No.6 double bottom water ballast tank (S) - slight deformation (max. 13mm) on bottom plates at Fr.151 between SG3 and SG9

No.7 double bottom water ballast tank (P) - slight deformation (max. 18mm) on bottom plates at Fr.117 between SG3 and SG9

No.7 double bottom water ballast tank (S) - slight deformation (max. 12mm) on bottom plates at Fr.117 between BL7 and SG9

Action by Mitsui O.S.K Lines

4.30 It is worth noting the proactive approach and actions taken by Mitsui O.S.K Lines in the immediate aftermath of the casualty. Just over one week after the initial reports they issued a statement regarding "Safety Enhancement on Sister Vessels of the Containership MOL Comfort" as follows:

"Mitsui O.S.K. Lines, Ltd. together with shipbuilder, Mitsubishi Heavy Industries and the classification society (Nippon Kaiji Kyokai, ClassNK), will continue the thorough investigation to find the cause of the MOL Comfort incident, which occurred on June 17 on the Indian Ocean.

We have decided to take extra preventive measures as it may take some time to identify the cause. For the six sister vessels that we operate, we have already started the operational precautions to reduce the stress on the hull. These vessels sufficiently fill the safety standard required by ClassNK in compliance to IACS, but we will conduct upgrade works to further strengthen the hull structure at the earliest timing. This will enhance the strength of the hull twice as much as the safety standard mentioned above.

The vessels will phase-out from the service for the upgrade works and the sailing schedule will be revised accordingly."

4.31 The reinforcements carried out were extensive as described, inter alia in MOL Press Release issued 12 August 2013 "Update (No.2) Safety Enhancements on Sister Vessels of the Containership MOL Comfort[4]":

"MOL began preventative measures to enhance the safety of six sister vessels immediately after the incident. Measures taken to reinforce the hulls of MOL Celebration, MOL Courage, and MOL Creation were recently completed, and these vessels return to Asia-North Europe service beginning August 10.

[4] http://www.mol.co.jp/en/pr/2013/13067.html

The work done on the three containerships aimed to strengthen the hull structures to approximately twice that required by Nippon Kaiji Kyokai (ClassNK), Japan's classification society, which conforms to the safety standards of the International Association of Classification Societies (IACS). ClassNK has confirmed that the work done on these three vessels was executed according to plan. Further, LR [Lloyds Register] expressed its opinion that the structural reinforcement completed for the vessels is considered to be the best preventive measure against a similar failure at present.

MOL Charisma and MOL Competence among three remaining three sister vessels are already at the dockyards of Mitsubishi Heavy Industries, Ltd. and their hull reinforcement will be completed by the end of September to beginning of October. The work for MOL Commitment which was newly delivered this June will be completed by February 2014." (See Appendix III for further details.)

Action by ClassNK and Japan

4.32 In addition to the surveys carried out ClassNK announced that it would carry out its own investigation on 12th July 2013. The ClassNK Casualty Investigation Team published its Preliminary Report in November 2013 concluding that the fracture originated in the bottom of the mid-ship section but noted that it was unclear as to whether the bottom plating deformations observed during surveys of sister ships could have acted as the trigger for the fracture. The report recommended that crews on similar ships inspect the midship region bottom plating.

4.33 In view of the fact that the ship's builder, operator and Classification Society were all located in Japan the Ministry of Land, Infrastructure and Transport decided to establish the Committee on Large Container Ship Safety ("the Committee") to examine the issues raised by the loss of the MOL Comfort. The Committee issued its Interim Report[5] in December 2013 and its final report[6] in March 2015.

4.34 Meanwhile ClassNK had, in response to the interim report of the Committee on Large Container Ship Safety, established its Investigative Panel on Large Container Ship Safety to work in parallel with the Committee. The Panel issued its final report[7] in September 2014. A summary of the work carried out and the proposed actions is found in ClassNK Annual Report 2014[8] pp 9-10.

[5] http://www.mlit.go.jp/common/001029660.pdf
[6] http://www.mlit.go.jp/common/001081297.pdf
[7] http://www.classnk.or.jp/hp/pdf/news/Investigation_Report_on_Structural_Safety_of_Large_Container_Ships_EN_ClassNK.pdf
[8] http://www.classnk.com/hp/pdf/publications/Publications_image/an_rp_2014_e.pdf

4.35 The comprehensive work carried out by both ClassNK and the Committee indicated that the MOL Comfort design and construction met all relevant Class Rules and the existing IACS Requirements Regarding the Strength of Ships (S11 Longitudinal Strength Standard) at the time of construction. However, in comparison with the design of similar, but non-sister, ships there were significant observed differences "…on the margin of the hull girder ultimate strength calculated by 3-hold model elasto-plastic analysis against the wave induced vertical bending moment specified in IACS UR S11."

4.36 Furthermore the ClassNK report concluded that "It is considered that the difference between [MOL Comfort] and the other target ships observed in this investigation is mainly derived from the difference in possibility of buckling collapse of stiffened bottom panel adjacent to the keel plate panel under bi-axial compression with consideration of the superimposition of local stress in double bottom structure due to lateral loads and compressive stress by vertical bending."

Action by Bahamas and Japan

4.37 Following the issue of the interim report of the Committee the Bahamas and Japan submitted a paper to the 93rd session of the Maritime Safety Committee (MSC 93/9/2 supported by INF.14) to draw attention to the content of the report and the recommendations regarding special examinations of bottom structures in large container ships and the need for verification of container masses. The action taken by the MSC at the 93rd session was limited to the approval of the draft amendments to SOLAS regulation VI/2 related to mandatory verification of gross mass of a container.

4.38 The Bahamas and Japan made a further submission to the 95th session of the Maritime Safety Committee (MSC 95/16 supported by INF.11) in June 2015. The papers reported on the outcomes of the final report of the Committee and proposed that the following recommendations made be implemented on a global basis: the effect of the lateral loads which induce bi-axial stress of bottom shell plates should be considered in the requirements of the hull girder ultimate strength, taking into account the close relationship between the lateral loads and the hull girder ultimate strength; effects of whipping responses should be explicitly considered in the requirements of the vertical bending strength; and representation of technical background of the requirements for vertical bending strength, such as sea states, etc. should be considered.

4.39 In response to this proposal the delegation of IACS made a statement which included the following comments:

"Paragraph 4.1 relates to the bi-axial stresses which would be induced by lateral loading, i.e. external pressure on the bottom shell. Most, if not all,

IACS Members have for many years addressed these bi-axial" stresses in their individual rules and procedures. However, to ensure that in the future all IACS Members consider this effect in a consistent way, text has been included in the new IACS Longitudinal Strength Standard for Container Ships, known as Unified Requirement S11A which will enter into force on 1 July 2016.

Paragraph 4.2 relates to the whipping effect on container ships. This phenomenon continues to be the subject of research, in conjunction with aspects such as how the ship's speed and bow shape influence the magnitude of the whipping component. These effects are becoming better understood, and some individual IACS Members have developed specific rule requirements for consideration of this whipping effect. The development of explicit IACS Unified Requirements for the whipping component of hull girder loading will take time; and for the interim period IACS has introduced a functional requirement into the new Unified Requirement S11A which requires IACS Members to take into account whipping in accordance with their individual procedures. Entry into force is again 1 July 2016 for IACS members.

Regarding paragraph 4.3, in the development of the new Unified Requirement S11A, which originally commenced after the MSC Napoli incident in January 2007, a revised wave bending magnitude and longitudinal distribution has been included. To support this revision to the wave bending moment a comprehensive technical background document has already been developed and will be available on the IACS web site before the end of MSC 95[9]*."*

4.40 The IACS Unified Requirement S11 Longitudinal Strength Standard was issued in Rev.8 in June 2015 and a new UR S11A Longitudinal Strength Standard for Container Ships was issued at the same time. These standards are further supported by the issue in May 2015 of S34 Functional Requirements on Load Cases for Strength Assessment of Container Ships by Finite Element Analysis[10].

4.41 IACS has also indicated that it is considering whether its publication "Container Ships – Guidelines for Surveys, Assessment and Repair of Hull Structures" First Edition 2005 needs to be updated and re-issued following the work completed to date.

