Report of investigation into the boiler explosion on board the Hong Kong Registered General Cargo Ship "*CSC Rong Hai*" on 02 March 2012



The Hong Kong Special Administrative Region
Marine Department
Marine Accident Investigation Section

30.12.2013

Purpose of Investigation

This incident is investigated in accordance with the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (the Casualty Investigation Code) adopted by IMO Resolution MSC 255(84).

The purpose of this investigation conducted by the Marine Accident Investigation and Shipping Security Policy Branch (MAISSPB) of Marine Department, in pursuant to the Merchant Shipping Ordinance Cap. 281, the Shipping and Port Control Ordinance (Cap. 313), or the Merchant Shipping (Local Vessels) Ordinance (Cap. 548), as appropriate, is to determine the circumstances and the causes of the incident with the aim of improving the safety of life at sea and avoiding similar incident in future.

The conclusions drawn in this report aim to identify the different factors contributing to the incident. They are not intended to apportion blame or liability towards any particular organization or individual except so far as necessary to achieve the said purpose.

The MAISSPB has no involvement in any prosecution or disciplinary action that may be taken by the Marine Department resulting from this incident.

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1. Summary

1.1. On 02 March 2012 at 2309 hrs, the boiler on board the Hong Kong registered general cargo vessel *CSC Rong Hai* exploded while the vessel was alongside the Zi Jin Shan Shipyard in Nanjing, China.

1.2. As a result of the accident, a ship superintendent, a shipyard staff, two crew members were killed, and seven other crew members were injured. The boiler was totally destroyed. The upper deck and the aft wall of the accommodation on the accommodation deck were ruptured. Structural members in the accommodation areas were distorted.

1.3. The investigation into the accident revealed that the main contributing factors to the accident are:

a) The duplex type safety valve was mistakenly blanked-off by the shipyard staff on the day of the accident as instructed by a management company staff whose intention was to gag one of the safety valves only; and

b) The Ship Superintendent, Chief Engineer and crew-in-charge of the boiler did not follow the company's procedure to ensure correct set-up of the boiler, including the steam pressure signal cocks, prior to starting up and raising steam; and

c) The ship management company of *CSC Rong Hai* did not ensure the personnel assigned to supervise the boiler maintenances and surveys was competent and experienced; and

d) The Chief Engineer did not ensure that the person whom he assigned to the full commissioning of the boiler was competent for the job.

2. Description of the vessel

Particulars of CSC Rong Hai

Port of Registry:	Hong Kong
Flag:	Hong Kong, China
IMO No.:	9556911
Type of Vessel:	General Cargo Ship
Year of Built:	2009
Classification:	China Classification Society
Ship Management Company:	Yangtze Navigation (Hong Kong) Co., Limited
Main Engine:	Diesel Engine, 2500kW
Boiler:	Green ShazhouLYF0.8/70-0.7 Composite Boiler
Length:	117.8m
Breadth:	18.0m
Depth:	10.4m
Gross Tonnage:	6550
Net Tonnage:	2854
Speed:	11.58knots
Number of Crew:	20



Figure 1: CSC Rong Hai

3. Sources of Evidence

a) The Captain and crew of *CSC Rong Hai*

b) The Ship Management Company

4. Outline of Events

4.1. On 4 February 2012, after loaded with iron ore, the vessel departed Surabaya, Indonesia for China. The vessel arrived at the discharge port, Tai Zhou, China on 17 February. On 18 February, after discharging all the cargoes, the ship departed Tai Zhou and arrived at Nanjing on the same day for dry docking in Zi Jin Shan Shipyard.

4.2. The Ship Superintendent of the company boarded the ship on 19 February.

4.3. The boiler on board the vessel was due for survey in June 2012, hence the Class Survey of the boiler was arranged to be carried out in this docking. The maintenance work and the preparation of the boiler for survey were contracted to the shipyard. The Ship Superintendent was responsible for coordinating and monitoring the work of the shipyard on the boiler, with the assistance of the crew-in-charge. They were also responsible for examining the boiler before taking over it after the survey. During the final inspection of the boiler, the crew-in-charge was responsible for starting up the boiler for the function tests of the boiler mountings, the control and the alarm systems. In this docking, according to the Chief Engineer, the crew-in-charge of the boiler maintenance and survey was the ship's Fourth Engineer.

4.4. The boiler maintenance works were started on 19 February 2012. The ship was dry-docked on 20 February. On 22 February, the duplex type safety valve of the boiler was disassembled for inspection and serviced. The condition of the valve was found to be poor and beyond repair. The shipyard suggested that the safety valve should be renewed. A new duplex type safety valve without type approval certificate was later supplied by the shipyard (Figure 2).



Fig. 2
The safety valve supplied
by the shipyard,
recovered after the
explosion

4.5. There was crew change on 23-24 February involved seven crewmembers with proper

handover and familiarization. They were the Captain, the Chief Officer, the Second Engineer, a sailor, an AB, a motorman and the Chief Cook. In the handover for the Second Engineer, only the maintenance related to the steering gear was discussed and the maintenance related to the boiler which was understood to be the duty of the Fourth Engineer was not mentioned.

