The Bahamas Maritime Authority

Report of the investigation into the structural failure of Cargo Hold No.1 "SETSUYO STAR" Fully laden with Iron Ore from Brazil to China June 2006

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1 SUMMARY

1.1 The "Setsuyo Star" is a Cape Sized, dry Bulk Carrier, on passage from Brazil to China in June 2006, fully laden with a cargo of Iron Ore. While on passage, following a period of adverse weather, the crew detected that there was a gradual increase in the hold bilge soundings within No.1 Cargo Hold; water ingress was also detected into the duct keel of the vessel. Further investigation revealed substantial structural damage to the single side shell structure of cargo hold No.1 initially detected on the Port side, but subsequently repairs were required on both the Port and Starboard sides. Seawater was entering the hold through a crack in the side shell plating, approximately 400mm in length and a number of side frames were detached. The vessel, which was approximately 100 nautical miles to the south west of the Cape of Good Hope when the damage was confirmed, immediately put engines to Stand-by and diverted towards Cape Town to seek shelter and a port of refuge. The vessel was granted access to sheltered waters by the South African Maritime Safety Authority (SAMSA), surveyed and temporary repairs were made to the Vessel at False Bay. The temporary repairs were approved by Class BV and enabled the Vessel to complete the intended voyage to China, where the cargo was discharged and permanent repairs were then carried out in dry-dock.

1.2 This report into the casualty sets out to investigate the survey and repair history of the side shell structure of cargo hold No.1 and the potential causes of the damage. Bahamas Maritime Authority (BMA) approved inspectors attended the vessel in South Africa, China and the services of leading industry experts in vessel structural analysis have been retained.

1.3 Recommendations for the shipping industry are considered, especially for dry bulk carriers, which have a well documented history of catastrophic structural failure at sea. These incidents have often resulted in the vessel foundering, with loss of life, due to the rapid sinking of these vessel types. The report will comment on the lessons that can be learned from this extremely serious incident.

2 PARTICULARS OF VESSEL

2.1 "SETSUYO STAR" is a gearless Cape Size, Dry Bulk Carrier registered at Nassau, Bahamas, of welded steel construction having a raised forecastle. The accommodation and machinery spaces are situated at the stern of the vessel. She had the following principal particulars:

- Official Number - 8001168
- IMO Number - 8406391
- Call Sign - C6VI8
- Length overall - 290 metres
- Length BP - 284.03 metres
- Breadth - 46 metres
- Depth - 23.7 metres
- Gross Tonnage - 88,921 tons
- Net Tonnage - 56,133 tons
- Deadweight - 170,808 tonnes

2.2 She is powered by an IHI SULZER RT84 main engine that developed 12050 kW (16372 bhp / 69 rpm) and which drove one, right handed propeller fitted with five fixed blades. She had three main generators 2 x D.G x 700 kW and 1 x S.S.G x 600 kW, that developed a total of 2000 kW.

2.3 The cargo was carried in 9 holds that were arranged from forward to aft.

2.4 The vessel was built in 1984 at ISHIKAWAJIMA HARIMA HEAVY INDUSTRIES Co. Ltd. and named "SETSUYO MARU". At the time of building the vessel was specially strengthened for the carriage of heavy cargoes. The keel was laid on 28 August 1984; the vessel was launched on 01 February 1985 and delivered to Japanese owners on 04 June 1985. The vessel was registered under the Japanese flag and entered with Class NK.

2.5 The "SETSUYO STAR" is one of two vessels constructed by ISHIKAWAJIMA HARIMA HEAVY INDUSTRIES Co. Ltd. In 1986 the keel was laid for a second vessel, ship no: 2912, which was delivered as the "MAGELLAN MARU" IMO: 8512839 (now "ANDROS. WARRIOR").

2.6 At the time of construction of the "SETSUYO STAR", there were no requirements regarding the design life for ships, although it was generally agreed that vessels were constructed for a 20 / 25 year design life.

2.7 At the time of the incident she was owned by SETSUYO MARITIME, managed by CHARTWORLD SHIPPING CORPORATION and chartered to NOBLE CHARTERING Inc of B.V.I.

2.8 The vessel had transferred to the Maltese Flag and was entered with BUREAU VERITAS (BV) Classification Society on 14 April 2001, around the time of the 3rd Special Survey which was conducted on 12 May 2001. The vessel was first registered under the Bahamas Flag on 8 April 2006. At the time of the incident she complied with the all statutory and international requirements and certification.

2.9 "SETSUYO STAR" was last subjected to a Bahamas Maritime Authority Annual Inspection at the Port of RIZHAO, CHINA on 08th April 2006. The following observations were made:

i The vessel was considered to be suitable for permanent registration.

2.10 She had received Port State Control Inspections at the Port of DAMPIER, AUSTRALIA on 09th December 2005 where the following relevant defects were noted:

i There was only one minor ISM related deficiency, the vessel was not detained.

2.11 Photographs of the vessel at False Bay, South Africa in June 2006.

3 NARRATIVE OF EVENTS

3.1 All times noted in this narrative are given in the style of the standard 24 hour clock without additional annotation and as local time at the vessel, which was adjusted on passage to coincide with Local Mean Time (LT). Other timing is noted in brackets.

3.2 The vessel arrived at Sepetiba in Brazil on the 19th May 2006, and went to anchor awaiting a berth for loading. The vessel berthed and commenced loading operations at 2116 LT on the 25th May, the usual loading rate for Iron Ore at this terminal was 16,000 metric tonnes per hour and the vessel was encouraged to minimize ballast upon arrival, in order to avoid any possible delays to the loading operation.

3.3 The loading operation was completed at 0921 LT on 27 May 2006; the Vessel had loaded 167,770 tonnes of Iron Ore at Guaiba Island Terminal, Brazil for discharge at Bayuquan, Peoples Republic of China.

See Appendix "I" Loading Plan and Terminal Instructions in Brazil.