[9] http://www.iacs.org.uk/document/public/Publications/TBs/URTB.pdf (pages 727-783)

[10] http://www.iacs.org.uk/document/public/Publications/Unified_requirements/PDF/UR_S_pdf158.PDF

Further developments in container ship safety at the International Maritime Organization (IMO)

4.42 The safety of container ships was brought into sharp focus at the IMO following the structural failure of the MSC Napoli in the English Channel in January 2007. Following recommendations made in the investigation report the World Shipping Council and the International Chamber of Shipping developed the "Safe Transport of Containers by Sea: Guidelines on Best Practices".

4.43 One of the significant findings of the MSC Napoli case was in respect of the mis-declaration of container weights. The audit of weights of containers which had remained on deck and without water ingress revealed that 137 of 660 containers were weighed to be at least 3 tonnes more than declared.

4.44 In 2010 the Maritime Safety Committee agreed to a proposal to amend the International Convention on the Safety of Life at Sea (SOLAS) and work was completed in November 2014 with the adoption of amendments to SOLAS Chapter VI Regulation 2 pertaining to verification of container weights and MSC.1/Circ.1475 "Guidelines Regarding The Verified Gross Mass Of A Container Carrying Cargo"

4.45 While the SOLAS amendments enter into force on 1 January 2016 the World Shipping Council issued further guidance on the implementation of the new Regulations[11] in July 2015.

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[11] http://www.worldshipping.org/industry-issues/safety/WSC_Guidelines_for_Implementing_the_SOLAS_Container_Weight_Verification_Requirement.pdf

5 CONCLUSIONS

5.1 The conduct of a marine safety investigation where the operational records of a ship have been completely lost with the ship is hampered by a lack of objective evidence. While the statements obtained at interviews provide useful and important information it is understood that recall can be flawed depending upon the level of trauma suffered and the time elapsed since an event. However, the investigation has been provided with evidence in the form of Noon Reports, Voyage Planning documents and weather data which allow some analysis of operational performance.

5.2 It is based on the obtained information and evidence that the investigators conclude that the ship was navigated with due care and professionalism during the voyage from Singapore to the point where the structural failure occurred and the ship was lost.

5.3 The Master's decisive action to abandon ship was fully justified in the fact that all the crew were safely rescued albeit that some danger was experienced during the rescue. It is hoped that the amendments to SOLAS will help to avoid future difficulties of a similar nature.

5.4 While the lifeboat was safely launched and used the thermal discomfort suffered by the crew after only a relatively short period is noted with concern.

5.5 The crew were rescued but some members, having fallen into the water while attempting to climb a rigged cargo net, did not manage to board the rescuing vessel without danger. SOLAS amendments to address safe recovery have subsequently entered into force and it is concluded that early implementation would be beneficial.

5.6 With regard to the mechanism by which the catastrophic structural failure was initiated the significant efforts expended by ClassNK and the Committee on the Safety of Large Container Ships are acknowledged as providing valuable development in the safe design and construction of post-Panamax container ships.

5.7 Similarly the publication of Unified Requirement S11A and associated guidance by the International Association of Classification Societies is welcomed as a further step in the safe design and appraisal of increasingly large container ships.

5.8 In respect of the root cause of the casualty it is concluded that this cannot be stated with any certainty. Great significance has been placed on the damages to bottom shell plating found in five of the six sister ships to the MOL

Comfort. Whether or not the MOL Comfort had similar damages and, if so, to what extent remains an unknown. However, it is noted that no such damages were recorded during the Special Survey examinations in late 2012. However, the proactive approach to reinforcing the bottom structure in sister vessels taken by Mitsui OSK Lines is considered to be highly prudent and laudable.

5.9 The introduction of SOLAS amendments to introduce provisions regarding the verified gross mass of containers is welcomed as a measure intended to improve the safety of large container ships. However, the efficacy of these measures remains to be proven as the Regulations represent shipper self-declaration of verified gross mass as opposed to independent weighing at the terminal prior to loading on board.

***

6 RECOMMENDATIONS

In view of the significant research and modelling work carried out by the Committee on Large Container Ship Safety and ClassNK, the development work completed by IACS, the further development work underway and the uncertainties surrounding the cause of the structural failure no safety recommendations are made on design and construction matters.

Recommendations for the Bahamas

6.1 The Bahamas Maritime Authority is recommended to further investigate the issue of the ventilation of totally enclosed lifeboats with a view to improving thermal loading of occupants in emergency situations

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LIST OF APPENDICES

I. Voyage Planning Sheet

II. MHI 2234 Construction Standard (provided by Class NK)

III. Sister ship structural reinforcement plans (courtesy Government of Japan)

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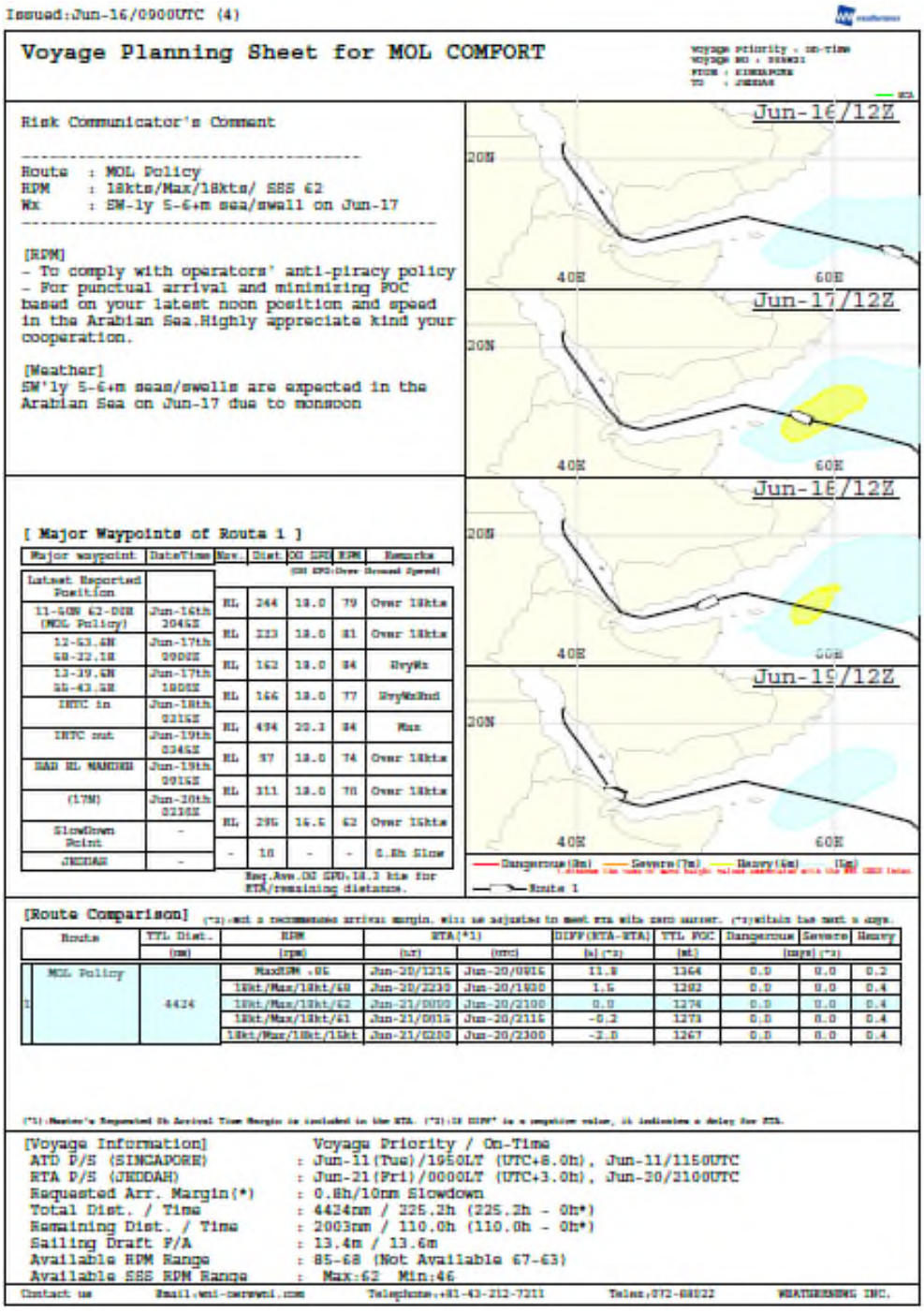
Appendix 1

Voyage Planning Sheet



Issued:Jun-16/0900UTC (4)

Voyage Planning Sheet for MOL COMFORT

voyage priority : on-time
voyage NO : 008W21
FROM : KINGAPORE
TO : JEDDAH

Risk Communicator's Comment

Route : MOL Policy
RPM : 18kts/Max/18kts/ SSS 62
Wx : SW-ly 5-6+m sea/swell on Jun-17

[RPM]
- To comply with operators' anti-piracy policy
- For punctual arrival and minimizing FOC based on your latest noon position and speed in the Arabian Sea.Highly appreciate kind your cooperation.

