Departmental investigation into the structural failure of a cargo crane on the vessel LODZ 2 in the port of Melbourne on 7 March 1997

Report No. 110

Australia
Department of Workplace Relations
and Small Business

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Navigation Act 1912
Navigation (Marine Casualty) Regulations
investigation into the structural failure
of a cargo crane on the vessel
LODZ 2
in the port of Melbourne on 7 March 1997

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Investigations into marine casualties occurring within the Commonwealth's jurisdiction are conducted under the provisions of the Navigation (Marine Casualty) Regulations, made pursuant to subsections 425 (1) (ea) and 425 (1AAA) of the *Navigation Act 1912*. The Regulations provide discretionary powers to the Inspector to investigate incidents as defined by the Regulations. Where an investigation is undertaken the Inspector must submit a report to the Secretary of the Department.

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Summary

On 7 March 1997, the Polish flag general cargo vessel *Lodz 2* was lying at no. 24 berth, Victoria Dock, Melbourne. Using one of the its own cranes, the ship was discharging a general cargo of steel products, including bundles of steel pipes, from no. 2 hold and tweendeck.

At about 0740, the sixth load of steel pipes, for that morning, was being discharged onto the wharf by no.1 crane, a 12.5 tonne capacity crane situated on the aft end of the forecastle on the ship's centreline. The crane was being driven by one of the waterside workers.

The load, weighing approximately 8.6 tonnes, consisted of 18 lengths with diameters varying up to 273 mm. As the load reached the side of the ship, there was a violent jolt and a bang as the slew bearing failed, then the crane fell from its pedestal into the port tweendeck of no. 2 hold. The jib struck the port bulwark, setting it down and out from the ship's side, while the body of the crane hit the inboard edge of the port hatch coaming, before rotating through 180° and finishing up, upside-down, in the tweendeck.

The driver was able to climb out through one of the broken cab windows and up the ladders, out of the tweendeck to the main deck, before the effects of shock caught up with him. He had fallen, in the cab of the crane, approximately 17 metres into the tweendeck from the crane's position on its pedestal.

An ambulance was called and the crane driver and a waterside worker acting as the hatchman, also suffering from shock, were taken to a medical clinic but were not detained. The crane was severely damaged and the badly twisted jib had to be cut up to remove it from the ship.

The incident was investigated by the Marine Incident Investigation Unit under the provisions of the Navigation (Marine Casualty) Regulations.

Sources of information

The Master, officers and crrew of *Lodz 2.*

Patrick the Australian Stevedore

Australian Maritime Safety Authority

Maritime Union of Australia

Robert Reid and Associates Pty Ltd

Peter Raymond and Associates Pty Ltd

Towimor S.A.

Consolidated Bearing Co. (NSW) Pty Ltd

Imtec Pty Ltd.

Amalgamated Marine Engineers Pty Ltd

Acknowledgement

Analysis of particles of dried grease from the slew bearing of no. 1 crane was carried out by the Australian Federal Police Scientific Branch, Canberra.

Lodz 2

Lodz 2 is a Polish flag, semi-container, tweendecker, general cargo vessel of 11,574 gross registered tonnes fitted with six cargo cranes and two derricks. It has a length of 149.01 m, a beam of 21.98 m and a moulded depth of 12.02 m. The main engine is a 6 cylinder Sulzer 6RTA58 two-stroke single-acting diesel engine of 7,080 kW driving a single screw and giving the vessel a maximum service speed of 16 knots. The vessel is classed with the Polish Register, Polski Rejestr Statków.

The ship was built in 1988 in Gdynia, Poland, by the Stocznia im. Komuny Paryskiej shipyard. It was originally named *Lodz 2,* but its name was later changed to *Pineseas Venture,* before being renamed *Lodz 2* in February of 1997. It is owned and operated by POL - America Inc. of Gdynia, Poland.

As a general cargo vessel, *Lodz 2* was employed, before the incident, on voyages between ports of the Philippines, Taiwan, Korea, China, Thailand, Singapore, Indonesia and the Australian ports of Fremantle, Brisbane, Sydney and Melbourne. It has a crew of 25 consisting of the Master, three deck officers, a "deck assistant", a radio officer, four engineer officers, two electricians, a Bosun, a deck fitter, two motormen, a cook and two stewards, five seamen and a storekeeper.

The Master, officers and crew were all Polish nationals.

The Incident

At 1130 on 5 March 1997, *Lodz 2* arrived at the Melbourne pilot station after a passage from Fremantle, West Australia. The ship was carrying 20-foot containers on deck and a general cargo of steel products in the holds, including bundles of steel pipes, in various sizes, and rolls of steel sheet. The cargo of steel products had been loaded at Inchon in Korea, where the voyage had originated.

The ship was first berthed at Webb Dock, where it discharged 217 containers, before moving to Victoria Dock to discharge the steel cargo.

On the morning of 7 March 1997, a fine, sunny day with no wind, *Lodz 2* was lying at no.24 berth in Victoria Dock. The ship was due to sail that evening. Shortly after 0700, the morning shift of stevedore employees commenced work, resuming the discharge of bundles of steel pipes which had been started the previous day. The discharge of the cargo was being carried out using the ship's own cranes, there being no craneage facilities at the berth.