4.6. On 24 February, all the services and maintenance works of the boiler were completed. When preparing the boiler for the hydraulic test, the shipyard staffs blanked off all openings on the boiler and closed all valves including the cocks at the steam pressure signal pickup manifold to the local pressure gauge, the combustion control transducer and the over-pressure protection devices.

4.7. On 25 February, in the presence of the Class surveyor, the boiler was hydraulic tested to a maximum pressure of 0.75MPa[1]. The attending Class surveyor had made no comment on the structural condition of the boiler including the structural plating, furnace, combustion chamber, doors, fittings, smoke and stay tubes after the test.

4.8. In order to put the boiler back to service after the hydraulic test, the shipyard staffs removed all the blanking plates from the boiler but without re-opening the cocks at the steam pressure signal pickup manifold to the local pressure gauge, the combustion control transducer and the over-pressure protection devices as found in the investigation after the accident.



Fig. 3
Photo shows the steam pressure signal pickup manifold and the cock for the pressure relays after the explosion. The cock was found shut

[1] 1MPa=10 bar

4.9. In the evening of 26 February, the ship staffs started the boiler under the oil-fired mode and raised steam for the function tests. However, when the steam pressure indicated in the pressure gauges was 0.1MPa, steam was found leaking from the new safety valve. The shipyard was informed of the situation and the combustion was stopped. The steam pressure was then released and boiler cooled down.

4.10. On 27 February, the safety valve was inspected and serviced in situ by the shipyard staffs, but still steam pressure could not be raised. The valve was further serviced several times in situ during the day but the leakage problem persisted. The valve was then taken down from the boiler and brought back to the shipyard workshop for service and the blow-off pressure setting checked. However, after installed back on the boiler, the valves were still found leaking when the pressure indicated in the pressure gauge of the boiler was 0.1MPa. At the same time, steam started to leak from various gasket joints of the boiler mountings.

4.11. On 28 February, the ship left dry-dock and berthed alongside. The boiler was not tested on that day. According to the docking schedule, the Class Surveyor had to complete all the docking survey items including the boiler survey on 29 February. If all the docking surveys were completed on 29 February, the vessel would commence her voyage immediately.

4.12. On 29 February, the safety valve was re-installed on the boiler and the Class Surveyor came on board. The surveyor noticed that the boiler took a long time to build up steam pressure and did not function properly. He then instructed the boiler internal surfaces to be cleaned and the burner unit to be serviced. The ship staffs shut down the boiler and the shipyard staffs serviced the boiler as required. However, the services took a long time to complete. The Class Surveyor did not wait and left the ship.

4.13. Since the survey of the boiler was not completed, the voyage plan of the vessel was deferred to the next day on 1 March 2012.

4.14. On 1 March 2012, the boiler was started up for steam leakage test. Steam was found leaking from the boiler duplex type safety valve, flanges of the water gauges and the water level transducer again. On that day, the safety valves were taken back to shipyard workshop several times for service and for the setting of the blow-off

pressure. However, whenever the safety valve was installed back to the boiler, the leakage problem persisted. Since the problem with the boiler could not be identified and fixed, the voyage of the vessel was rescheduled to 2 March 2012 at 07:00.

4.15. On 2 March 2012 morning, at 04:00, the shipyard staffs installed the serviced safety valves back to the boiler again, but the steam leakage problem remained when the steam pressure was raised to 0.005MPa as indicated in the pressure gauges of the boiler. The shipyard staffs claimed that they were unable to solve the problem and left the vessel. As the sailing time was approaching, the captain informed the Ship Management Department Manager of the shipping company of the situation of the boiler. The manager then called the Shipyard. The Operation Manager of the shipyard arranged shipyard staffs to go back to the vessel to work on the boiler under the pressure of the shipping company. As instructed by the Ship Management Department Manager of the shipping company, the Shipyard Operation Manager had arranged his staff to renew all the gaskets and fix all the leaking positions. The Ship Management Department Manager further suggested that if the leakage remained after leaving the dock, they would have to stop the leakage and look into the problem in the next port. At 5.30, the Shipyard Operation Manager enquired the Ship Management Department Manager about the gagging of the duplex safety valve. The forward safety valve that was leaking was identified by the Ship Management Division Manager.

4.16. At about 07:00, the shipyard staffs deployed to blank off the boiler safety valves by inserting a blanking plate to the inlet of the safety valve body, instead of gagging the safety valve identified by the Ship Management Department Manager. The blanking completely blocked the operation of both valves from the boiler.

4.17. At about 09:00, the Superintendent on board called the Ship Management Department Manager and reported that the water gauge was leaking and they had difficulties with the feed water system and needed more time to fix the boiler. The sailing schedule had to be postponed to the morning of 3 March 2012. In his telephone communication with the Ship Management Department Manager, he was instructed to make sure that the safety valve was properly maintained and restored to operational state before sailing. However, this instruction was not carried out and the safety valve remained inoperable until the explosion took place.