[Weather]
SW'ly 5-6+m seas/swells are expected in the Arabian Sea on Jun-17 due to monsoon

Jun-16/12Z
Jun-17/12Z
Jun-18/12Z
Jun-19/12Z
20N
40E
60E
Dangerous(8m)
Severe(7m)
Heavy(6m)
Route 1

[Major Waypoints of Route 1]

Major waypoint	DateTime	Nav.	Dist.	OG SPD	RPM	Remarks (OG SPD:Over Ground Speed)
Latest Reported Position						
11-40N 62-00E (MOL Policy)	Jun-16th 2045Z	RL	244	18.0	79	Over 18kts
12-53.6N 58-22.1E	Jun-17th 0900Z	RL	223	18.0	81	Over 18kts
13-39.6N 55-43.5E	Jun-17th 1800Z	RL	162	18.0	84	HvyWx
ITCZ in	Jun-18th 0315Z	RL	166	18.0	77	HvyWx&Mnd
ITCZ out	Jun-19th 0345Z	RL	494	20.3	84	Max
02N 61-00E	Jun-19th 0915Z	RL	97	18.0	74	Over 18kts
(17N)	Jun-20th 0230Z	RL	311	18.0	70	Over 18kts
SlowDown Point	-	RL	295	16.6	62	Over 15kts
JEDDAH	-	-	10	-	-	0.8h Slow

Req.Ave.OG SPD:18.2 kts for ETA/remaining distance.

[Route Comparison]

(*2):set a recommended arrival margin. will be adjusted to meet eta with zero margin. (*3):obtain the next 4 days.

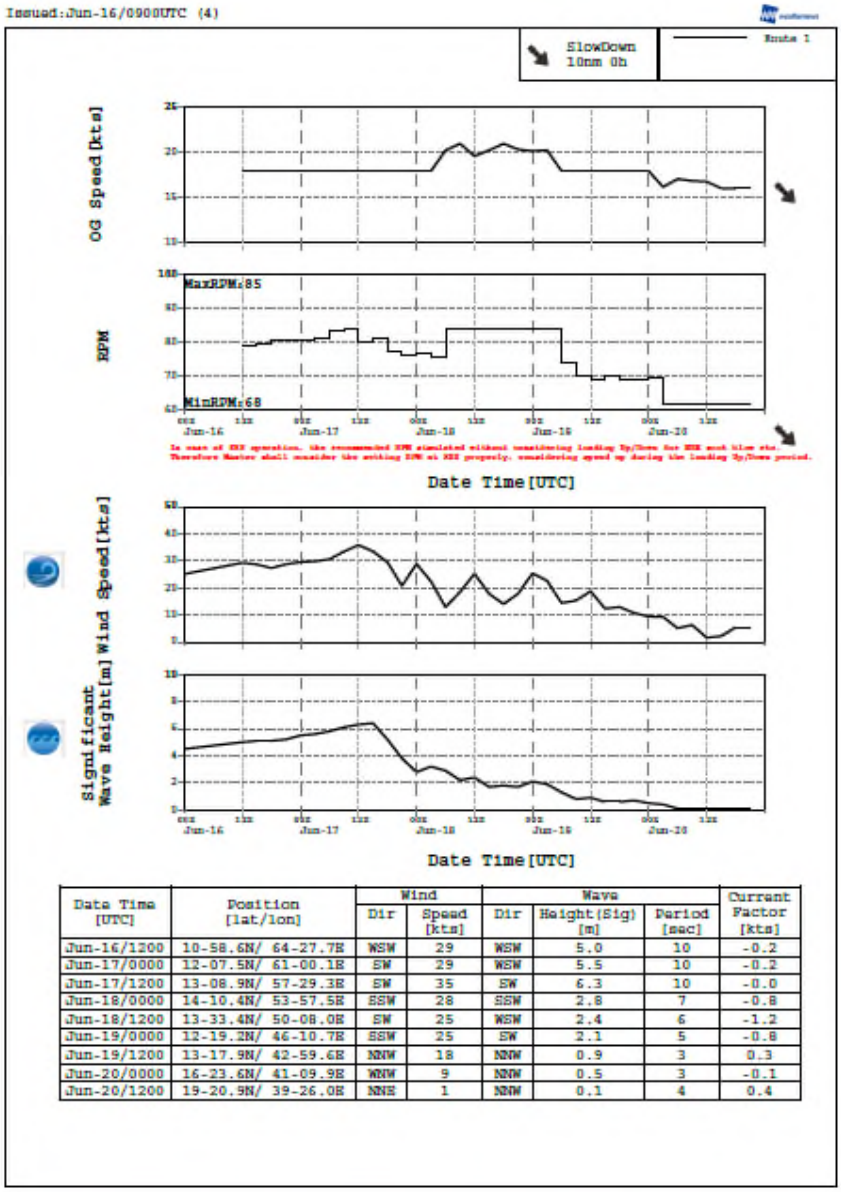
Route	TTL Dist. (nm)	RPM (rpm)	ETA(*1) (ut)	ETA(*1) (utc)	DIFF(ETA-RTA) (h) (*2)	TTL FOC (mt)	Dangerous (days) (*3)	Severe (days) (*3)	Heavy (days) (*3)
MOL Policy	4424	Max&RPM -.8%	Jun-20/1215	Jun-20/0915	11.8	1364	0.0	0.0	0.2
		18kt/Max/18kt/68	Jun-20/2230	Jun-20/1930	1.5	1282	0.0	0.0	0.4
		18kt/Max/18kt/62	Jun-21/0000	Jun-20/2100	0.0	1274	0.0	0.0	0.4
		18kt/Max/18kt/61	Jun-21/0015	Jun-20/2115	-0.2	1273	0.0	0.0	0.4
		18kt/Max/18kt/18kt	Jun-21/0200	Jun-20/2300	-2.0	1267	0.0	0.0	0.4

(*1):Master's Requested Un Arrival Time Margin is included in the ETA. (*2):If DIFF' is a negative value, it indicates a delay for ETA.

[Voyage Information] Voyage Priority / On-Time
ATD P/S (SINGAPORE) : Jun-11(Tue)/1950LT (UTC+8.0h), Jun-11/1150UTC
RTA P/S (JEDDAH) : Jun-21(Fri)/0000LT (UTC+3.0h), Jun-20/2100UTC
Requested Arr. Margin(*) : 0.8h/10nm Slowdown
Total Dist. / Time : 4424nm / 225.2h (225.2h - 0h*)
Remaining Dist. / Time : 2003nm / 110.0h (110.0h - 0h*)
Sailing Draft F/A : 13.4m / 13.6m
Available RPM Range : 85-68 (Not Available 67-63)
Available SSS RPM Range : Max:62 Min:46

Contact us Email:wni-carrwni.com Telephone:+81-43-212-7211 Telex:372-68522 WEATHERNEWS INC.

Issued:Jun-16/0900UTC (4)



Date Time [UTC]	Position [lat/lon]	Wind		Wave			Current Factor [kts]
		Dir	Speed [kts]	Dir	Height(Sig) [m]	Period [sec]	
Jun-16/1200	10-58.6N/ 64-27.7E	WSW	29	WSW	5.0	10	-0.2
Jun-17/0000	12-07.5N/ 61-00.1E	SW	29	WSW	5.5	10	-0.2
Jun-17/1200	13-08.9N/ 57-29.3E	SW	35	SW	6.3	10	-0.0
Jun-18/0000	14-10.4N/ 53-57.5E	SSW	28	SSW	2.8	7	-0.8
Jun-18/1200	13-33.4N/ 50-08.0E	SW	25	WSW	2.4	6	-1.2
Jun-19/0000	12-19.2N/ 46-10.7E	SSW	25	SW	2.1	5	-0.8
Jun-19/1200	13-17.9N/ 42-59.6E	NNW	18	NNW	0.9	3	0.3
Jun-20/0000	16-23.6N/ 41-09.9E	WNW	9	NNW	0.5	3	-0.1
Jun-20/1200	19-20.9N/ 39-26.0E	NNE	1	NNW	0.1	4	0.4

Appendix II

MHI 2234 Construction Standard
(Supplied by Class NK)

Ship Name: MOL COMFORT
IMO Number: 9358761
Construction: 20 Apr. 2005
Application: 28 Apr. 2005
Keel Lay: 23 Aug. 2007
Launching: 08 Mar. 2008
Delivery: 14 Jul. 2008

1.) Rules/ Guidance for the Survey and Construction of Steel Ships(NK Rules/Guidance)

Subject vessel is 6th of a series of six 8,100TEU Container Carrier Series (S.No. 2225-8, 33/34) built by Mitsubishi Heavy Industries Ltd. Applications for the entire series were submitted to ClassNK in 2005, and in accordance with the vessel's building schedule, the 2005 version of NK Rules and Guidance was applied to its construction as follows:

(1) Forward Part

- All structural members were evaluated using the formula defined in NK Rules/Guidance (Part C), and confirmed as satisfying the relevant requirements.