3.4 The sea passage to China commenced at 1330 LT on 27 May 2006. The vessel experienced adverse weather shortly after the commencement of the sea passage, the worst conditions being experienced between the 2 and 5 June 2006 with recorded wind direction various between south east to north east, up to gale force 8 / 9. There was also a heavy easterly swell of up to 7 metres in height. The Vessel was pitching and rolling heavily at times, shipping seas on the weather deck and over the hatch covers. The strongest winds, with the highest seas were experienced on the 2 June 2006 and at 1800LT the course was altered from degrees 100(T) to 115(T), to ease the effect of the heavy north westerly swell, with heavy seas being shipped on deck, up to the height of the hatch covers. The vessel maintained the engine revolutions around 63 RPM throughout, making good an average speed of between 10 to 11 Knots, a course of degrees 095 (T) was resumed on the afternoon of 3 June.

3.5 On 7 June 2006 the bilge sounding of cargo hold No.1 showed an increase in the amount of water present within that space. Due to the high moisture content of the Iron Ore cargo, declared at approximately 9% at the time of loading in Brazil, the mandatory water ingress alarms which were situated in the cargo holds of the Vessel had been turned off, due to them being permanently in alarm. The bilges were being sounded manually.

3.6 On 8 June the bilge soundings of cargo hold No.1 and the duct keel showed a further increase in the amount of water present and the Master and Officers became extremely concerned. The duct keel was entered by the Chief Mate and after further investigation, water was found to be entering that space through an

open bolt hole to a manhole cover situated in the lower stool sloping plating, at the aft transverse bulkhead of cargo hold No.1, from which a bolt was missing.

3.7 On 9 June 2006 the weather abated and with the improving conditions it was possible to arrange an internal inspection of cargo hold No.1, during the internal hold inspection it was found that there was severe damage to the port and starboard side shell frames, with frames reported as detached from the side shell structure and a crack about 400mm in length, in the single side shell plating, resulting in seawater entering into the hold, in way of frame 311 on the port side.

3.8 The Vessel immediately put the engines to standby, the crew were alerted to the very serious situation and an emergency flooding and abandon ship drill was carried out. The Vessel contacted their managing owners and diverted to Cape Town, arriving at Cape Town anchorage at 2045 LT on 9 June 2006 where Company personnel and South African Maritime Safety Authority (SAMSA) Officers attended and inspected Hold No.1, No.1 port double bottom tank and No.1 port top side tank. With the cooperation and agreement of the SAMSA, the decision was made to send the vessel to False Bay in South Africa, together with a tug escort, in order to assess the vessel further and carry out temporary repairs. The Vessel anchored in False Bay at 0825 LT on 11 June 2006.

3.9 The Vessel at anchor, together with a tug escort at False Bay, South Africa.

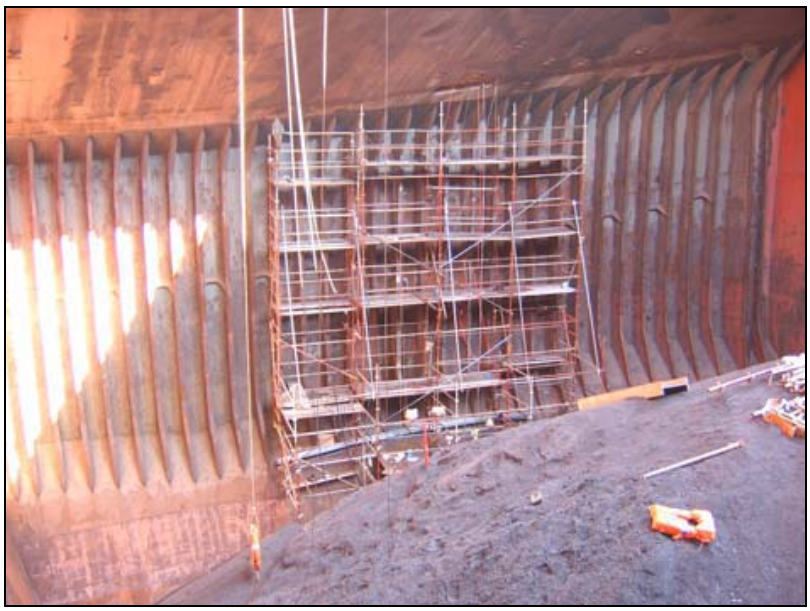
3.10 On 11 June 2006 and subsequent dates a Bureau Veritas (BV) surveyor, attended the vessel to examine the damage in cargo hold 1 and approve the temporary repairs on behalf of Class BV. The BV Survey and Report of attendance (ref LCP0/2006/J0086) on the nature of the damages and temporary repairs carried out when the Vessel was in False Bay is included at Appendix "II" to this report.

See Appendix "II", BV Survey and Report for Temporary Repairs at False Bay

3.11 Temporary repairs at False Bay, photograph of repair material being brought on board the vessel.

Access was cut through the deck of the vessel in order to position and weld the new steel in place, photograph taken on the port side of cargo hold No.1

Inside cargo hold No.1 – Port side, temporary repairs in progress at False Bay, the Iron Ore cargo can be seen in the foreground.



Cargo hold No.1, Port side, frames 312 and 313, temporary repairs in progress, new steel welded to badly corroded / wasted frames.

Cargo hold No.1 – Starboard side, temporary repairs in progress at False Bay.

Following completion of the temporary repairs at False Bay to the damaged side shell structure in cargo hold 1, the vessel resumed the passage to China to discharge the cargo of iron ore. The Vessel was then taken into a repair yard, dry-docked, underwent permanent repairs and the completion of the 4th Special survey, which was due. The permanent repairs were conducted at Guangzhou CSSC-OCEANLINE-GWS Marine Engineering Co. Ltd Shipyard, in China (the "Repair Yard / Dry-dock").

4 ANALYSIS

Impacted Damage

Damage to the shell plating and frames caused by impacting when berthing and alongside loading berths was discounted, having looked at all the evidence available at the time.