4.18. Since steam was still found leaking from a number of locations and there was a

problem with the feed water system, the shipyard staffs spent the whole day to solve these problems.

4.19. On the same day, the Chief Engineer told the Second Engineer that the ship might sail in the next day and asked him to prepare the engine room for sailing. At about 20:00, the Second Engineer made a general check of the engine room before going to sleep. The Second Engineer remembered that before he left the engine room, he saw the Chief Engineer, the Fourth Engineer and the duty motorman in the engine control room but the Superintendent was not in the boiler space.

4.20. At 20:00, the shipyard staffs completed all the steam leakage repairs and the feed water inlet valves was overhauled. The boiler was ready for raising steam again. The shipyard staffs and the ship staffs (Superintendent and the Fourth Engineer) agreed that if there were no steam leakage when the steam pressure rose to 0.3MPa, both parties would consider the repair of the boiler completed.

4.21. The Fourth Engineer asked the duty motorman to add water to the hot well to prepare for the lighting up of the boiler. At 21:30, the Fourth Engineer instructed the motorman to station in the control room to take note of the boiler water level and steam pressure of the boiler.

4.22. At 21:30, the Fourth Engineer, the Superintendent and four shipyard staffs started the boiler with auto-mode to raise steam to test the leakage. When the steam pressure indicated in the pressure gauge was at 0.05MPa, steam started to leak from the water gauge and from the water level control transducer packing. The shipyard staffs tightened the glands on the gauge and transducer to reduce the leakage. During the steam raising process, the Fourth Engineer found that the boiler space was too small for six persons and asked the shipyard staffs to stay in the engine control room. The Superintendent remained in the boiler space.

4.23. In the engine control room, the motorman observed that the steam pressure, which was indicated in the pressure indicator, slowly increased. From 21:30 to 23:00, there were two high water level alarms appeared.

4.24. At about 23:07 (2 minutes before the explosion), the Fourth Engineer heard an abnormal noise from the boiler. He asked the Superintendent to stop firing the boiler. The Superintendent agreed and the Fourth Engineer stopped the burner unit and went

to the control room to call the Chief Engineer. The Chief Engineer replied that he would come down to the boiler room to have a look.

4.25. At that moment, the motorman in the engine control room noted that the reading of steam pressure shown in the remote pressure gauge was 0.104MPa and one of the shipyard staffs went from the engine control room to the boiler space to inspect the boiler.

4.26. When the Fourth Engineer was about to go back to the boiler room, the boiler exploded at 23:09hr. The force of explosion totally destroyed the boiler space and its surrounding structure as shown in Fig. 4. The accommodation deck plate and the accommodation side wall in the aft-direction were burst open as shown in Fig. 5 and Fig. 6 and the lifesaving deck buckled into a dome shape due to the explosion as shown in Fig. 7. The general arrangement of the superstructure and the engine room is shown in Fig. 8.



Fig. 4 Photo shows the remains of the smoke tubes of the boiler after the explosion.



Fig. 5 Photo shows the deck aft. the accommodation was burst opened in the explosion



Fig. 6 Photo shows the totally raptured aft-wall of the accommodation deck structure



Fig. 7 The lifesaving deck buckled into dome shape under the immense pressure during the explosion.