(2) No.1 ～No.7 Hold Part

- A majority of the structural members were evaluated using the formula defined in NK Rules/Guidance (Part C), and confirmed as satisfying the relevant requirements.

- Scantlings of the other structural members* were determined based on the result (Yield Strength and Buckling Strength) of the Direct Strength Analysis (DSA) on a Hold FEM Model, which were used to evaluate the scantlings of primary members in accordance with NK Rule/Guidance (Part C), and confirmed as satisfying the relevant requirements.

- For this vessel, special considerations for additional stresses and deformation of hatchway openings due to torsion are required by NK Rule/Guidance (Part C).

Therefore, the Yield Strength of the applicable members* was calculated using the DSA on a Full Length Hull FEM Model (DSA (Full Length)), which were used to evaluate the scantlings of primary members in accordance with NK Rule/Guidance (Part C), and confirmed as satisfying the relevant requirements.

- In addition to the above, fatigue strength of the members* where high stress was found by the DSA (Full Length) were further examined on voluntary basis.

(3) Engine Room Part

- All structural members were evaluated using the formula defined by NK Rules/Guidance (Part C), and confirmed as satisfying the relevant requirements.

(4) Stern (No.8 & No.9) Hold Part

- All structural members were evaluated using the formula defined by NK Rules/Guidance (Part C), and confirmed as satisfying the relevant requirements

2.) IACS Unified Requirement

Structural requirements of IACS UR (2005 ver.) as specified below have been introduced into ClassNK Rules/Guidance (Part C) and applied on to the sign of this ship:

Requirements concerning STRENGTH OF SHIPS

S1: Requirement for Loading Conditions, Loading Manuals and Loading Instruments
S2: Definition of Ship's Length L and of Block Coefficient Cb
S3: Strength of End Bulkheads of Superstructures and Deckhouses
S4: Criteria for the Use of High Tensile Steel with Minimum Yield Stress of 315 N/mm2, 355 N/mm2 and 390 N/mm2
S5: Calculation of Midship Section Moduli for Conventional Ship for Ship's Scantlings
S6: Use of Steel Grades for Various Hull Members - Ships of 90 m in Length and Above
S7: Minimum Longitudinal Strength Standards
S10: Rudders, Sole Pieces and Rudder Horns
S11: Longitudinal Strength Standard
S14: Testing Procedures of Watertight Compartments
S26: Strength and Securing of Small Hatches on the Exposed Fore Deck
S27: Strength Requirements for Fore Deck Fittings and Equipment

3. HT Zone HT Zone HT Zone

High Tensile Steels (HT32, HT36, HT40 and HT47) were used to satisfy Longitudinal Strength of the vessel as follows.

Bottom & Bilge Plate: HT32
Bottom Longl. (BL-1 & 2): HT36
Bottom Longl. (BL-4 ~ 20): HT32
Bilge Longl.: HT32
Inner Bottom Plate: HT32
Inner Bottom Longl. (TL-1 & 2): HT32
Inner Bottom Longl. (TL-4 ~ 20): HT36
Bottom Girder and Stiffener (Center, No.3, No.9 & No.15): HT32
Bottom Girder and Stiffener (No.21): HT36
Side Shell Plate (above B.L. 4.592m ~ 21.922m): HT32
Side Shell Plate (above B.L. 21.922m ~ 25.150m): HT40
Side Longl. (SL-1): HT36
Side Longl. (SL-2 ~ 12, 15 ~ 22): HT32
L.Bhd. Plate (above B.L. 4.792m ~ 16.437m, 20.457m ~ 22.607m): HT32
L.Bhd. Plate (above B.L. 22.607m ~ 25.000m): HT40

L.Bhd. Stiff. (LS-1, 24 & 25): HT36
L.Bhd. Stiff. (LS-2 ~ 22): HT32
No.23 Side Stringer: HT32
No.23 S.Stringer Longl. (DL-22, 23 & 25): HT32
No.14 Side Stringer: HT32
2nd Deck Longl.: HT32
Upper Deck and Longl.: HT40
Hatch Coaming / Coaming Top / Stiffener: HT47

Appendix III

Structural Reinforcement Plans (Courtesy of Government of Japan)

1. General

This plan is reinforcement plan of the bottom shell structure for MOL C-Class Container Carrier. Structures on port and starboard sides are to be symmetrical unless otherwise noted. Each section shows looking forward, downward, or to port side view. All scantlings and dimensions are shown in millimeters except as specially noted.

2. Material

Materials are to be used in compliance with the requirement of the Classification Society "NK (NIPPON KAIJI KYOKAI)" or equivalent and each material grade is indicated on the drawing.

MARK	QUALITY
Not marked	Mild steel grade "KA"
"AH"	Higher tensile steel grade "KA32"
"AH36"	Higher tensile steel grade "KA36"

On condition of approval of NK surveyor, thicker plate and/or higher tensile material can be used according to dockyard's convenience of material arrangement. In such case, material list showing the following item of material actually uses shall be submitted to MHI.

1) Location / Material ID number
2) Plate thickness
3) Steel grade
4) Classification society

3. Welding material

LB-52/LBM-52/LB-50A: NK class low hydrogen type welding for normal higher tensile steel

SF-1: NK certified rutile type seamless flux cored welding wire. (For use with CO_2 shielding gas)

According to welding procedure such as automatic /semi-automatic welding, other welding material can be used with approval of NK surveyor.

4. Reinforcement plan

13 Correct by NK

Reinforcement plan are shown on pages 4 to ~~12~~.

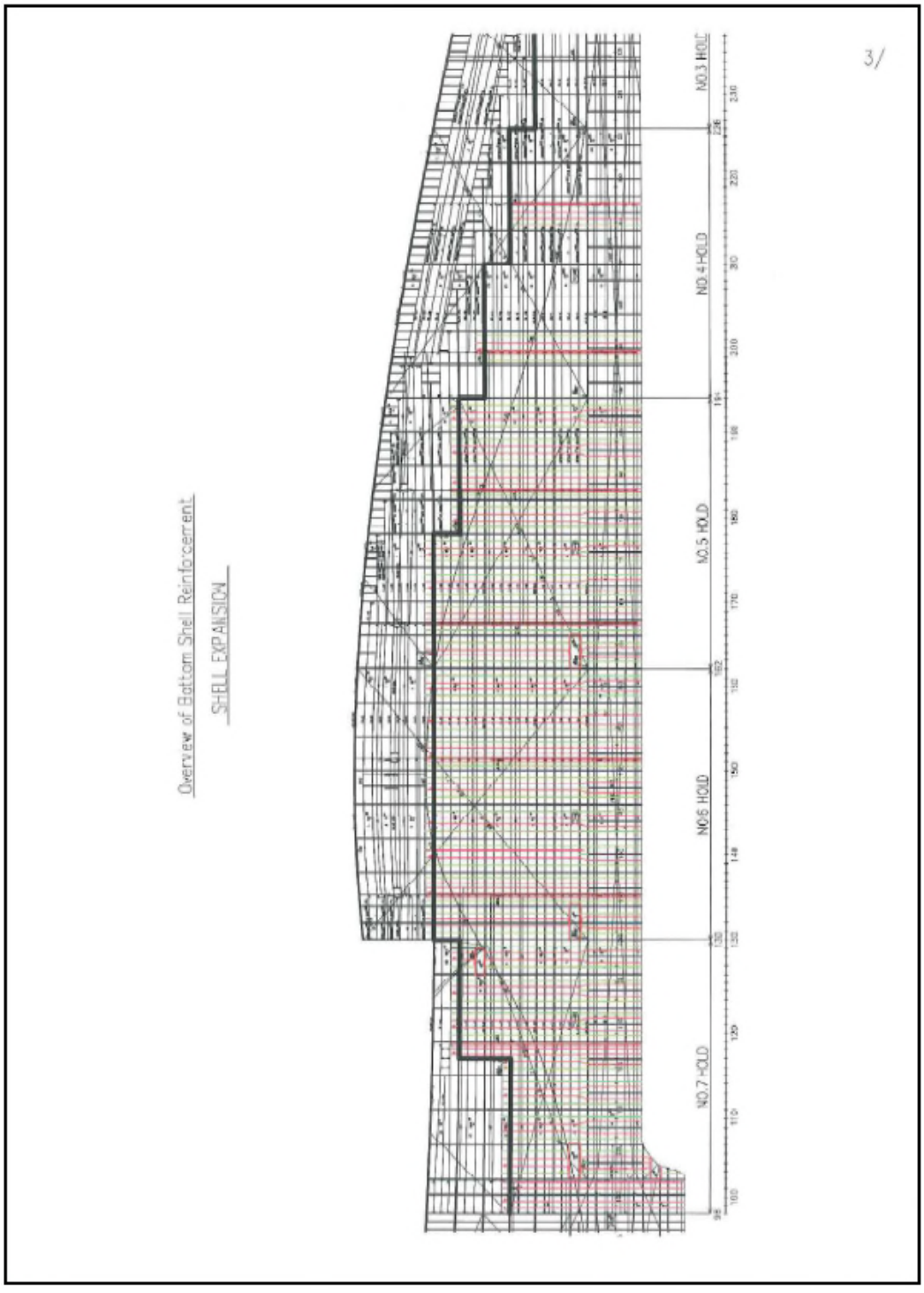
Parts marked in red and green are added or altered parts.