Damage and repairs to cargo hold No.1 single side shell and frames

4.1 The Class BV report which was produced following their attendance on board the Vessel at False Bay provides a comprehensive description of the damage to the port and starboard side shell structures in cargo hold No.1 which can be summarised as follows:

4.2 Side shell frames 310, 311, 312, 313 and 314 were detached from the shell plating and tripped. These frames had also cracked over their full depth in way of the connection to the hopper tank end brackets. A section of web plate at frame 316 was also detached.

4.3 Side shell frames 309, 310, 311, 312, 313 were cracked at their upper ends in way of the connection to the topside tank end brackets.

4.4 There was a vertical crack in the side shell plating 350mm to 400mm long at the fillet weld of the web plate of frame 311. The crack was at about mid span of the frame between the top and bottom end brackets.

4.5 The port side shell plating was set in generally over the area of detached and tripped frames. There is no survey information stating the amount the plating was set in, however it was reported as being set in approximately 300mm.

4.6 There was a crack in side shell frame 322 commencing at about mid span. The crack extended the full depth of the frame through the face flat and the web plate and extended upwards at the fillet weld to the shell plating as far as the upper bracket connection to the topside tank.

4.7 It is clear from the photographs supplied by the BMA approved inspectors, together with the photographs in the Class BV report and those taken at the Repair Yard, that there was very significant corrosion wastage to the damaged side shell frames at the starboard side. The areas of greatest diminution were generally found to be in way of the frame connection with shell plating (grooving). It is apparent that in addition to this grooving, corrosion in way of the frames' web plates more likely by pitting, has been present at the time of the Annual and change of flag surveys.

4.8 Thickness measurements of port side frames 306 to 317 and the single skin side shell plating in way, were made when the Vessel was in False Bay. The report of those measurements was attached to the BV report (refer to Appendix "II"). There appear to be two sets of measurements.

4.9 A report of a first set of measurements is dated 17 June 2006 and relates only to port side frames 307 to 317. The report is annotated with the note "BADLY PITTED AND CORRODED AREAS" and thickness measurements show very high levels of diminution in the web plating of a number of the frames. However only two readings are recorded for frames 311 and 313 and none at all for frames 312 and 314 which were the frames exhibiting the worst damage and which are seen to be visibly wasted in the photographs. These measurements show areas of diminution on frames that did not fail of over 50%, for instance at frame 317 close to the side shell. We note that the report of measurements shows certain inconsistencies as it also indicates the original thickness of the web plates as 11mm whereas the correct original thickness is given as 12mm in the second set of measurements.

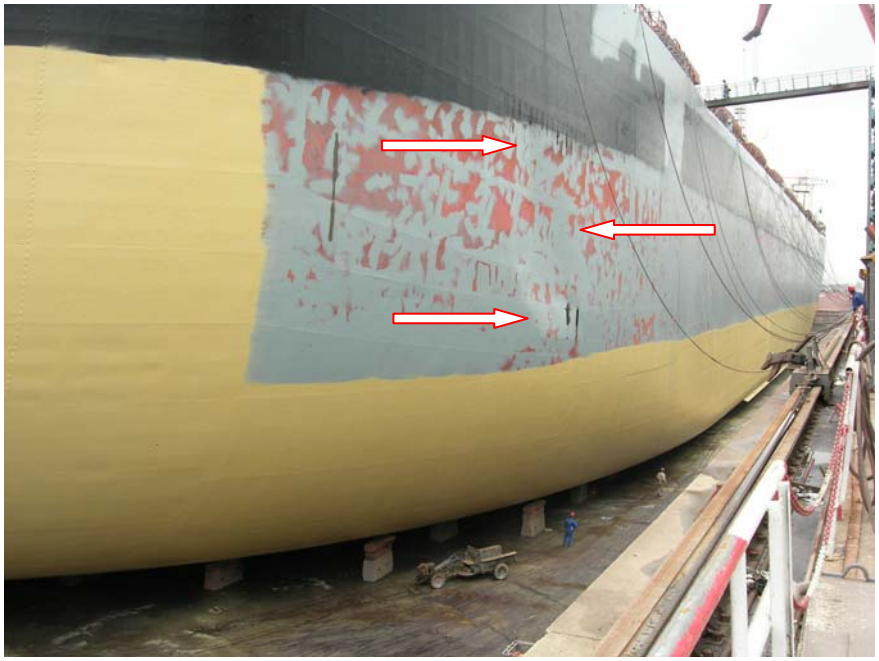
4.10 The first set of measurements also shows locations of significant corrosion of the side shell plating, for instance near to the location of the crack in the shell plating a frame 311.

Cargo hold No.1 – Port side frames 310 and 311, corroded, tripped and detached.

4.11 The second set of measurements is dated 22 June. These exclude measurement of frames 310 to 315 which were the frames that were cracked and detached. These measurements show diminutions of web plates of up to 24.2%, assuming an original thickness of 12mm. Maximum diminution of side shell plating in way of the port side frames was found to be 17.3%.

4.12 At the Repair Yard all side shell frames 293 to 327 at the port side of cargo hold No.1 were renewed between the upper and lower end brackets. All upper brackets were renewed except for frames 326 and 327. The lower brackets of frames 306 to 318 were renewed in their entirety and the lower brackets of frames 294 to 304 were partly renewed. The renewal of frames at the starboard side was nearly as extensive. There was also extensive renewal of the side shell frames in all holds, except hold 6. The Repair Yard record of renewals indicates that renewed frames including upper and lower brackets used web plate of 16mm thickness, stated to be justified as requirement of IACS UR S31. This is a significant increase on the original thickness of 12mm for the frames and 14mm for the lower end brackets.

4.13 Repairs also included the renewal of the single side skin side shell plating at the port side of cargo hold No.1. Where the frames were detached from this area the plating was reported to be "panting", even in the relatively calm and sheltered sea conditions at False Bay. The area of damaged plating is clearly indicated and can be seen "set-in" in the repair- yard photographs below. A section of plating 9m deep and 8 m long between frames 309 and 315 was renewed.



4.14 See Appendix "III" – The appendix shows the extent of the steel replacement that it was carried out on this Vessel, the shaded areas indicating the steel that was replaced at the repair yard in China, following the discharge of the cargo.