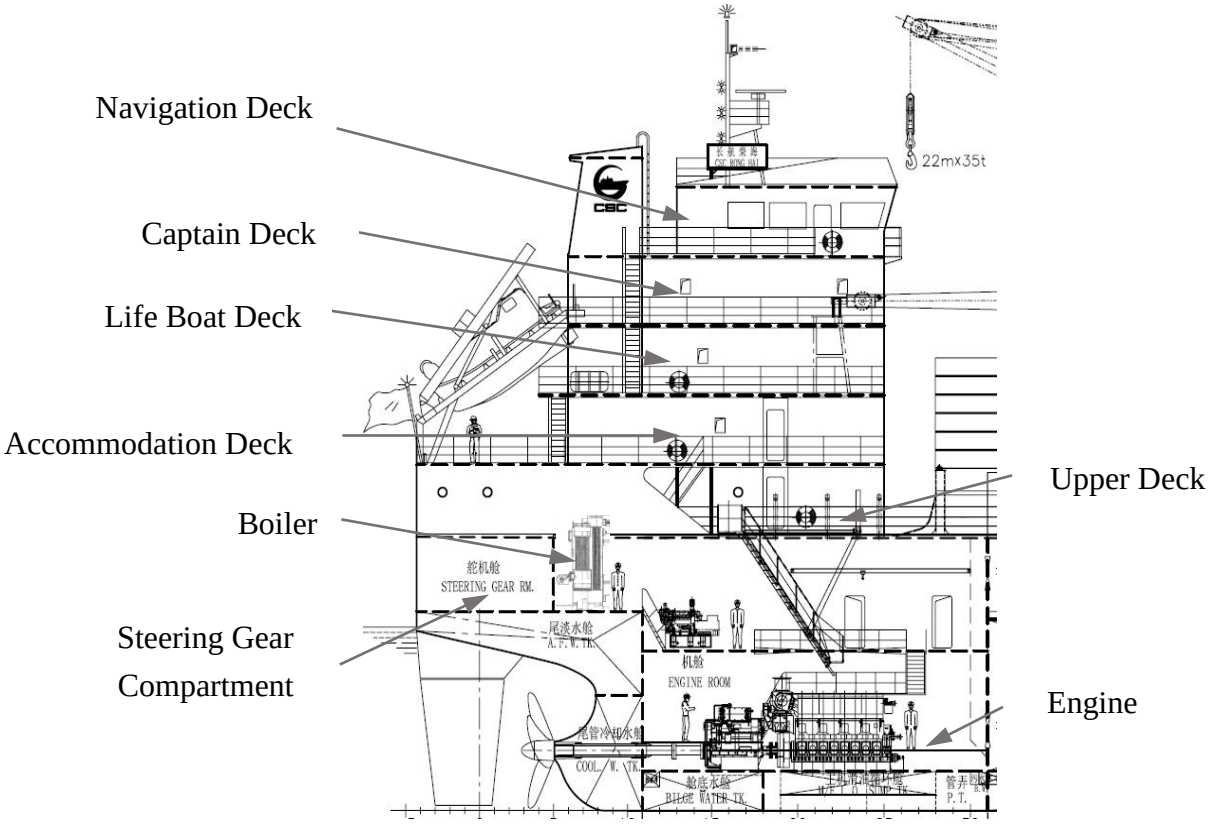


Fig. 8 General Arrangement of the Super structure and the Engine Room

4.27. Before the explosion, there were five persons inside the control room: the Fourth Engineer, the duty motorman and 3 shipyard staffs. After the explosion, all five went from the engine control room to the steering gear compartment at the stern of the vessel and tried to escape to the accommodation deck via the emergency escape route. However, the opening of the escape route was blocked. They stayed in the steering gear compartment to wait for help. Since the boiler space was situated outside the steering gear compartment, they called out loudly for the Superintendent and the shipyard staff who were working together then but heard no reply.

4.28. At the moment of the explosion, the Captain was walking downstairs from the wheelhouse to his cabin and heard a very loud noise. He was pushed into his cabin by a burst of air and fell down to the floor. The Captain stood up again and shouted to the Third Officer, who was working on the wheelhouse, to see whether he was injured or not. The Third Officer replied that he was not hurt. The Captain went to the Second Officer's cabin next door and woke the Second Officer. The Captain, Second Officer and Third Officer went to rescue the Chief Engineer and the Third Engineer because their cabins were on the same deck. The Chief Engineer was found in his cabin with eyes injured. The Third Engineer was found buried under piles of fallen objects in the walkway. The Captain and his officers helped the Chief Engineer out to the Captain's deck but they were unable to pull the Third Engineer out from the fallen rubbles. The Captain then called the local police and the local rescue unit and the Third Officer called the local fire department. The Captain asked if anybody had informed the company. The Second Engineer replied that he had called the company already. The Captain also informed the local agent.

4.29. At the moment of explosion, the Second Engineer was sleeping in his cabin and was awakened by the noise of the explosion. He found that there was no power supply. After he switched on a torch, he found that the ceiling of his cabin had collapsed and the door had torn apart. The Second Engineer cried out if there was any body around. The Chief Officer who was fine after incident responded to his call. The Second Engineer and Chief Officer went upstairs as the staircases going downstairs had been blocked already. They escaped through the back door of the accommodation deck and went to the main deck.

4.30. Upon arrival at the upper deck, the Captain asked the Chief Officer and Second

Engineer to muster the crewmembers who had escaped to the shore for a roll call. The Captain then organized a rescue team to search for the missing crews. At the same time, the company called the Captain asking about the situation of the accident. At about 7 minutes later, the fire brigade and the ambulance arrived at the ship. Briefed by the Captain of the situation (at that time 14 crew members had retreated to shore already) and checked with the fire control station, two rescue teams were formed to search the accommodation and the upper deck. In the search, one of the rescue teams discovered that the Chief Cook was serious injured in the aft port side accommodation deck. The other team discovered two more crewmembers in the accommodation deck.

4.31. In 02:20, a roll call was taken again. A total of 8 crewmembers and shipyard workers were still missing. The search and rescue operation continued. The Captain successfully contacted the missing shipyard worker via his mobile phone. It was reported that there were 2 crewmembers and 3 shipyard workers trapped in the steering gear compartment.

4.32. At 02:30, the shipyard arranged a cutting torch to cut open the emergency escape route opening to the steering gear compartment. At the same time, the skylight of the engine room was opened and a ladder was lowered into the engine room to rescue the entrapped crewmembers and the shipyard workers. The Fourth Engineer was found injured.