For access, ventilation, installation of material and equipment, temporary manholes may

be provided on bottom shell plating, inner bottom plating and other hull structure. In such case, the modification shall be subject to approval by owner and local class surveyor.

5. Non destructive test

Dye penetration test and /or ultrasonic test are to be done according to the request by class surveyor. The report shall be submitted to MHI.

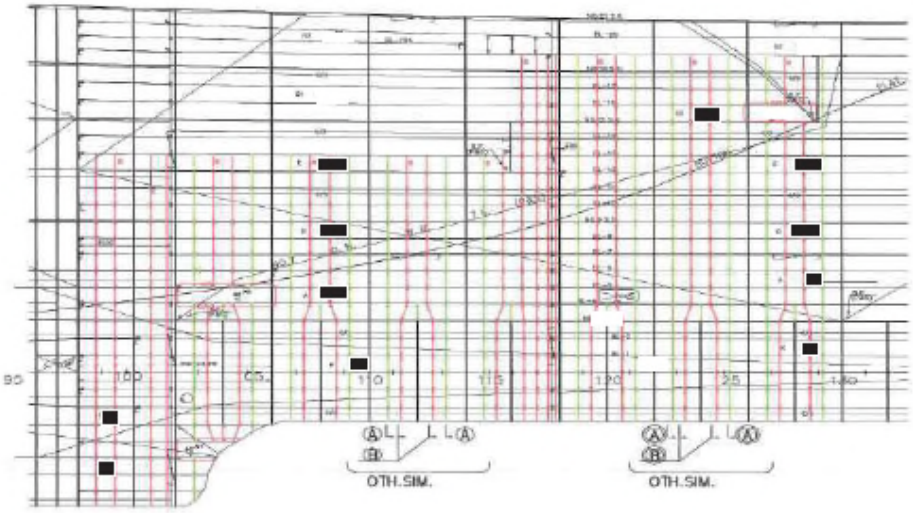

3/
Overview of Bottom Shell Reinforcement
SHELL EXPANSION
NO.3 HOLD
NO.4 HOLD
NO.5 HOLD
NO.6 HOLD
NO.7 HOLD

4/

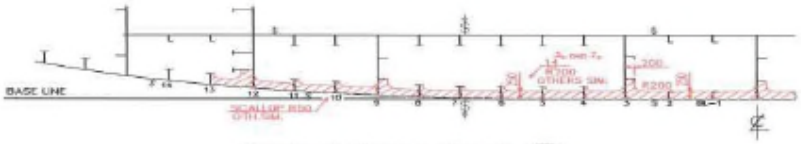
Reinforcement for No.7 HOLD

SHELL EXPANSION

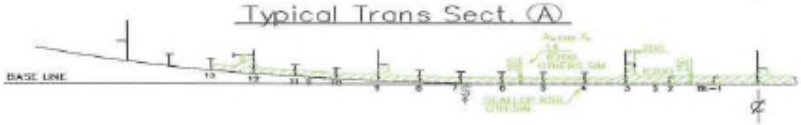
(No.7 CARGO HOLD)



Typical Trans Sect. (B)



Typical Trans Sect. (A)