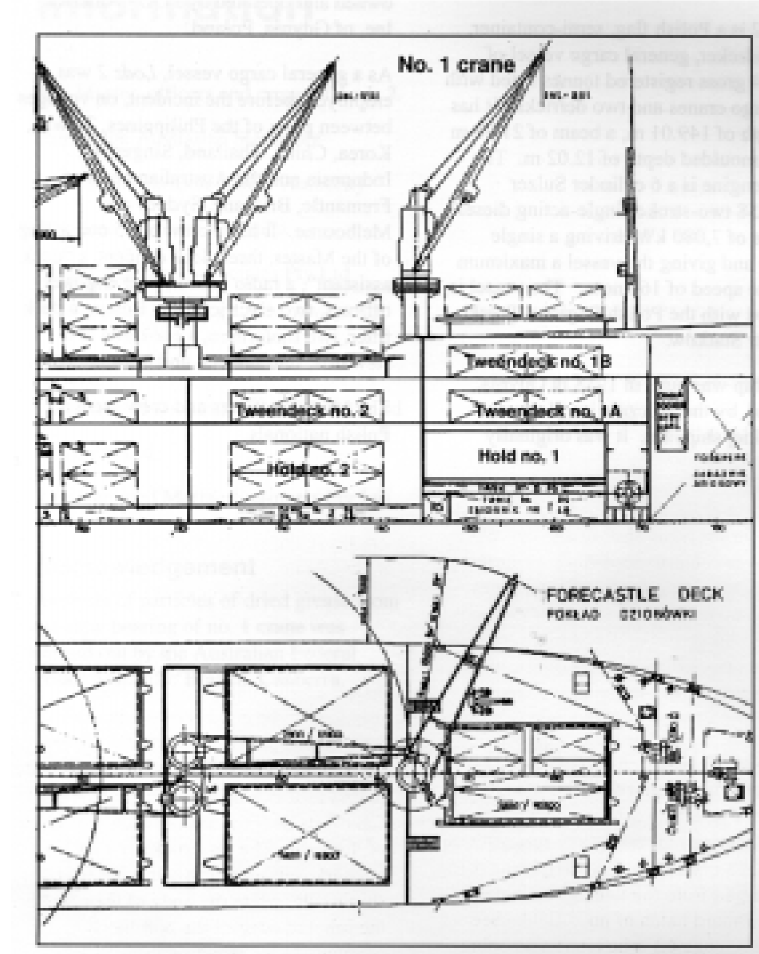


Diagram showing layout of fore-part of Lodz 2

By about 0735, five loads of steel pipes had been discharged onto the wharf by no. 1 crane, a 12.5 tonne capacity crane situated on the aft end of the forecastle on the ship's centreline. The cargo was being discharged from the tweendeck beneath the starboard hatch of no. 2 hold. (See diagram, above.) The crane was being driven by one of the waterside workers, while their Foreman was in the hold supervising three members of his shift, hooking the pre-slung bundles of pipes onto the crane hook to form each load. The Shift Supervisor, accompanied by three other members of the shift, was in charge of receiving the loads on the wharf. A "hatchman", also a waterside worker, directed the crane from a position at the hatch coaming. The bundles of steel pipes were 12.1 m in length while the distance between the forward and aft coamings of the hatch was 12.8 m, giving a fore-and-aft clearance of only 350 mm at each end.

The sixth load of pipes, consisting of 18 lengths and of diameters varying up to 273 mm, was lifted from the hold. The crane driver tapped one end of the load against the folded hatch covers, to swing it around and so position it for moving across the ship, then started to slew the crane towards the port side and the wharf. The load was about one metre above the hatch. As the load reached the side of the ship, the crane driver checked the slewing gauge in his cab to see if the head of the jib was in the right position to plumb the cradle on the wharf, out of his line of sight. At that moment he felt a violent jolt and heard a bang, then sensed that he was plunging into the hold.

The hatchman, at the coaming of the starboard side hatch on no. 2 hold, watched as the crane slewed the load towards the port side. As it did so, he heard a loud cracking noise, such as a tree makes as it is felled, then the whole crane fell off its pedestal and into the port side of the hold. The jib struck the port bulwark, setting it down and out from the ship's side, while the body of the crane hit the inboard edge of the port hatch coaming, before rotating through 180° and finishing up, upside-down, in the tweendecks. (See photographs, in Comment and Analysis.)