4.33. At 02:45, a roll call was taken again. Three persons were still missing and one of them was the motormen. The rescue teams started to search the areas around the accommodation of the missing motorman. At 02:50, on the upper deck starboard side accommodation corridor, the missing motorman was found buried under a big pile of fallen objects. Upon removal of all the objects, another missing person was found lying on top of the missing motorman. A third missing person was also found nearby. The shipyard cut open the partitions of the accommodation to rescue them at 03:30. The motorman was later certified dead in the hospital. The other two persons were identified as the Ship Superintendent and the shipyard staff working with him. Both were certified to be dead in the hospital.

4.34. At 03:05, the staffs from the company arrived at the vessel.

4.35. The casualties in this accident included four deaths and seven injuries. The deaths were:

a) The Ship superintendent, one shipyard worker and one motorman were found in the upper deck starboard side accommodation corridor and certified dead in the hospital. The Chief Cook was rescued from the port side of accommodation deck and was certified dead in the hospital.

b) The seven injured persons were:

i) The Chief Engineer was rescued from his cabin in the port side of the Captain deck with eye injury;

ii) The electrician was rescued from his cabin in the port side of the accommodation deck with the right leg and his face injured;

iii) The Third Engineer was rescued from the corridor outside his cabin in the starboard side of the lifeboat deck with bone fracture on the left lower limb and scratches were found on his face and his right arm;

iv) The bosun was rescued from his cabin in the starboard side of the accommodation deck with bones at his right heel fractured and scratches on his abdomen;

v) The Fourth Engineer was rescued from the steering gear compartment with the calcaneus of his right foot fractured;

vi) One motorman was rescued from his cabin in the forward starboard of the accommodation space of the upper deck with soft tissues of his shoulders suffered from contusion;

vii) One Able-body seaman was rescued from his cabin in the forward portside of the accommodation deck with scratches on his right shoulder and his feet.