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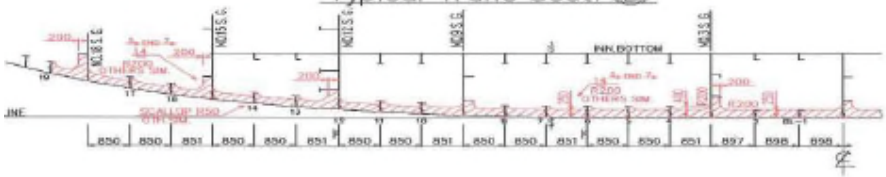
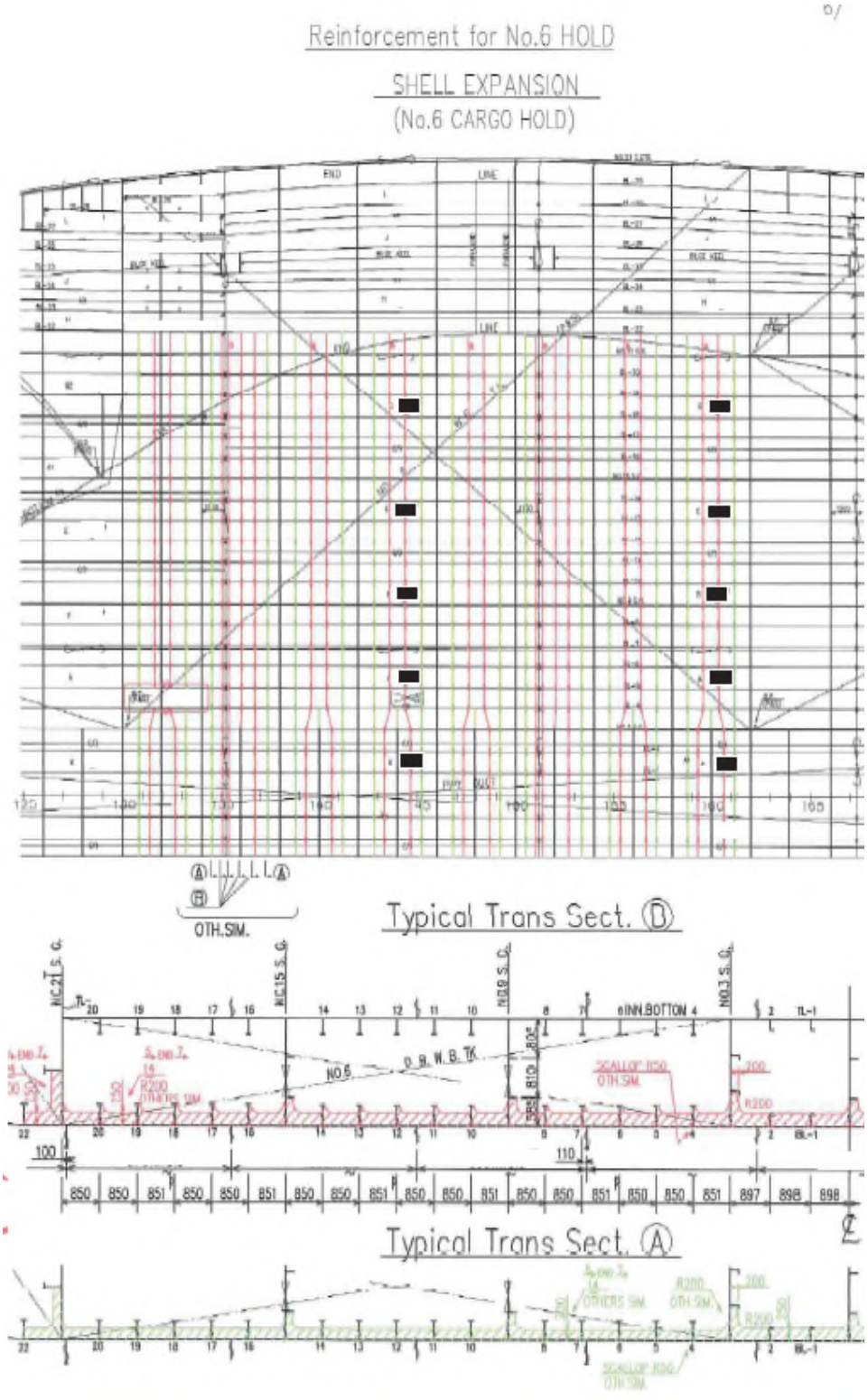
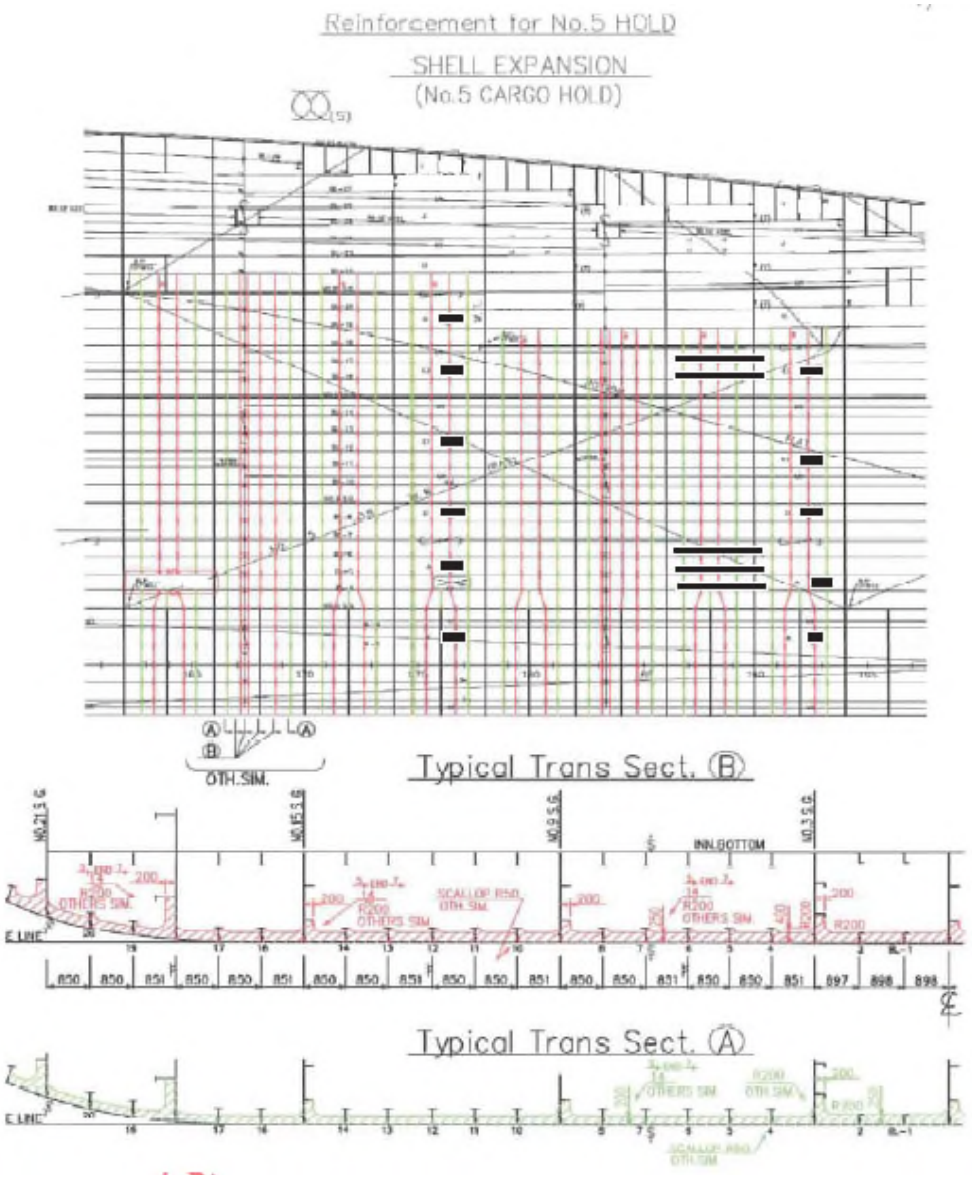


Typical Trans Sect. (A)

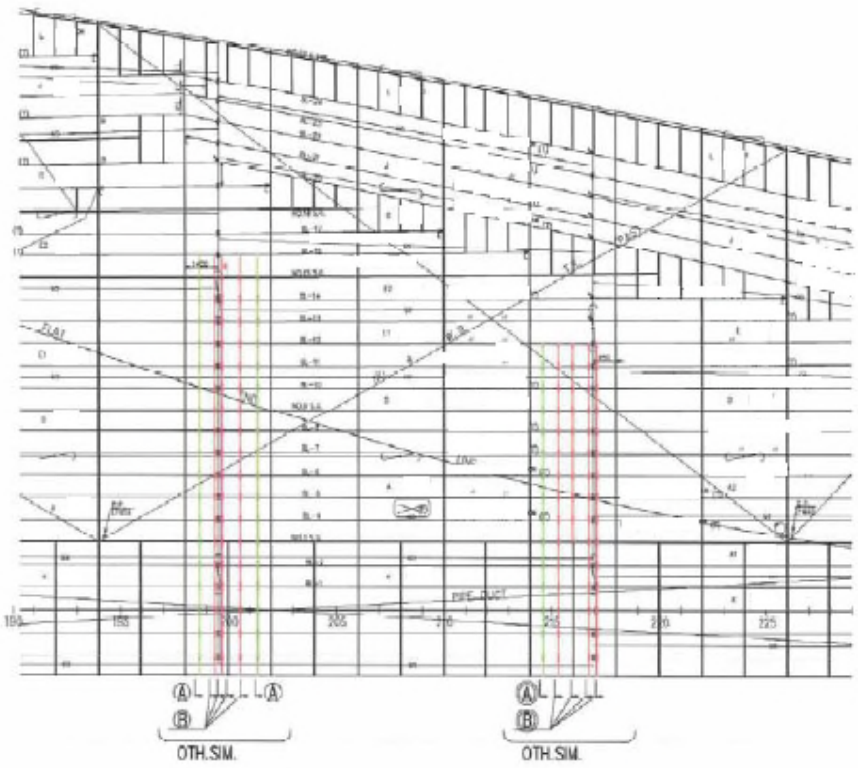

Reinforcement for No.6 HOLD
SHELL EXPANSION
(No.6 CARGO HOLD)
OTH.SIM.
Typical Trans Sect. (D)
Typical Trans Sect. (A)