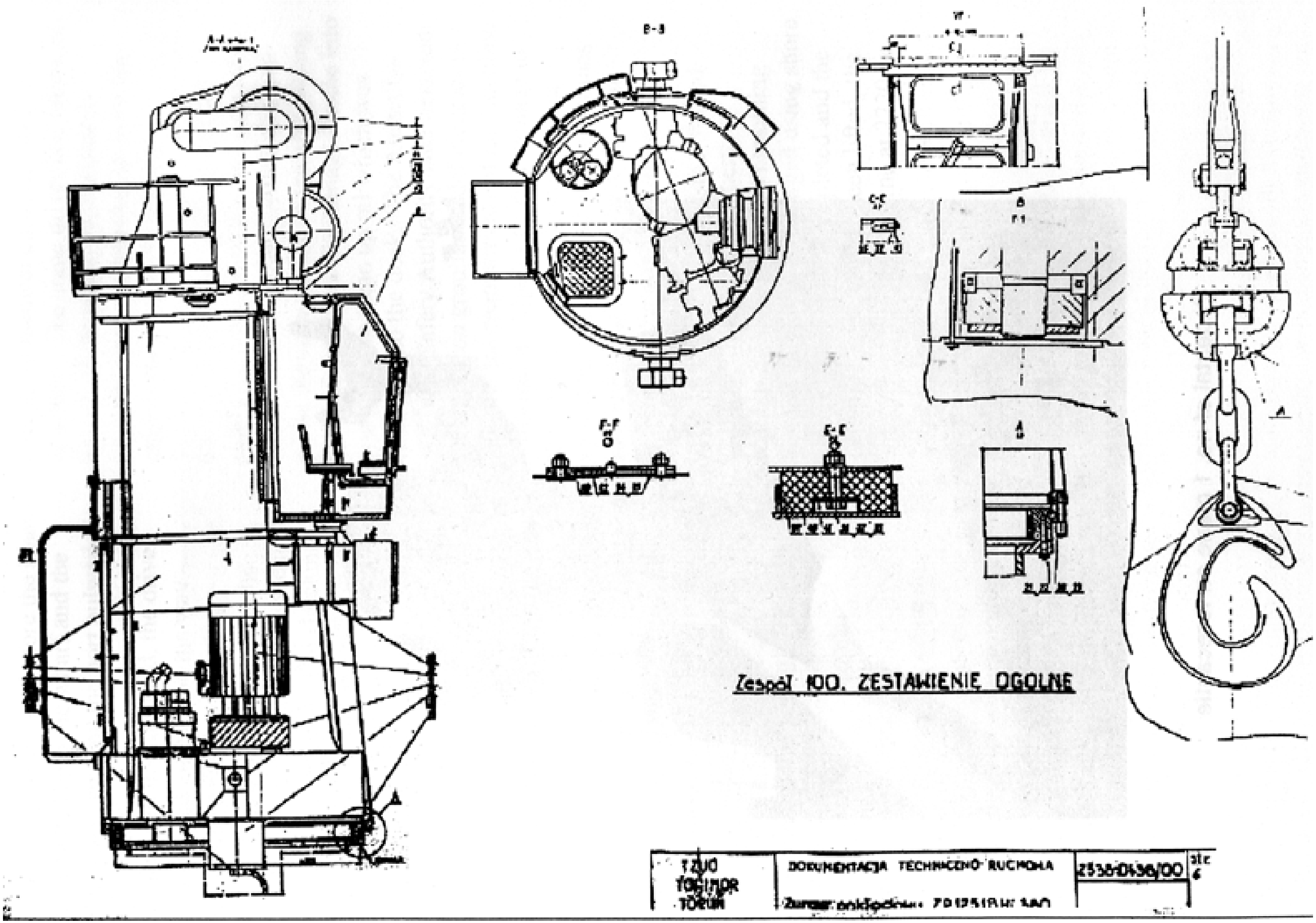
The waterside workers on the wharf were watching the crane slew the load, to a position outboard of the ship's side and about 3 or 4 m above the wharf, when they saw, what appeared to them to be, the jib buckling, an instant before the load of pipes crashed onto the wharf and the jib came down, striking the port bulwark.

As the crane fell into the hold, the driver in the cab closed his eyes on the way down. He was next aware of glass smashing all around him, but when he opened his eyes, to his surprise he seemed to be relatively uninjured. The Hatchman ran down into the hold to assist the crane driver, along with the other waterside workers who had been working in the starboard side of the tweendeck, but the driver climbed out through one of the broken cab windows and up the ladders, out of the tweendeck to the main deck, before the effects of shock caught up with him.

Those on the wharf, seeing the collapse of the crane, shouted to the clerks in the Stevedoring company office, above the shed at no. 24 wharf, to call an ambulance. This they immediately did, the time of the call being recorded at the ambulance station as 0740. A Port of Melbourne Emergency Service ambulance arrived at the vessel at 0744. Both the crane driver and the Hatchman, who was also suffering from shock, were taken to a doctor at a medical clinic but were not detained. The crane driver had fallen, in the cab of the crane, approximately 17 metres into the tweendeck from the crane's position on its pedestal.

Shortly after the incident, one of the ship's electricians arrived and isolated electrical power to the crane's pedestal while the crew started to transfer leaking hydraulic oil from the damaged crane into drums and to clean up oil which was spilling onto the deck. The Australian Maritime Safety Authority later detained the vessel on grounds of deficiencies in meeting the requirements of the Loadline Convention, stipulating that damage to the bulwark and port hatch coaming should be repaired, and all other cranes inspected and load tested, before the detention order would be lifted.

At 2115 on 13 March, *Lodz 2* shifted from Victoria Dock to D berth at Appleton Dock, where the remaining general cargo was discharged using shore cranes. The repairs completed and the detention order having been lifted, the ship sailed from Melbourne at 2220 on 16 March.



Cross section of the crane body

showing machinery compartment and cab

Comment and Analysis

Cranes

The ship's six cargo jib cranes, all of similar construction, were manufactured by the Polish company Towimor S.A. of Torun. The foremost crane, no. 1, on the forecastle, had a safe working load (SWL) of 12.5 tonnes with a jib working radius of 3.8 to 18 metres. Nos. 2 and 3 cranes, in a "Gemini" arrangement on a single pedestal, also have the same SWL and can work to the same radii. (Photo, Frontispiece.)