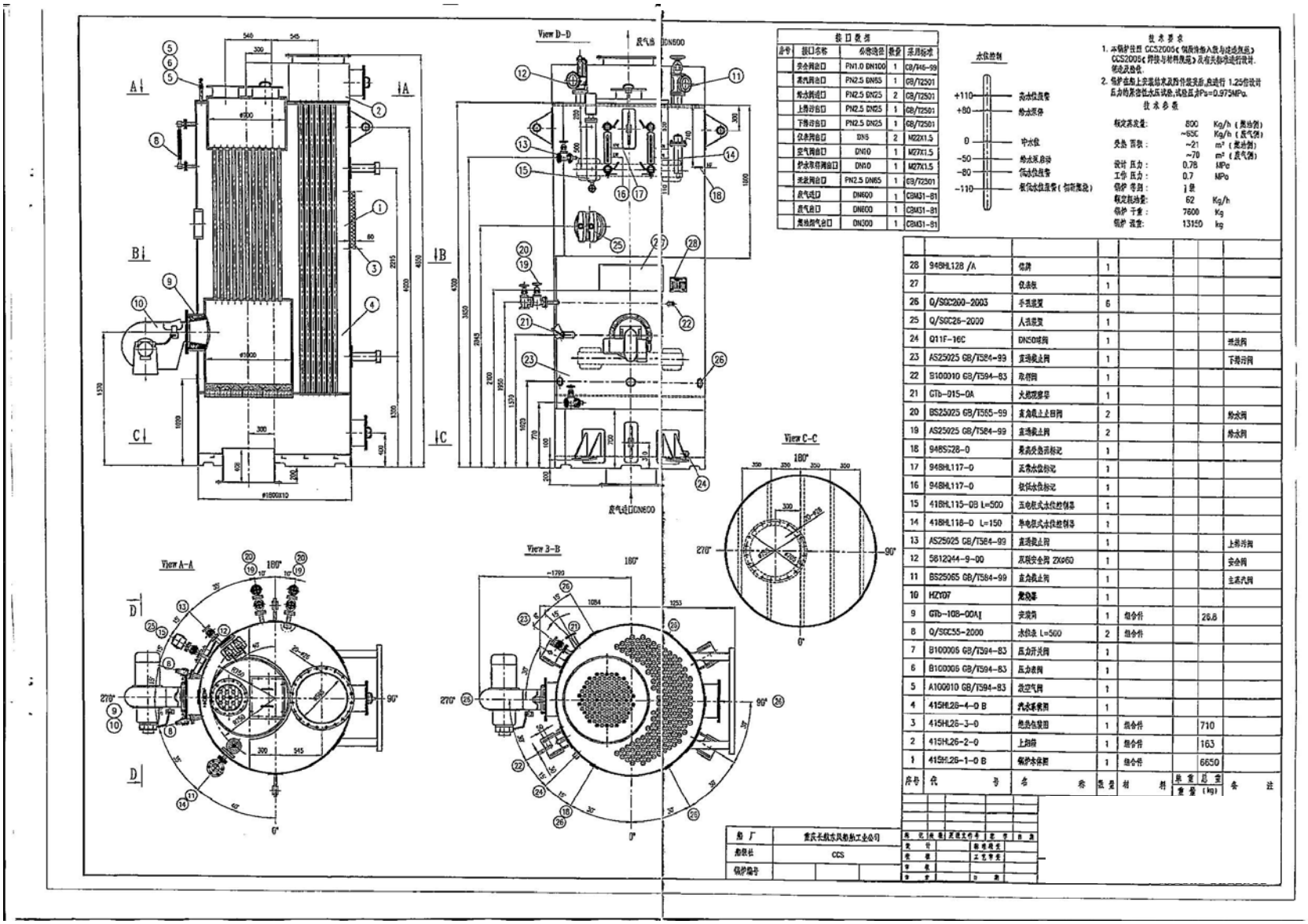
5. Analysis

The safety protection of the composite boiler

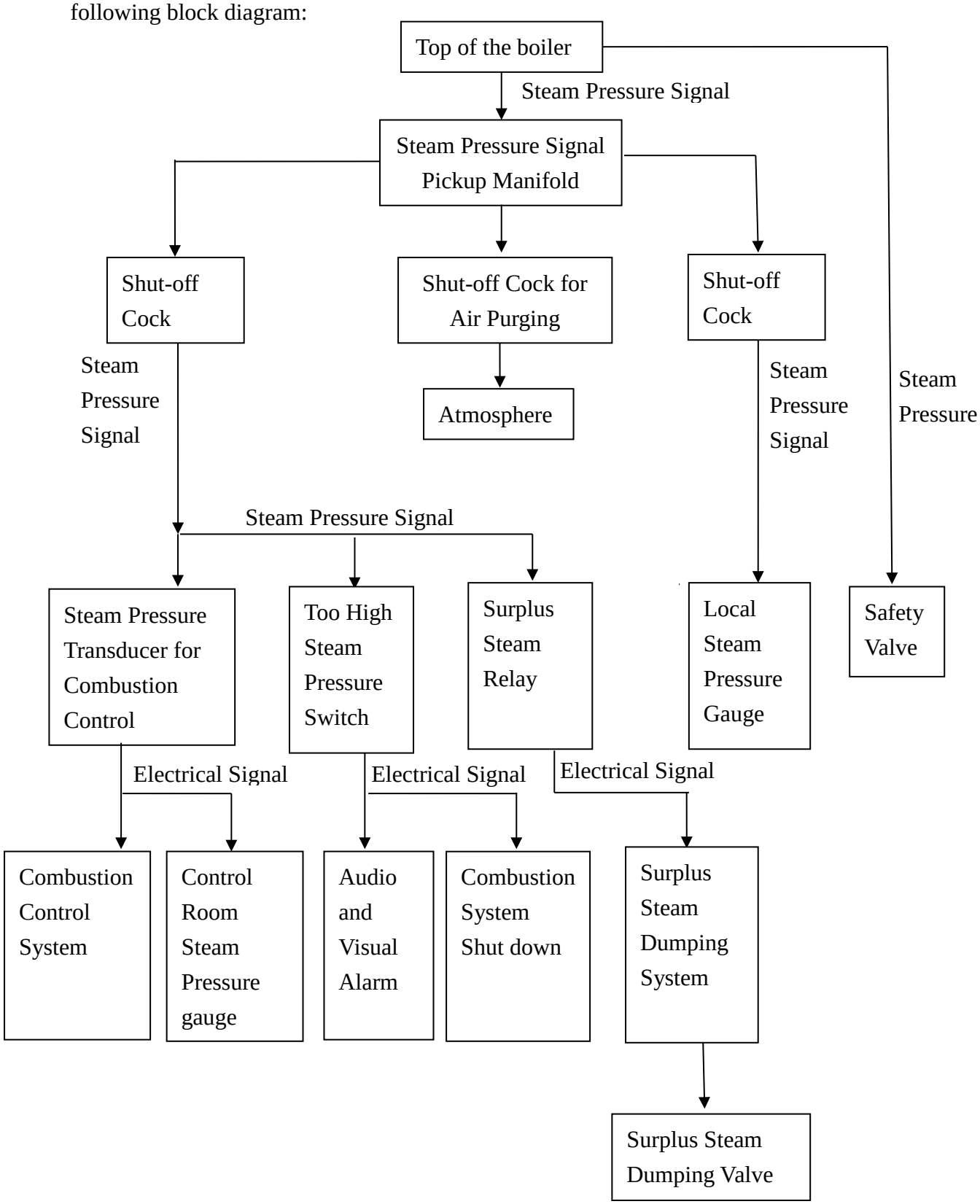
5.1 The boiler was located outside the steering gear room at the port side of the engine room tween deck as shown in Fig. 8. It was a vertical oil-fired and exhaust gas composite boiler. The general layout of the boiler is shown in Fig. 9. Both the oil-fired section and the exhaust gas section were contained in one single cylindrical shell. They shared one steam-water space. The smoke tubes of the oil-fired section and the exhaust gas section were isolated from each other.