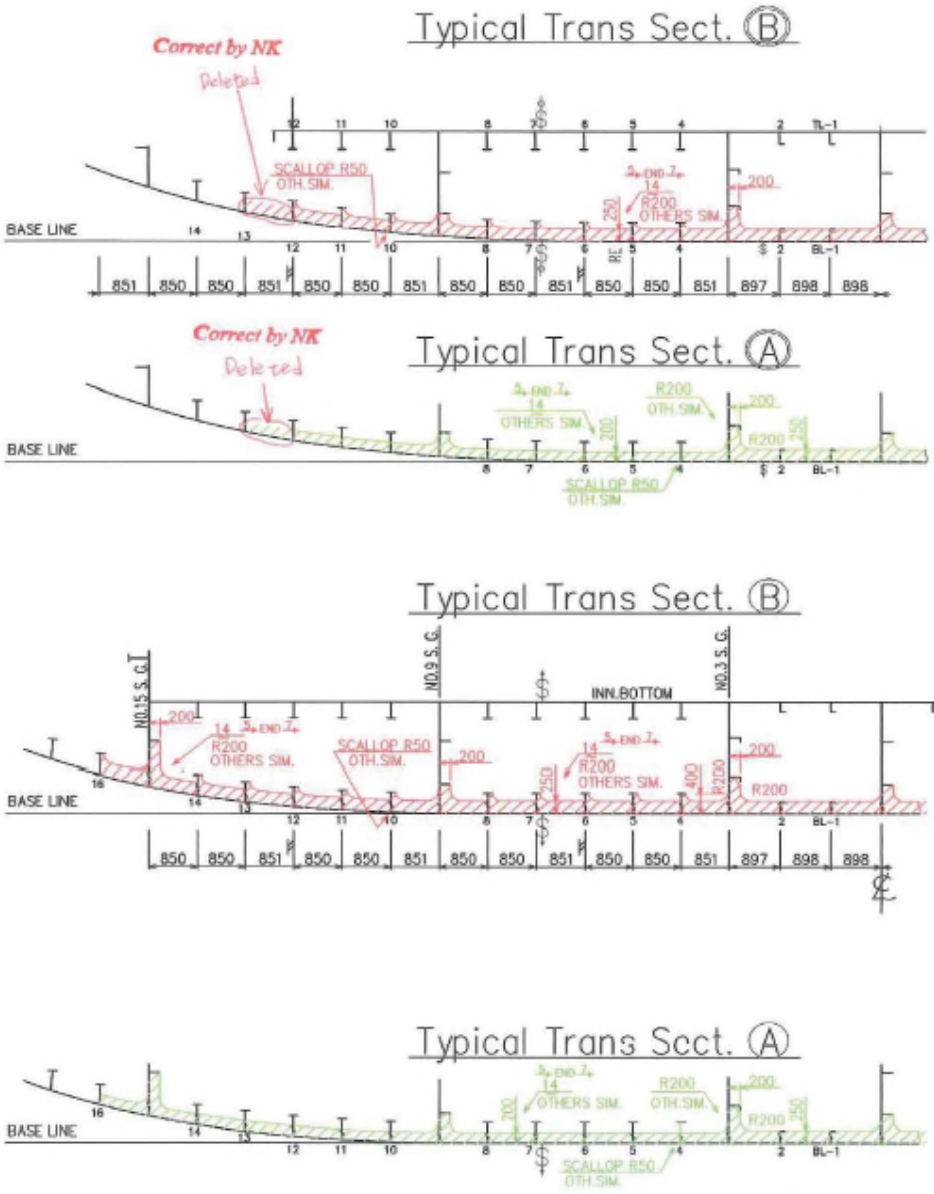

Reinforcement for No.5 HOLD
SHELL EXPANSION
(No.5 CARGO HOLD)
(5)
Typical Trans Sect. (B)
INN.BOTTOM
Typical Trans Sect. (A)

Reinforcement for No.4 HOLD

SHELL EXPANSION

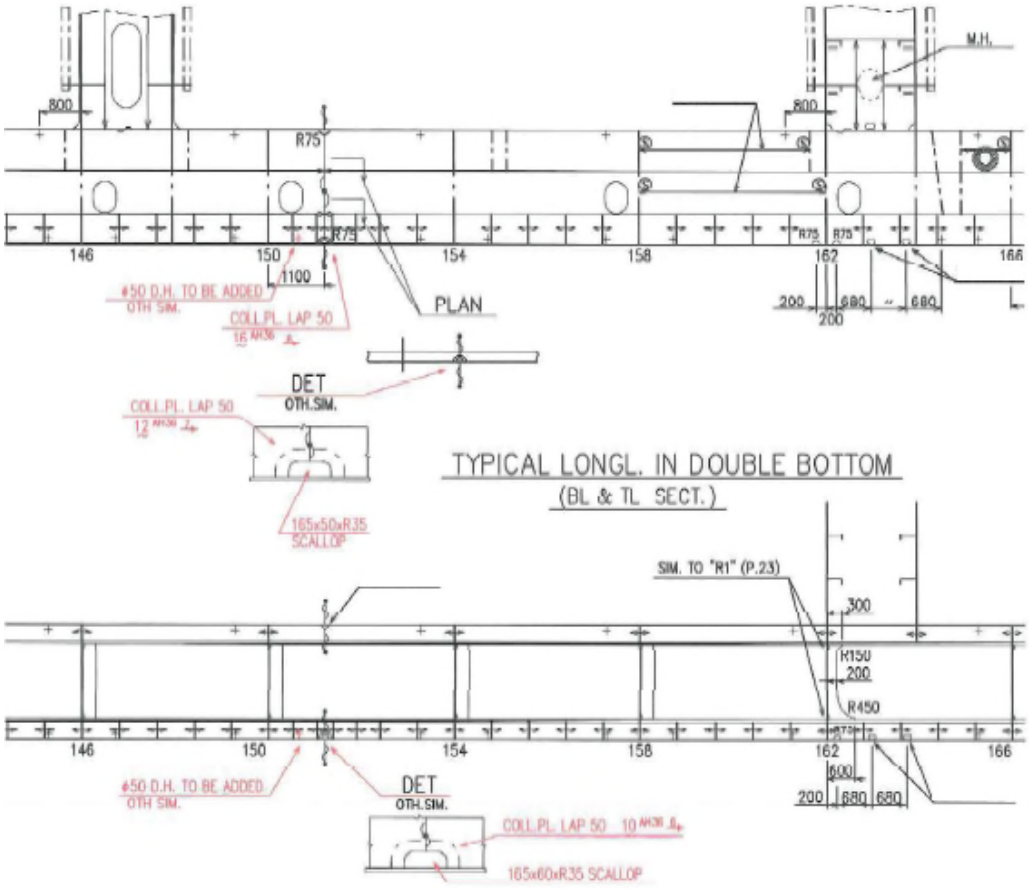
(No.4 CARGO HOLD)