Nos. 4 and 5 cranes, although of similar construction and in a "Gemini" arrangement, have double sheaves and an SWL of 25 tonnes at the same radii. no. 6, the aftermost crane, is also of 25 tonne capacity but, like no. 1, is a single crane. All the cranes are of electro-hydraulic operation, with the machinery located in the body of the crane, and controlled from a cab set into the top of the crane body above the machinery compartment. (See drawing, previous page.)

Inside the cab there are the usual controls for luffing, slewing and hoisting, actuated by a joystick. There is no load gauge, but indicators are fitted to show the outreach of the jib and the angle of slew.

Damage

Shortly after the incident, the wreckage of the crane was examined, as was the damage to the structure of the vessel. The port bulwark and its stanchions, in way of no. 2 hatch, was set out and down over a length of approximately 8.5 m. The inboard side of the no. 2 port hatch coaming was set down over a length of approximately one metre where it had been struck by the body of the crane. An area of the hatch at the bottom of the port tweendeck was dented where it had arrested the fall of the crane body and the guardrails around the top of the crane's pedestal were severely damaged.

The jib of the crane was extensively buckled and had to be cut up in order to be removed. (See photo, next page.) Its lower end had parted from the trunnion bearings on the body of the crane during the incident. The exterior fittings on the body of the crane had suffered extensive damage, but it was not possible to

Jib of no. 1 crane lying over the port side of the vessel

Body of no. 1crane lying upside-down in no. 2 port tweendeck

assess what damage had occurred to the machinery or to the structure of the crane body itself, although it was evident that the crane's slew ring bearing had experienced a catastrophic failure.

The swivel at the top of the ponder ball, above the hook, was found to have parted during the incident.

Evidence of earlier repairs was found, where steel doublers had been welded to the jib. This was at a critical load area of the jib, approximately 2 m from the trunnion bearing or hinge pin. This may indicate that a significant force or tipping moment had been placed on the slew ring bearing at some time before the incident under investigation, although it would not have been the immediate cause of the crane's collapse.

Witnesses who were on the wharf when the crane collapsed were adamant that the jib buckled before the crane collapsed. Evidence from those on the deck of the vessel indicated that it did not, until it struck the hatch coaming and the bulwark. Examination of the jib after the incident did not reveal any evidence to support the theory that buckling of the jib had been an initiating factor in the collapse. All agreed, however, that the incident happened extremely quickly, and it is quite possible that the motion of the crane as it fell provided an illusion of the jib buckling to those seeing it from their positions on the wharf.

The load

The driver of the crane that morning was highly experienced and had worked on the waterfront for 47 years. He had been driving cranes for approximately 30 of those years. On that morning shift, the waterside workers were taking particular care to lift only relatively light loads, well below the crane's SWL, as, the previous evening, there had been an incident (qv) in which the load had fallen from a crane and two of the ship's cranes were already condemned by AMSA.

The sixth load to be discharged from no. 2 starboard tweendeck that morning consisted of 3 lengths of steel pipe with an outside diameter of 273 mm and a wall thickness of 9.7 mm, 10 lengths with an O.D. of 114.3 mm and a wall thickness of 13.5 mm and 5 lengths of 141.3 mm O.D with a wall thickness of 12.3 mm. All the lengths were 12.1 m long and were banded into bundles. The bundles were pre-slung, i.e. the lifting slings were already in position on each bundle when the cargo was loaded at its port of origin. The weight of each bundle was originally supplied on a tag attached to it, but several of the tags were missing or else it was not possible for the stevedores to read the tags as the pipes were lying on top of them. In these instances it was the responsibility of the Foreman of the waterside workers to estimate the weight and allocate bundles for each load. The Foreman would be in possession of a copy of the cargo stowage plan. Should the load be too heavy for a crane, this would become immediately apparent to the crane driver through the response of the hydraulics which powered the crane.