Classification and statutory survey history for the Vessel.

4.15 The analysis within this section remarks only on classification or other surveys which are relevant to the examination of the side shell frames in the cargo holds.

4.16 The Vessel was credited by Class BV with a Hull annual Survey before Renewal (Special survey) on 14 March 2001. It appears that prior to this survey the Vessel had been classed by Class NK. The survey report of that survey (BGK0/2001/J0030) confirms that thickness measurements of all shell frames were carried out in the cargo holds. At that survey in cargo hold No.1 at the port side the lower part and lower bracket of frames 294 – 309 and were renewed. At the starboard side the lower part and lower bracket of frames 296 – 309 as well as frames 312-313 were renewed.

See Appendix "IV" – SETSUYO STAR, relevant hull survey data, March 2001

4.17 An intermediate class survey was carried out at COSCO Dalian Shipyard, China in May / June 2004. At that survey, in cargo hold No.1, the mid and upper parts of the port side shell frames 315 to 317 were renewed. There is a report of thickness measurements for the hold frames made prior to renewals at that survey. The diminution to the web plating of port side frames 315 to 317 was measured to be up to 22.3%. The mid part of frames 310 to 314 on the other hand had diminutions in the range 14.1% to 14.8% which was just below the substantial corrosion parameter but not the allowable limit and these frames were not renewed. At the starboard side of cargo hold No.1 a far larger number of frames were renewed.

4.18 At the intermediate survey in all holds, frames were also checked for compliance with IACS unified requirement UR-S31 "Renewal Criteria for Side Shell Frames and Brackets in Single Skin Bulk Carriers or Single Skin OBO Carriers not Built in Accordance with UR S12 Rev.1 or Subsequent Revisions". UR S31 requires that all hold frames are thickness gauged. If the thickness of a frame is less than prescribed by criteria within UR S31 renewal or reinforcing of the frame has to be carried out as necessary. Where thickness of frames is below a prescribed limit grit blasting and epoxy coating or equivalent is applied to the frames. Class BV carried out a study for compliance of the Vessel's hold frames as designed with UR S31 (refer to report HPO/04/01145/EK/lk, dated April 2004). This determined that the lower end and lower bracket of frames 316,317,323,324 and 325 required reinforcing even if in as built condition. BV survey report SG10/2004/J0149 (June 2004) states that on completion of repairs at the intermediate survey the Vessel complied with UR-S31.

4.19 An inspection report prepared by COSCO includes drawings illustrating the renewals made to side shell plating; frames in cargo hold No.1 and other holds (refer to Appendix "V"). This indicates that the lower part (1500 mm length approximately) of frames 315 to 327 as well as the lower brackets at the port side were replaced. The web plate thickness was increased to 16mm from an original

thickness of 12mm for frames 315 to 325 and there was an increase in the scantlings of the face flats. At the starboard side the lower bracket and the lower 1.47 metre length of frames 299 to 325 were replaced. The web plate thickness of the new part of these frames was 16mm which was in place of an original thickness of 12mm. There was also an increase in the scantlings of the face flats. There is no record of epoxy coating of the frames having been carried out. Therefore, at the intermediate survey there was no renewal or strengthening of port side frames 309 to 314 which were the frames that were most damaged in the incident. Furthermore, there was no renewal of frames 310 to 314 at the previous special survey in 2001.

4.20 A hull annual survey was held between 6 and 7 May 2005 (refer to BV report SG10/2005/J0176 dated10/05/2005). The surveyor remarked for cargo hold No.1 and all other holds *"coating found in poor condition, rust and corrosion found to the middle and lower part of side shell frames…"* The surveyor also carried out a close up inspection of *"25% of frames, middle and lower part with attachment and adjacent shell plating"*. However, it was not found necessary to carry out thickness measurements and the surveyor concluded that the structure was satisfactory.

4.21 An Occasional Survey was carried out by Class BV between 7 and 8 April 2006 at Rizhau, China. The Vessel's Class Renewal Survey of the hull (4th Special survey), was due to be completed by 12 May 2006. The Occasional Survey had the scope of an annual survey and was conducted for the vessels change of Flag from Malta to Bahamas (in accordance with IACS PR 28 – Change of Flag) and for postponement of the Renewal Survey to 7 August 2006, due to a lack of available dry-dock facilities. The survey report ref SG10/2006/J0128 confirms that the scope of description of the "Safety Construction" survey for the change of flag was carried out. The survey should have been conducted to the fullest possible extent with the vessel afloat and included an examination of the hold frames in accordance with the requirements of an annual survey as outlined in the "Guidelines on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers" Resolution A.744(18) and in accordance with IACS Requirements concerning SURVEY AND CERTIFICATION. The cargo on board at the time of the survey was Iron Ore, so the majority of the cargo holds area would have been accessible to conduct the necessary hold inspections. This would have included close up examination and thickness measurements if considered necessary. The survey report does not follow the format of an annual survey which would list, in Annexes, the holds examined and describe the condition of the hold frames. The condition of the frames is therefore not recorded. However we understand that the surveyor did not consider it necessary to carry out thickness measurements and was of the opinion that the structure of cargo hold No.1 was satisfactory