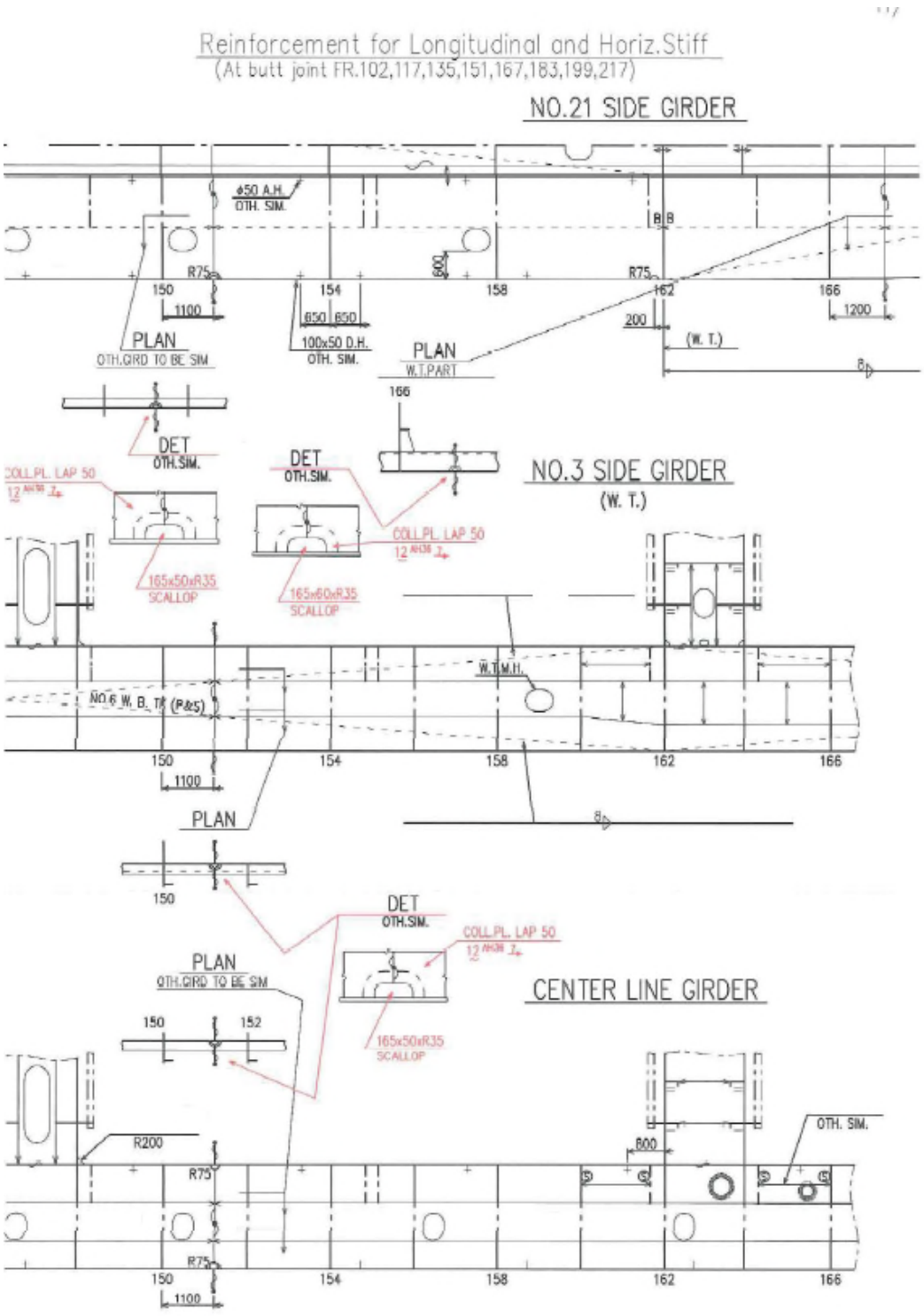



Typical Trans Sect. Ⓑ
Correct by NK
Deleted
SCALLOP R50
OTH.SIM.
R200
OTHERS SIM.
200
250
BASE LINE
851 850 850 851 850 850 851 850 850 851 850 850 851 897 898 898
Typical Trans Sect. Ⓐ
Correct by NK
Deleted
R200
OTH.SIM.
OTHERS SIM.
SCALLOP R50
OTH.SIM.
BASE LINE
Typical Trans Sect. Ⓑ
NO.9 S.G.
NO.3 S.G.
NO.15 S.G.
INN.BOTTOM
R200
OTHERS SIM.
SCALLOP R50
OTH.SIM.
400
BASE LINE
850 850 851 850 850 851 850 850 851 850 850 851 897 898 898
Typical Trans Scct. Ⓐ
R200
OTH.SIM.
OTHERS SIM.
SCALLOP R50
OTH.SIM.
BASE LINE

Reinforcement for Longitudinal and Horiz.Stiff
(At butt joint FR.102,117,135,151,167,183,199,217)

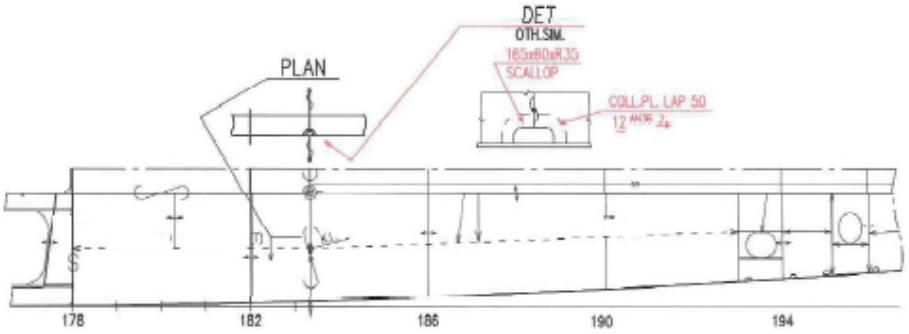
TYPICAL DOUBLE BOTTOM GIRDER
NO.9 SIDE GIRDER



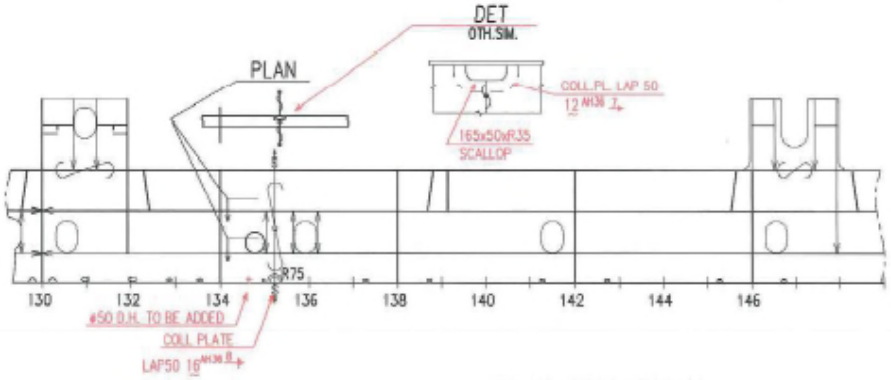

Reinforcement for Longitudinal and Horiz.Stiff
(At butt joint FR.102,117,135,151,167,183,199,217)
NO.21 SIDE GIRDER
ϕ50 A.H.
OTH. SIM.
R75
150
1100
154
650
650
100x50 D.H.
OTH. SIM.
600
158
R75
162
200
(W. T.)
166
1200
PLAN
OTH.GIRD TO BE SIM
PLAN
W.T.PART
DET
OTH.SIM.
COLL.PL. LAP 50
165x50xR35
SCALLOP
DET
OTH.SIM.
COLL.PL. LAP 50
165x60xR35
SCALLOP
NO.3 SIDE GIRDER
(W. T.)
W.T.M.H.
NO.6 W. B. T. (P&S)
150
1100
154
158
162
166
PLAN
150
DET
OTH.SIM.
COLL.PL. LAP 50
PLAN
OTH.GIRD TO BE SIM
150
152
165x50xR35
SCALLOP
CENTER LINE GIRDER
R200
R75
R75
800
OTH. SIM.
150
1100
154
158
162
166

Reinforcement for Longitudinal and Horiz.Stiff
(At butt joint FR.102,117,135,151,167,183,199,217)

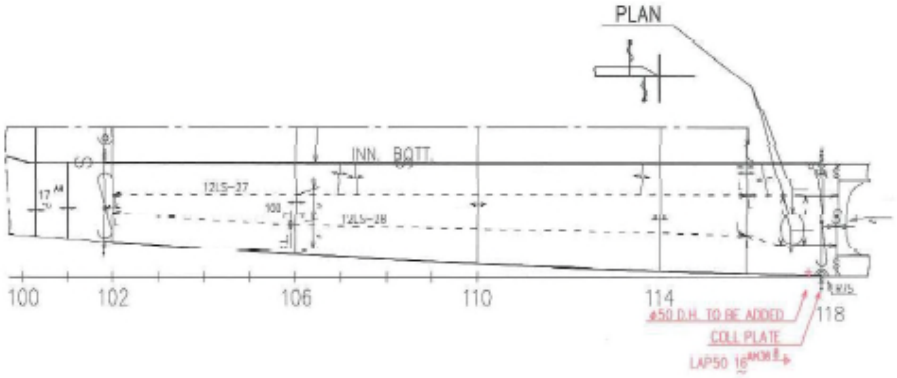
NO.18 SIDE GIRDER



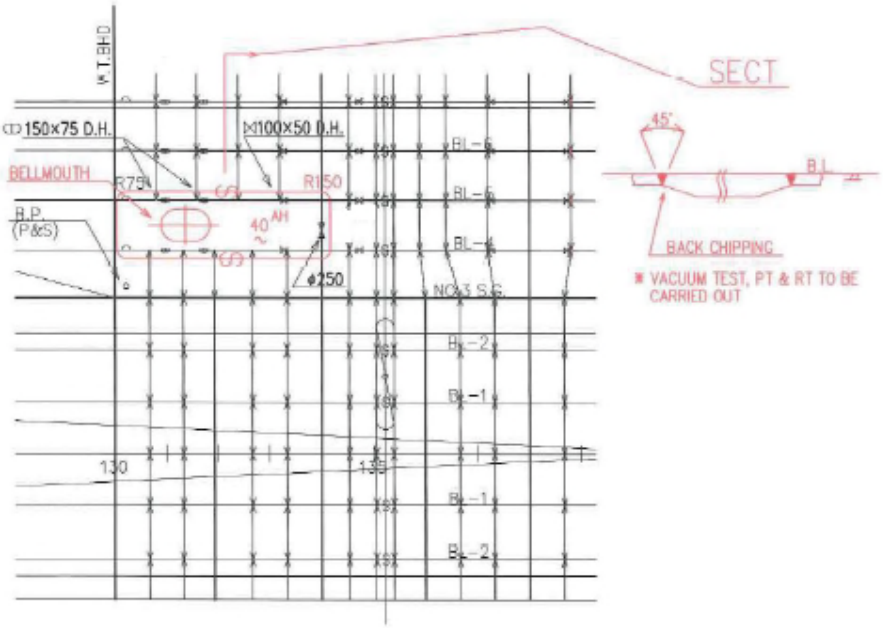
NO.15 SIDE GIRDER



NO.12 SIDE GIRDER



Reinforcement in way of Bellmouth



Arrangement of Bottom Shell Carling (Typical)