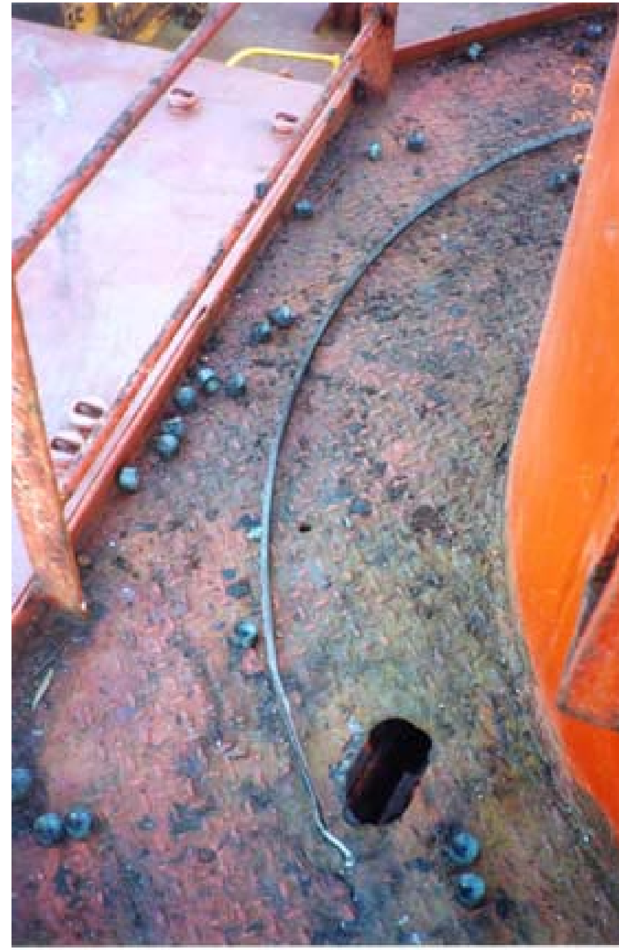
After the incident, the sixth load, of 18 pipes, was carefully measured while lying on the wharf and its weight calculated. The total volume of steel was found to be 1.11 m^3 and the weight, taking a specific gravity of 7.8 for the steel, as 8.66 tonnes. Allowing approximately 1 tonne for the weight of the spreader and the chains, the total weight on the crane at the time of the incident was approximately 9.7 tonnes. This is rather more than the reported weight, estimated by the waterside workers, of 5 to 7 tonnes but, nevertheless, it is well within the crane's maximum safe working load of 12.5 tonnes; the crane was not overloaded.

Hook

The fracture surface of the failed swivel above the ponder ball was examined. The surface did not exhibit the characteristics of a fatigue failure, but appeared to be fine-grained and smooth and the evidence would indicate that the swivel snapped under a tensile load caused by the jib recoiling after it had struck the bulwark. The hook and spreader beam had landed on the concrete wharf further outboard from the load of pipes, which had suffered relatively little damage. This would further indicate that the swivel fractured during recoil of the jib as, if it had failed before the load struck the ground, the hook and spreader would have landed on top of the load of pipes and they would have suffered significant damage.

Bearing

The crane's slew ring bearing is a four-point (angular) contact single row ball bearing 2.25 m in diameter, manufactured by Hoesch Rothe Erde in Germany. The balls, approximately 150 in number, are each 35 mm in diameter and are separated by plastic (nylon or teflon) spacers. The outer race is drilled for 12 grease points and grease is distributed along the row of balls via small grooves set into the middle of the groove for the balls in each race. Grease seals are carried by the outer race above and below the row of balls. The inside of the inner race carries the annular ring of gear teeth which mesh with the slewing pinion, driven by the slewing motor. A diagrammatic sketch of the bearing arrangement is shown next page.



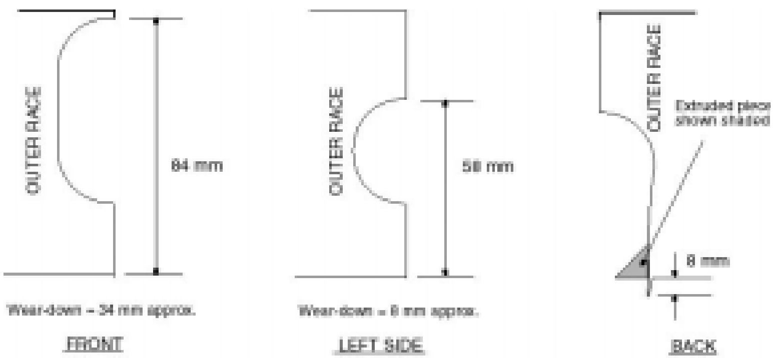
Bearing debris
Lower edge of outer race, sheared off, surrounded by balls and spacers from the bearing

After the incident, the bearing was examined. The outer race had remained attached to the crane body and the inner, to the pedestal. There had been no failure of the bearing bolt securing system. The balls and the plastic spacers had been scattered around the pedestal. There was little evidence of grease on any of the bearing components, which were quite dry, and the outer race showed that extensive wear had been occurring before the failure. A curved strip of steel, about 2 m long and of roughly triangular section, was found on the platform around the pedestal. (Photo opposite.) It was severely worn and the two ends exhibited evidence of a fracture surface, tapering away, although the centre section appeared to have been sheared off and partly extruded, forming a knife edge. Further examination of the remains of the outer race, on the crane body in the tweendeck, indicated that this strip of steel had been the lower, inner edge of the outer race, from a position directly opposite that of the jib.

The construction of the crane is such that the entire weight of the crane and the forces generated by the tipping moment when the jib is extended and carrying a load, are taken by the slew ring bearing. When the jib is extended to 18 m and carrying the maximum safe working load of 12.5 tonnes, the upward force at

Outer race bearing

Note secondary roller path, the result of extreme wear, and absence of grease



Wear down of the outer race

Inner race of bearing on crane pedestal

Note absence of lubricant in groove (grease on top has been extruded from internal ring gear)

the rear of the crane (opposite the jib), where the outer race failed, would be in excess of 200 tonnes. This force is resisted solely by the wedging effect of the balls in their grooves.