Voyage History

4.22 The vessels cargo loading history, following the intermediate survey in May/June 2004 was as follows:

Port	Arrival	Sailing	Reason	Remarks / Cargo
Dalian	**12.05.04**	**28.06.04**	**DD/Repairs**	**Intermediate survey**
Yosu	29.06.04	29.06.04	Bunkers	
Dampier	10.07.04	17.07.04	Loading	Iron Ore - 161,974MT Fines
Yantai	29.07.04	05.08.04	Discharge	Iron Ore - 161,974MT Fines
		02.08.04	Bunkers	
Port Hedland	17.08.04	25.08.04	Loading	Yantai Iron Ore - 149,667MT Fines
Tobata	08.09.04	14.09.04	Discharge	Yantai Iron Ore - 40,502MT
Nagoya	16.09.04	19.09.04	Discharge	Yantai Iron Ore -109,165MT
Dalrymple Bay	30.09.04	30.10.04	Loading	Coal - 153,598MT Oaky North Coking Coal North Goonyella Coal Coppabella Coal Burton Semi Hard Coal
Kimitsu	11.11.04	14.11.04	Discharge	Coal - 84,100MT
Nagoya	16.11.04	18.11.04	Discharge	Coal - 69,498MT
Haypoint	29.11.04	04.12.04	Loading	Coal - 154,021MT Saraji Coking Coal Peak Down Coking Coal
Kwangyang	17.12.04	20.12.04	Discharge	Coal - 154,021MT
Singapore	27.12.04	28.12.04	Owners	
Mormugao	04.01.05	14.01.05	Loading	Iron Ore - 156,475MT Fines
Jeddah		22.01.05	Bunkers	
Suez	24.01.05	25.01.05	Transit	
Kalamata	28.01.05	28.01.05	Owners	
Ijmuiden	06.02.05	13.02.05	Discharge	Iron Ore - 156,373MT
			Bunkers	
Ponta do Ubu	01.03.05	05.03.05	Loading	Iron Ore - 165,906MT Pellets
Singapore	10.04.05	10.04.05	Bunkers	
Qingdao	18.04.05	08.05.05	Discharge	Iron Ore - 165,753MT
Port Hedland	19.05.05	25.05.05	Loading	Iron Ore - 166,578MT Fines, Lump
Qingdao	05.06.05	20.06.05	Discharge	

Port	Arrival	Sailing	Reason	Remarks / Cargo
Esperance	06.07.05	09.07.05	Loading	Iron Ore - 165,000MT Fines, Lump
Qingdao	26.07.05	31.07.05	Discharge	Iron Ore - 165,022.664MT
Port Walcott	13.08.05	17.08.05	Loading	Iron Ore - 165,000MT Fines, Lump
Rizhao	30.08.05	05.09.05	Discharge	Iron Ore - 165,196MT
Port Hedland	17.09.05	19.09.05	Loading	Iron Ore - 166,547MT Fines, Lump
Beilun	04.10.05	07.10.05	Discharge	Iron Ore - 166,626MT
Port Walcott	17.10.05	31.10.05	Loading	Iron Ore - 166,957MT Fines, Lump
Qingdao	12.11.05	21.11.05	Discharge	Iron Ore - 167,030MT
Dampier	02.12.05	11.12.05	Loading	Iron Ore - 164,248MT Fines, Lump
Rizhao	24.12.05	01.01.06	Discharge	
Port Dampier	12.01.06	06.02.06	Loading	Iron Ore - 143,033MT Fines, Lump
Singapore	12.02.06	13.02.06	Bunkers	
Xingang	23.02.06	27.02.06	Discharge	Iron Ore - 143,078MT
Dampier	11.03.06	18.03.06	Loading	Iron Ore - 166,682MT
Rizhao		10.04.06	Discharge	Iron Ore - 166,778MT
Singapore	18.04.06	19.04.06	Bunkers	
Guaiba Island	19.05.06	27.05.06	Loading	Iron Ore - 167,777MT Corse Sinter Feed

4.23 It can be seen that following the intermediate survey in May / June 2004 the vessel performed two voyages carrying Iron Ore. It then carried two cargoes of Coal between September and December 2004. It then carried ten further Iron Ore cargoes before the voyage of the incident, the average loading rates of these cargoes were between 3500 and 4500 MT/H. With all Iron Ore cargoes being loaded homogeneously throughout the length of the vessel, the practice of alternate cargo hold loading with Iron Ore was not utilized during the time the vessel was under Chartworld Shipping Corporation management.

Cause of damage

Within this section we analysis the various contributory factors which affected the Vessel, resulting in the damage sustained during the laden voyage.

Weather

4.24 The weather conditions experienced were heavy but not of a severity that should have caused the failure of side shell frames in the cargo holds, unless there was a pre-existing weakness. The vessel is recorded as having experienced heavy pitching and rolling in seas that were initially from starboard and subsequently on the port side. The vessel was also shipping seas on deck forward to the height of the hatch covers. It is very likely that the seas and swell caused particularly high pressure loads on the port and starboard single side shell structure of cargo hold No.1, but should not have caused the structural failure experienced.

4.25 The relatively long duration of the heavy weather is likely to have been a factor in the development of the damages, particularly in consideration of the pre-existing structural weakness.

4.26 While the Master altered course from 100(T) to 115(T) to ease the effects of the worst weather conditions on the vessel, it was not considered necessary to substantially reduce the vessels speed, the maximum engine revolutions were 69 RPM and the maximum, laden service speed advised as 12.5 knots. The vessel was proceeding at 63rpm and making good an average speed of between 10 and 11 knots. Commercial considerations of the Charter Party may have influenced this decision.

4.27 Without the fitting of Hull Stress Monitoring Equipment it can be difficult for mariners on very large vessels of this type, at a relatively remote location on the bridge, to fully appreciate the stress that the hull structure is being placed under in the forward part of a large vessel. This is particularly true during periods of prolonged adverse weather. Mariners need to be alert to the inherent dangers of subjecting any Vessel, but particularly large vessels of this type, to excessive forces during adverse weather and a further reduction in the vessels speed may have been considered. The managing owners have now introduced independent weather routing requirements on all their vessels to assist the vessels and reduce the commercial pressure on the master to maintain a speed / ETA, as may be determined within a Charter Party.

Corrosion Wastage

4.28 There is clear evidence that there was severe corrosion wastage of frames 310 to 314 at the port side of cargo hold No.1, particularly toward the side shells which became detached from the side shell plating and were buckled. The severity of the corrosion would have resulted in a substantial reduction in the web plate buckling strength. The damage to frames 310 to 314 is typical of that resulting

from corrosion wastage allowing buckling of the web plate and/or detachment of the web plate from the shell plating under the influence of hydrostatic and wave pressure loading. Buckling and/or detachment of the frame from the side shell plate would allow the unsupported plating to "pant" excessively in a seaway and to be set in permanently. The breaking of the frames 310 to 314 on the port side at the connection with the lower bracket and at the connection with the upper bracket is likely to have occurred as a consequence of the detachment and buckling of the web plates. The severity of the wastage and resultant damage can be clearly seen in the photograph below.