5.2 When the ship was en route, steam was generated at a pressure of 0.4MPa-0.5MPa by the exhaust gas section of the boiler. The oil-fired section was put on the auto-mode. It would fire automatically to keep the pressure in the boiler when the steam pressure inside dropped below a preset limit. The boiler was stopped while the vessel was in port. The crewmember would manually start the boiler to maintain the steam pressure inside the boiler when it was low. Before sailing, the boiler would be started in the manual mode to raise the steam pressure inside the boiler to 0.4-0.5MPa before switching over to the auto-mode.

Fig. 9 General layout of Green Shazhou LYF0.8/70-0.7 Composite Boiler



5.3 The boiler pressure control and the over pressure protection system was shown in the following block diagram:



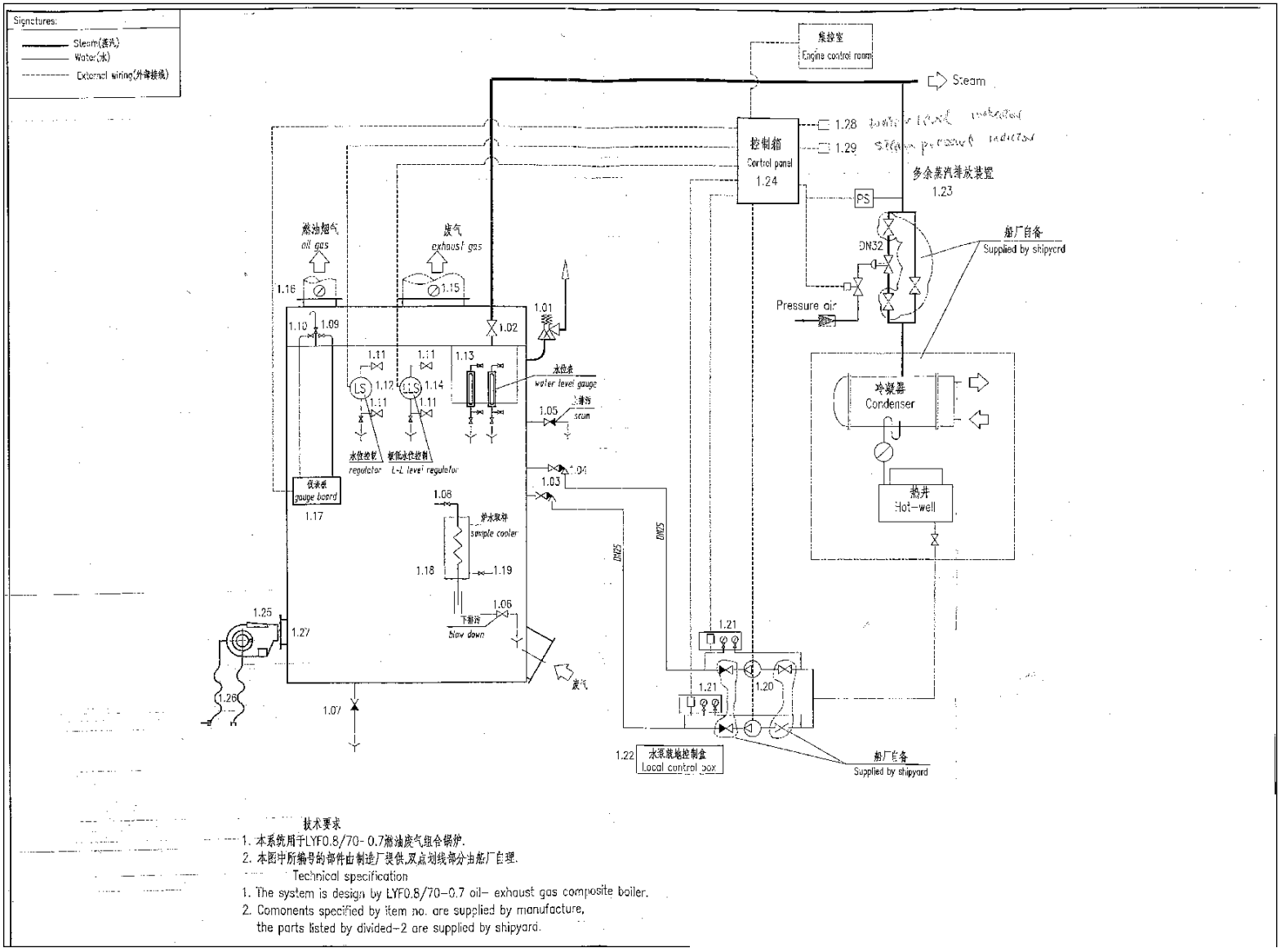


Fig. 10 Schematic diagram of the Boiler Systems

5.4 When operating the boiler in the oil-fired mode, the steam pressure in the boiler was automatically controlled by the oil-fired burner unit. The pressure signal was taken from the steam pressure signal pickup manifold of the boiler. A shut-off cock was installed on the manifold where the signal was taken. The same signal was also fed to a pressure transducer. The pressure transducer converted the steam pressure signal to an electrical signal to control the boiler combustion. When steam pressure inside the boiler dropped below the lower desired value, the control system would initiate the fire starting sequence and started the combustion. When the steam pressure rose to the upper desired value, the pressure signal would shut the fire. The steam pressure inside the boiler was maintained between the upper and lower limits this way.