An angular-contact bearing is designed to withstand greater thrust in one direction than the other. The critical loaded areas of the slew ring bearing are in line with the centreline of the jib. At the front of the crane, under the driver’s cab, the direction of loading of the bearing was downwards and the forces borne by the larger contact surface. However, at the opposite side, the rear of the crane, the force is acting upwards, against the smaller angular contact surfaces of the bearing. This was the area over which the bearing had worn the most and where the failure had been initiated. There was no device, incorporated in the crane design, to prevent the crane separating from the pedestal in the event of a total failure of the slew ring bearing. Such a device, in the form of a safety or retaining ring, is incorporated into some designs.

Bearing wear

The evidence indicated that the surfaces of the grooves in the bearing had been wearing over a considerable period of time. A secondary roller path had been formed in the outer race indicating that the crane had been operating for an extended period of time in a very badly worn condition. Wear eventually progressed to the point where there was insufficient material remaining at the lower edge of the outer race to withstand the upward forces generated during normal crane operations. What remained of the lower edge had finally been sheared off.

In bearings of this size, the surfaces of the grooves in which the balls run are usually induction hardened (to a Rockwell $_c$ number of around 57) to a depth of only about 5 mm. The underlying steel remains in a soft condition. The process of induction hardening cannot easily be carried out around the full 360°, and where it starts and ends, a short “soft spot” remains. This spot is usually marked with a stamp in the metal and the bearing is installed in such a position that the soft spot is located at a point where the bearing loading would be at a minimum - in this instance, at one side or the other, 90° from the jib.

The wear observed at the lower side of the outer race was extreme and is depicted in the following diagram on the previous page.

At the front of the crane the outer race wear down amounted to some 34 mm. At the left side, on the "neutral axis" where the loading is not so severe, it was 8 mm and at the back the lower edge had gone. The right-hand diagram, below, depicts the position from which the strip, found on the platform around the pedestal, had been sheared and extruded. Once the hardened surface of the grooves had been worn away, the wear would have progressed comparatively rapidly through the underlying, unhardened, steel.

Wear-down of the bearing should be monitored as part of normal planned maintenance and survey procedures. The degree of bearing wear-down, with the resultant excessive clearance between the bearing elements, found in the no.1 crane, would have been immediately obvious during a proper routine examination. No manufacturer's handbook, or other information giving the allowable wear tolerances and detailing the procedure for measuring this clearance, was held on board *Lodz 2.*

Lubrication

The severe wear observed in the outer race appeared to be due to a complete absence of proper lubrication.

Lodz 2 had no planned maintenance schedule detailing either the routines for the maintenance of deck machinery or the types of lubricants to be used in each application.

Greasing of the cranes, and other deck machinery, is normally carried out by the Shipwright, (whose function is performed by one of the deck ratings) on instructions from the Chief Officer. The Chief Officer checks the wires and sheaves before each port where the cranes are to be used and issues instructions for greasing as appropriate. It was stated in evidence to the investigation that if the cranes are not used for a lengthy period then they are given a greasing at 3 monthly intervals.

The Shipwright on board *Lodz 2*, at the time of the incident, had joined the vessel for the first time only three weeks earlier when it was at Singapore. He had inherited no records of work done, or greasing routines, from his predecessor and had received no instructions to grease the slew ring bearings during the time he had been on board. He was unaware of the existance of any different grades of grease, apart from a single Polish "standard" grease.

The cranes showed evidence of sufficient grease having been applied to the sheaves, wires, hook swivels, and other components, but not to the slew ring bearings. The slew ring gear teeth, on the inside of the inner bearing race of the no. 1 crane, were greased but the 12 grease nipples and the grease passages in the outer race were quite dry. It was evident that these grease nipples had been neglected for a long period of time.

Information regarding lubrication and maintenance was obtained from the bearing manufacturers, and also from other manufacturers of very similar types of crane slew ring bearings. This information states specifically that, under no circumstances must greases containing Molybdenum Disulphide (MS_2) be used in this type of bearing. The effect of MS_2 grease is to cause a plating effect in the raceway upon which the balls will start to slide instead of roll, thus significantly increasing the wear rate.

To ascertain whether or not MS_2 grease had been used in the bearing at some time in the past, two of the balls from the bearing were sent to the Australian Federal Police forensic laboratories for analysis of the minute residue of dried grease remaining in scratches and indentations on them. A negative result showed that the use of MS_2 had not been a contributing factor in the failure.

Various manufacturers indicate that the frequency of greasing varies considerably with the utilization and the environmental conditions. A general recommendation is every 150 hours in 'normal' usage. This however, would reduce to every 50 working hours where the environment is severe, dusty or wet. A crane exposed to salt water spray on the forecastle of an ocean-going vessel would fall into the latter category. Greasing is also required before and after long idle periods.

According to instructions provided by the manufacturers, there is a specific quantity of grease which should be applied, depending on the size of the bearing. In the case of the no. 1 crane on *Lodz 2*, the slew bearing should be purged through with a total of approximately 1.8 kgs of grease, applied over a period of every three months and in all cases a light extrusion of grease should appear at the grease seals. The lubrication must be done while the crane is rotating on its slew bearing.

The manufacturers also recommend that at intervals of 6 months, samples of grease should be drawn from the bearings and sent for analysis in order to further assess the condition of the bearing.

The Chief Officer on *Lodz 2* kept a log of work carried out on the deck cranes. This contained a page for each of the deck cranes, and each contained entries for general inspections, changing of wires, greasing etc. spread over the years 1988 to 1997.