4.29 It is interesting to note that, at the intermediate survey in 2004, the web plate thickness of the lower part of starboard frames 310 to 315 was measured at approximately 9.2mm but that the web plate thickness at the port frames was approximately 11.8mm. The starboard side web plate plates were renewed with 16mm plating as stated previously, but the port side plating was not renewed at the lower part of the frame. The one thickness measurement of frame 310 port following the incident shows a diminution of over 50% (thickness of 5.7mm). This is consistent with the nature of the damage exhibited in photographs of the area within this report (see also Appendix "II" the Class BV Report). The available measurements therefore indicate a very significant amount of corrosion wastage occurred to the web plate of those frames between May 2004 and June 2006, the severity of which went undetected at all surveys and inspections. However, there does not appear to have been the same degree of corrosion wastage to the lower parts of the webs of frames 316 and 317 which had been renewed with 16mm plate in 2004. Conversely, the upper parts of frames 316

and 317 which had measured thickness of approximately 11.4mm in June 2004 showed thickness reduced to as little as about 3mm (75% diminution).

4.30 These measurements and observations lead to the conclusion that there had been far greater rates of corrosion to the old steel than to the adjacent new steel inserted in 2004.

4.31 The area of failure within the old steel structure is also adjacent to the area of new steel inserted into the vessel in 2004, an issue of increasing concern which has been raised and considered as a contributory factor in previous casualty incidents.

4.32 Within the excellent report promptly provided by Class BV, see appendix "II" there is some concern expressed with respect to how the measurements were taken at previous surveys.

".....that previous thickness measurements taken of the shell plate frames in hold number 1 do not accurately reflect the poor state of the frames, in particular the "grooving" wastage. Close-up examination of some shell frames adjacent to the damage indicate initial buckling of webs in way of excessive wastage and compressive loads".

There are a few major points of concern for the industry to consider within this area, as a result of this incident, which are already common knowledge:-

i. The point at which survey structural measurements are taken is critical and dependent upon the training and skill of the attendant UTM Company personnel, to perform the detailed ultrasonic measurement work. With a team of technicians taking ultrasonic structural measurements, it is very difficult, if not impossible, for a trained Classification Surveyor to be in attendance at all times.

ii. Leading on from the point above there are no specific, industry wide training guidelines available for training technicians within the marine environment in ultrasonic measurement, as there are within the civil construction or aviation industry. The point at which measurements are taken is critical, especially when "pitting" and "grooving" are clearly evident within the structural members, as they were on this vessel.

iii. A measurement taken in the base of a pit or groove within the steel structure will be substantially different and reflect a considerably different perspective of the vessel, from a measurement taken alongside a pit or groove, through the thicker / less corroded steel. There are no specific clear guidelines, applied uniformly across the marine industry. Refer also to A744(18).

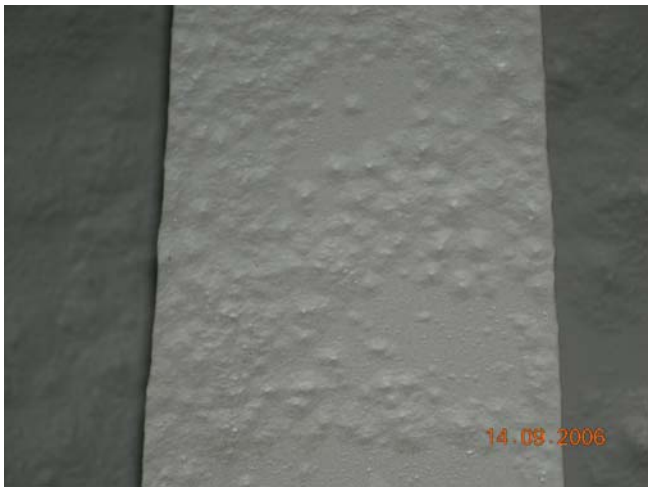
iv The lack of proper facilities being available to conduct a "close up" inspection was a major contributory factor within this incident. The photograph below illustrates how the managing owners have elected to address this problem by installing the permanent means of access; they have incorporated within the cargo holds on "SETSUYO STAR" at the repair-yard following the casualty in 2006. Round bars have been welded across every third frame, at Owners' recommendation, for the purpose of providing access for close-up inspections.

4.33 The thickness measurement of the shell plating in the vicinity of frames 310 to 314 taken in June 2006 also shows very significant wastage. The crack on the side shell plating at frame 311 appears to have been associated with an area of grooving corrosion adjacent to the frame. It is likely that the crack opened up because of the excessive panting and deformation to the plating that occurred following the failure and detachment of frames 310 to 314.

4.34 The failure of the upper part of frame 322 at the starboard side may also have resulted from a reduction in strength of that frame from corrosion. However, no thickness gauging measurements are available for this frame following the incident. It is probable that the cracks in the face plate of the frame resulted in a bending weakness and that the crack propagated by fatigue upwards.

Coal Cargoes

4.35 The problems associated with the corrosive effects of coal cargoes and the accelerated corrosive effects that can be experienced in ship's cargo holds are well documented. The hull structure can become seriously weakened by the accelerated corrosion within a relatively short time frame. Some grades of coal can contain a high level of sulphur and should the coal be loaded in a damp or wet condition and/or become wet during transit due to sweat or water ingress, the resultant damp environment and the subsequent production of sulphuric acid will greatly accelerate the corrosive process. This is often marked by the presence of "pitting" in the cargo hold plating and frames. There is significant pitting evident in the hold plating and frames on the vessel, as shown in the photograph below which was taken in the repair yard and is just one example of "pitting" on a cargo hold frame.



4.36 The "SETSUYO STAR" had a cargo history of carrying Iron Ore and Coal cargoes, which would have made the vessel particularly susceptible to any accelerated corrosive effects. Cargo hold coatings tend to be badly damaged by the high impacts associated with the loading and discharge of Iron Ore, which would have left the hold steel-work exposed and vulnerable to the more corrosive environment associated with coal. The vessel carried two consecutive coal cargoes between 30th September and 20th December 2004, see table of vessels loading history.

4.37 The cargo hold coatings were reported to be; "coatings found in poor condition, rust and corrosion found to the middle and lower part of side shell frames…" However it was not considered necessary to address this problem.

See Appendix "VII" – IMO Resolution A.866 (20) Bulk Carrier Inspections.

See Appendix "VIII" – West of England report, Structural Failure in Bulk Carriers.

4.38 The steel frame replacement within all cargo holds, with the exception of hold 6, following the incident was very extensive. Hold 6 was a designated ballast hold, within which the hold protective coating was reported to be in much better condition than the other non-ballast holds. The action of flooding this hold with ballast water following the carriage of a corrosive cargo, together with the much better intact protective coating would have substantially reduced any residual corrosive effect on the hold structure, more effectively than water-jet washing.

4.38 See appendix "III" – Repair Yard steel replacement, and the photographs below showing a sample of the corroded / wasted steel work which was cropped out of the vessel at the repair yard.

5 CONCLUSIONS

5.1 The vessel would have suffered a complete catastrophe had the frame and side shell failure in cargo hold No.1 not been detected by the crew and appropriate remedial action taken swiftly by the Master to seek shelter at a port of refuge, supported by the vessel's Managing Owners and SAMSA, despite adverse environmental protests

5.2 The major cause of the failure of side shell in cargo hold No.1 was corrosion wastage to the frames and in particular the web plate of the frames. Had the occasional Survey at the time of the Change of Flag been conducted to its fullest extent it is likely that the structural issues in No. 1 Cargo Hold would have become apparent.

5.3 The Vessel and crew were very fortunate, that the crew vigilance, followed by prompt action on the part of the Master, Managing Owners and SAMSA saved this vessel. It also allowed the vessel to be closely examined. Had the vessel been in a worse condition, it could have foundered and had the vessel been in a slightly better condition it would have gone through the 4th Special Survey, having the corroded steel cropped and renewed – without necessarily attracting special attention. There appears to be no system for analysing survey reports to identify corrosion trends and hot spots. More specific instructions should be provided regarding verification that the condition of the ship is properly maintained in accordance with the relevant requirements. Particular attention should be given to structural areas such as connections of frames to shell, where there are possibilities for corrosion to build up undetected, unless a thorough cleaning of the areas is carried out followed by a detailed close-up survey.

See Annex A7 Resolution A.744(18) Part 1 "Guidelines on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers"

5.4 It appears that a very significant amount of corrosion wastage to the port side shell frames 310 to 314 occurred over the two year period from the time of the intermediate survey in June 2004 to the time of the incident in June 2006. The cargoes carried during this period were Iron Ore, together with two consecutive cargoes of more potentially corrosive coal. No additional inspections of side shell frames were carried out following the carriage of the coal cargoes so far as it is known.

5.5 In June 2004 frames 310 to 314 were examined for Class compliance with IACS UR-S31. This included thickness measurements. It was found unnecessary for strengthening and/or part renewals to frames 310 to 314 port. The web plates of these frames had an original thickness of 12mm but had suffered only moderate wastage at that time by reference to the original thickness. There was no thickness gauging of these frames at the annual surveys in 2005 or the annual/change of class survey in 2006. These frames were not coated at the intermediate survey.

See Appendix "X" – IACS Unified Requirements S31

5.6 The vessel was in Class with all certification valid. The severe wastage of the frames which failed as detailed above was not detected and rectified within the current Classification Society survey and Statutory Survey regimes or by any other inspections conducted on the vessel during the previous two year period. This calls into question the adequacy of the present inspection and survey regime. Concern had been expressed by the attending Class Surveyor with respect to the accuracy of the survey regime on this vessel.

See Appendix "II" - BV Survey and Report for Temporary Repairs in False Bay

5.7 The facilities to conduct a close-up inspection of the area which failed were not readily available. Previous surveys of the area since 2004 had been conducted during cargo operations, with hold access gained on top of the cargo or by "riding squads" on passage. The inadequacy of this practice has been recognised and it has been discontinued by the current managing owners. They have now incorporated a permanent means of access within the cargo holds on their vessels, as a direct result of this incident. In this case the owners provided permanent access by welding steel bars into every third side shell frame within the cargo holds. This solution facilitates the close up inspection of all areas of the cargo holds, to prevent a repetition of this extremely serious incident. Periodic inspection of this facility should ensure that previous cargo has not collected behind the welded bars. It is however recommended that the condition of these means of access is regularly monitored in order to confirm that their continued effectiveness. It is further recommended that this practice be further investigated for further possible improvement.

See Appendix "XII" – Timeline of Surveys and Inspections 2005 - 2006

5.8 The side shell and frame failure in cargo hold No.1 occurred within an area where new steel had previously been connected to old existing steel. The older steel was corroded at a faster rate than the newly installed steel and failed. The repaired frames in which only part of the steel has been replaced may suffer similar differential corrosion rates and will require monitoring.

5.9 The replacement of 12mm steel with 16mm steel, where a frame is partially replaced, may result in a difference in rigidity between the two parts of the structure. This could result in cracking or buckling especially at the connection of the two.

See Appendix "XI" – IACS No.47 Shipbuilding and Repair Quality Standard

5.10 Due to the change of flag from Malta to the Bahamas, at the Owners request, with Class BV approval and Bahamas Flag State agreement, the Vessel's class renewal survey of the hull (4th Special survey), which was due to be completed by 12 May 2006 was postponed until 7 August 2006, due to a lack of dry dock facilities. The vessel underwent an Occasional survey, which had the scope of an Annual survey, for the change of Flag and in order to allow the postponement of the Renewal survey to7 August 2006. However the Occasional survey conducted by Class BV failed to detect the serious problems in cargo hold No.1, which became evident during the subsequent voyage. Had the 4th Special survey been conducted to its fullest extent, when due, it would have detected the severe corrosion.