The majority of entries in the page for no. 1 deck crane relate specifically to greasing of the crane rigging, however there are three entries which state simply (translated from Polish):-

Greasing points 01/08/94 Job done
Greasing points 20/01/95 Job done
Greasing points March 1995 Job done

There is an inference that these entries would include the greasing points on the slew bearing.

Only one entry, that of 13 January 1997, refers specifically to the slew bearing (*rotating device*) and states, (again, translated from Polish):-

Runner, topping lift, 13/01/97

Greasing of ropes, greasing rotating device and runner ball points, rotating device, chain swivel and runner ball

The date of this entry is only seven weeks before the failure of the slew bearing. The condition of the bearing when examined after the incident showed that, the above entry notwithstanding, grease had not been applied to the bearing.

This same entry was made for the other five deck cranes and dated *13/01/97* or *14/01/97* in each case.

The same book contained pages on which was maintained a log of quarterly inspections of the cranes. The last entry on this page was dated 13-18 January 1997 and states (translated):-

Good condition. Inspection of equipment. Inspection of audited equipment – comparison with certificates …..

The four previous entries, one dated during 1995 and three during 1996 state simply:- *Quarterly inspection*

Maintenance

Maintenance routines for bearings of this type are usually documented in detail by the manufacturers. It is particularly important to check that the required level of preload[1] in the bolts, which secure the inner and outer races to the crane structure, is still maintained. These fasteners are essentially working in fatigue, being subjected to constantly fluctuating loads as the crane is loaded, unloaded and rotated. A systematic yearly check of the preload should be carried out on these bolts, although some manufacturers recommend that this be done as frequently as every three months.

In the case of the no. 1 crane on *Lodz 2*, there were indications that there had been movement between each of the bearing elements and their respective support or bearing structures. This was made apparent by rust stains coming through circumferential cracks in the paint at the mating surfaces. This showed that the preload on the bolts, mentioned above, no longer existed.

Any wear in the raceway of this type of bearing is revealed by a change in the axial clearances. This can be determined by measuring the tilting clearance (using a dial test indicator) at a number of locations around the periphery of the bearing. The crane has firstly to be subject to a test load and a measurement taken, then unloaded and jacked up under the jib to effectively rock it on the bearing, and the clearance is measured. This procedure is repeated at each of about 8 azimuth positions of the crane. However, for the amount of <u>wear</u> to be accurately determined it is necessary to know the clearances obtained when the crane was newly installed. This provides a 'base' value for subsequent repeat measurements which, the bearing manufacturers recommend, should be carried out every 12 months.

Neither these base values, nor the results of subsequent measurements were recorded on *Lodz 2*.

Following the failure of no. 1 crane, the Australian Maritime Safety Authority detained the vessel on two grounds, firstly for repairs to be carried out to the damaged bulwark and hatch coaming and, secondly, pending load testing and examination of all the remaining cranes.

In addition to the load testing, nos. 2, 3, 4 & 5 cranes had deflections and their bearing clearances measured. However, the results obtained showed that the clearances in the slew ring bearings of all the other cranes were, according to figures for allowable wear obtained from the vessel's owners, well within the limits. Information from the crane manufacturers indicated that the bearing clearance, when new, was 0.8 mm, and the allowable wear was 2.0 mm, thus the maximum allowable clearance is 2.8 mm.

The difference between the relatively minor wear in the bearings of these cranes and the extreme wear in the slew bearing of no. 1 crane, remains unexplained.

Previous incidents

The driver of no. 1 crane on the morning of 7 March had, the previous day, been driving no. 2 crane to plumb the same hold and had found the crane difficult to control smoothly, particularly in slewing. It was reported to the investigation that no.2 crane had been making some of the same cracking noises which had emanated from no. 1 just before it collapsed. No. 2 crane would briefly fail to respond to a movement of the slewing control, but would then lurch rapidly around. For this reason, the waterside workers had chosen to use no. 1 crane the following day. No.1 crane was smoother, but its machinery was exceptionally noisy and the driver was not able to hear what was going on below him.

On the evening of 6 March, an incident had occurred while lifting a load of cargo from the lower hold. The load had cleared the hatch coaming when the slings parted and the load dropped back into the hold. The slings which had parted were those of the pre-slung cargo. Nobody was injured, but the waterside workers subsequently requested the Australian Maritime Safety Authority to inspect the cargo working gear aboard *Lodz 2*. During this inspection, it was found that the wire on the luffing spool of no.4 crane was frayed and AMSA condemned the crane until such time as the wire was renewed. It was on account of these factors that the waterside workers, on the morning when no.1 crane collapsed, were taking particular care to discharge only light loads, well below the crane's SWL.

Lodz 2 had arrived at the port of Melbourne with no.6 crane also condemned by AMSA.

On 6 January 1997, while the ship was at Sydney, no. 6 crane, with a SWL of 25 tonnes, was being used to load a 40 ft container onto the ship from the wharf. The container weighed

18.4 tonnes. Just as the container was clear of the wharf, by about 15 cm, there was a bang and the sheave from the crane's single runner lead was seen to fly through the air, landing about 10 m from the ship's side, before rolling and striking a fork lift truck about 20 m from the point of impact, narrowly missing a number of waterside workers.