5.11 The swift action by the Master, Managing Owners and the cooperation of the SAMSA contributed towards preventing a potential loss of the vessel, of life and associated environmental pollution which could have resulted. The resistance of SAMSA to strident environmentalist protests within the South African press at the time of the incident, calling for the vessel to be sent away, back out to sea, is a credit to that Authority. This is a fine example of how the provision of a sheltered location for a vessel experiencing difficulty to conduct repairs, in a port of refuge, prevented the loss of that vessel with no environmental damage. Once SAMSA had established that the vessel was well managed, fully Classified and operating under a reputable Flag State Administration, they cooperated fully with all parties concerned to bring about a successful conclusion.

5.12 Soon after the commencement of the voyage, the water ingress alarms sounded and were isolated, the initial assumption to the water ingress alarms being caused by the high 9% water content within the Iron Ore cargo. Manual bilge sounding were commenced and taken daily. The crew detected the initial structural failure of the hull and flooding of cargo hold No.1 at an early stage, having noted a slight increase in the bilge soundings. Further manual bilge soundings were taken the next day which showed a further increase in the sounding, which was confirmed by an Inspection of the Duct Keel.
It wasn't until 48 hours from the initial increase in the bilge soundings; following improvement in the weather conditions, that it was possible to arrange internal inspection of cargo hold No. 1. Only then were the emergency procedures activated by the Master.

5.13 The high loading rates at certain Iron Ore terminals (specifically in Brazil at 16,000 MT/H) are far in excess of the average bulk carrier's ballast pump capacity. The high stresses associated with entering port with minimum ballast in order to meet Port Authority and Charter requirements, while not a direct contributory factor in this case, are of increasing concern within the industry. The commercial pressures to meet the high demands for fast loading rates must not compromise the loading vessel's safety, by encouraging (or forcing) vessels under threat of financial penalties, to exceed the vessel's maximum permissible stresses. The average loading rate achieved for the vessel on this occasion was 4660 MT/H.

5.14 The Class BV Occasional survey proved to be inadequate, as it failed to detect the severe structural problems within cargo hold No.1 which became apparent during the subsequent voyage.

6 RECOMMENDATIONS

6.1 IMO, Classification Societies

6.1.1 The current Classification Society survey and Statutory Survey regimes failed to detect the potentially catastrophic weakness in cargo hold No.1, which was due to excessive corrosion within the hull structure. This should be re-examined to determine what improvements can be made to prevent a reoccurrence.

6.2 IMO, Governments and Classification Societies

6.2.1 The apparent similarity of this incident to the tragic loss of the "Alexandros T", a very similar ship and cargo, lost on passage in the same area, only five weeks previously is of extreme concern. The acceptance of water ingress alarms (assuming false alarms being due to the high water content of the Cargo) without further immediate investigation on bulk carriers should be avoided in light of the circumstances relating to this incident. Numerous technical publications have highlighted this matter which should be re-emphasised, including IMO MSC Circular 1143 "Guidelines on Early Assessment of Hull Damage and Possible need for abandonment of Bulk Carriers"

See Appendix "VI", Water Ingress Alarms and Relevant Press Articles

6.2.2 The postponement of major surveys, and in particular Special Surveys, especially on Bulk Carriers should be avoided, especially for any vessels approaching the end of their design life.

6.2.3 Consideration should be given to additional strength being added in areas where shell plating has been replaced as well as the effect of differential corrosion in areas adjacent to joining of new to old steel, where it appears that the rate of wastage of the old material appears to be substantially increasing.

6.2.4 The requirements and standards of cargo hold protective coatings should be re-examined, the corrosive effects of many bulk cargoes are well documented and it is notable that the only hold on this vessel which was not severely corroded, requiring extensive steel replacement was cargo hold No.6, being a designated ballast hold. The hold protective coating was maintained to a much higher standard than the other cargo holds, which had protective coatings in a poor condition. Within the current regulations, it was not considered necessary to address this problem.

6.2.5 Permanent arrangements for access to all remote and high risk areas within the cargo holds be considered for existing vessels, currently only a requirement for bulk carriers constructed on or after 1 January 2006.

6.2.6 Consideration should be given to the analysis of badly corroded and wasted steelwork removed from the vessel as reported in accordance with Resolution A.744(18) "Guidelines on the Enhanced Programme of Inspections during Surveys of Bulk Carriers" in order to identify corrosion trends and "hot spots"

6.3 Governments:

6.3.1 In the light of the experience of the SETSUYO STAR and with regard to Resolution A.949 (23) the need for "Port of Refuge" to be available should be re-emphasised.

6.4 Ship Owners, Managers and Charterers:

6.4.1 The crew, owners and terminals need to ensure that the cargo loading rate is appropriate to the age and the overall condition of the vessel.

6.4.2 Additional visual inspection may be required to be carried out by crew and/or surveyors with regard to the ship's structure following carriage of corrosive cargoes, such as coal.

6.4.3 During periods of prolonged adverse weather Masters should consider all possible options to reduce the stress on any seaworthy vessel by altering course and/or a reduction of speed.

6.4.4 Owners should consider the use of Independent Weather Routing.

6.5 Government of the St. Vincent and The Grenadines

6.5.1 In the context of the ongoing losses of Bulk Carriers, this report should be sent to the St. Vincent and The Grenadines, being the Flag State of the "Alexandros T". Five weeks previously, on 3rd May 2006, the St. Vincent and Grenadines registered vessel, Classified by LR "ALEXANDROS T", a very similar (but not an identical or sister vessel) on a similar voyage from Brazil to China with a cargo of Iron Ore, sank 300 miles off the South African Coast with the loss of 26 lives. The "ALEXANDROS T" was reported to be in Class and with all its certificates valid, as was the "SETSUYO STAR".

See Appendix "IX" – INTERCARGO Bulk Carrier Casualty Report 2006

6.6 Government of Panama

6.6.1 This report should be sent to Panama, being the Flag State of the Andros Warrior (ex Magellan Maru).