The failure was brought about by the shearing of six studs which secured the bush, on which the sheave was mounted, to the side of the runner wire drum.

The crane was condemned by AMSA until such time as it was satisfactorily repaired and fully load-tested. This had not been done by the time *Lodz 2* arrived in Melbourne two months later and no.6 crane remained out of service.

Surveys, tests and certification

The Register of Ship's Lifting Appliances for *Lodz 2* was issued on 14 October 1994. It was issued by the Polish classification society Polski Rejestr Statków.

Note 2, for Part 1 of the Register, states:

The thorough examinations to be indicated in column 3 or 6 include:

a) *Initial*

b) *12 Monthly*

c) *Five yearly*

d) *Repair/damage*

e) *Other thorough examinations*

An entry dated 30 September 1992 and stamped by the society records that all six deck cranes had undergone a five-yearly examination. No defects were recorded in the "Remarks" column.

A Certificate of Load Test for the six deck cranes, was issued by the Polish Register at Gdynia on 30 September 1992.

The only other certificate available to the investigation and dated later than the vessel's building, was a survey report on lifting appliances issued at Melbourne on 16 December 1996 by a Polish Register surveyor; less than three months before the incident. Although it is not stated on the survey report, it is probable that this survey, carried out at the request of the owner, was the 12 monthly examination due a year after the previous one dated
7 December 1995.

This report listed the lifting appliances on board *Lodz 2*, but contained no other information whatsoever to indicate what kind of examination or tests were carried out, or the results. No entry was recorded in the Register of Ship's Lifting Appliances regarding this survey.

Examinations

The ILO Convention No. 152, article 23, paragraph 2 states:-

"'A thorough examination' means a detailed visual examination, supplemented, if necessary, by other suitable means or measures in order to arrive at a reliable conclusion of safety.

If necessary for this purpose, parts of the Lifting Appliances must be dismantled."

Entries dated 20 September 1993,
14 October 1994 and 7 December 1995 and stamped by the Polish Register, indicated that 12 monthly examinations had been carried out on these dates. Only one entry in the "Remarks" column indicates any defect and that states simply "*Deck crane No.6 is out of order till overload test*" this entry is dated 19 August 1995. No further information regarding the defect is recorded but there is a subsequent entry, dated 23 August 1995, which states "*Deck crane No.6 has been load tested with 30t. Hamburg, on behalf of Polski Rejestr Statków*". The entry is stamped by the German classification society Germanischer Lloyd.

Lodz 2 would have been due for its five-yearly survey of lifting appliances on 30 September 1997. It is evident, however, that the interim 12 monthly examinations, between 30 September 1992 and 7 March 1997 when no. 1 crane failed catastrophically, could not have included an assessment of the wear in the slew ring bearing for that crane. This is particularly true in the case of the 12 monthly examination carried out in December 1996 by which time the wear in the slew bearing would have been extreme.

Conclusions

These conclusions identify the different factors which contributed to the circumstances and causes of the incident and should not be read as apportioning blame or liability to any particular organisation or individual.

1. No. 1 deck crane collapsed due to a catastrophic failure of the slew ring bearing. The crane was not overloaded at the time of the failure.
2. The slew ring bearing failed following a prolonged period of progressive wear which went undetected at any statutory survey or examination.
3. The extreme wear which led to the bearing failure was induced largely by an almost total absence of lubrication for the bearing.
4. The vessel had no established planned maintenance or lubrication schedules for the deck cranes.
5. There was no record relating specifically to a measurement of the bearing clearances at any time since the vessel was built, and there was no record on board of the initial bearing clearances, by which the wear rate could have been established.
6. Damage to the jib of the crane, as witnessed by repairs, may also indicate that damage to the slew ring bearing was initiated by some earlier incident.
7. The standard of record keeping and the absence of detail in certification, together with the condition of the slew bearing of no. 1 crane at the time of the incident, would suggest that the standard of survey over the last five years had not been of an acceptable quality.

Submissions

The provisions of sub-regulation 16 (3) of the Navigation (Marine Casualty) Regulations require if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or relevant part of the report. Sub-regulation 16(4) provides that such a person may submit written comments or information relating to the report.

The final draft of the report, or parts thereof, was sent to the following:

The Master, LODZ 2

POL-America Inc.

Polish Register of Shipping

Patrick Stevedores

The crane driver

An acknowledgment was received from:

Patrick Stevedores

The crane driver

In both cases the text was amended where necessary. Patrick Stevedores submitted further that:

The injuries to the crane driver have in fact turned out to be quite persistent and he is still suffering physical problems arising from the accident." (Submission dated 19 December 1997)

Details of Lodz 2

IMO No.	8302234
Flag	Poland
Classification Society	Polski Rejestr Statków
Ship Type	General cargo
Builder	Stocznia im. Komuny Paryskiej, Gdynia Poland
Year Built	1988
Owner	POL - America Inc.
Operator	POL - America Inc.
Gross tonnage	11,574 tonnes
Net tonnage	6,180 tonnes
Length overall	149.00 m
Beam	22.01 m
Depth (moulded)	12.02 m
Engine	Sulzer, 6 cylinder, 6RTA58
Engine power	7,080 kW
Service speed	16 knots
Crew	Polish
	Master, 10 officers, 14 ratings