5.5 When the vessel was en route, steam was generated in the exhaust gas section of the boiler. Steam pressure exceeding the preset upper limit was regulated by a surplus steam dumping system. The steam pressure signal was taken from the steam pressure signal pickup manifold at the top of the boiler via a shut-off cock. The signal was conveyed to a Surplus Steam Relay located in the local Gauge Board. When the pressure reached the upper limit set by the surplus steam relay, the relay would actuate the surplus steam dumping system and dump the steam inside the main steam line through the Surplus Steam Dumping Valve to the condenser. The dumping would stop when the main steam line pressure dropped below the preset lower limit. The arrangement of the Surplus Steam Dumping System was shown in Fig. 10.

5.6 The boiler was protected against steam over-pressure by two independent protection systems in the boiler. Firstly, steam pressure signal was conveyed to a ‘Too High Steam Pressure Switch’ from the steam pressure signal pickup manifold via a shut-off cock. When the steam pressure in the boiler reached the upper limit set in the ‘Too High Steam Pressure Switch’, audio and visual alarms would be actuated and the oil-fired burner unit would be stopped. Secondly, when the steam pressure inside the boiler reached the preset upper limit of the safety valves, the boiler’s duplex type safety valve would be opened to relief the pressure until the pressure inside the boiler dropped below the preset safety valve shut-off pressure.

5.7 For indication of the steam pressure, the boiler was fitted with two pressure gauges. One of the gauges was placed at the front of the boiler on the local gauge board. The

other pressure gauge was located inside the engine control room for remote indication. According to the design drawing, the local pressure gauge received its steam pressure signal directly from the steam signal pickup manifold on the top of the boiler while the remote pressure gauge in the control room received its electrical signal from the pressure transducer which took its signal from another direct line from the same manifold.

5.8 During this docking, the local steam pressure gauge for the boiler was calibrated by a laboratory.

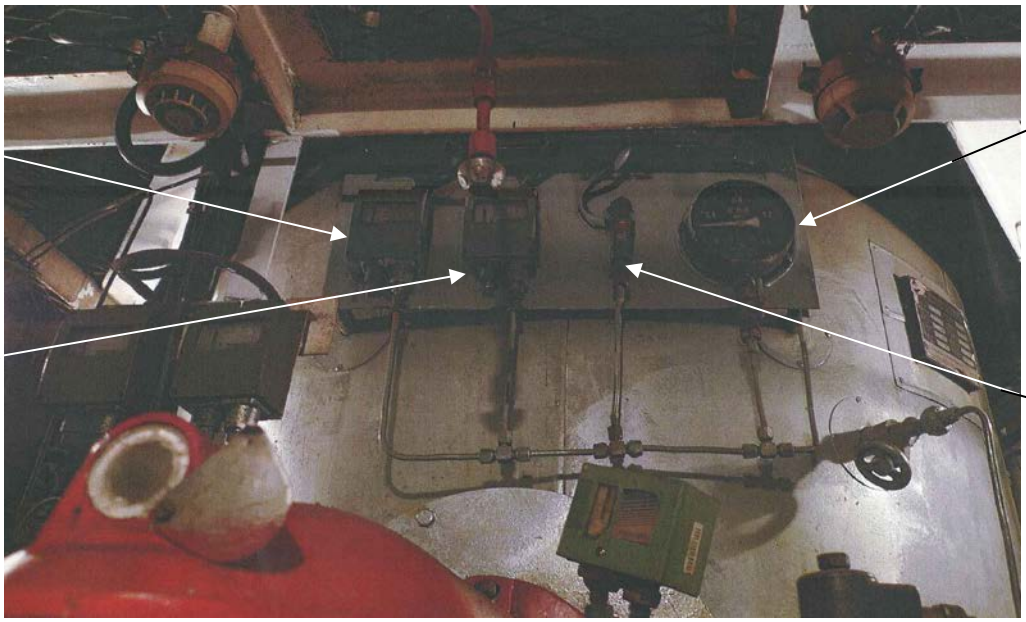


Fig. 11 The local gauge board of the boiler

Steam Pressure signal distribution

5.9 The Schematic diagram of the steam pressure signal distribution of the boiler is shown in Fig. 12. In the diagram, all steam pressure signals were picked up from a single sampling point on top of the boiler to a small manifold and distributed through three connecting tubes. Each of them was fitted with a shut-off cock. They fed to the following instruments :

i) the air vent;

ii) the local steam pressure gauge; and

iii) the Steam Pressure Transducer for Combustion Control, the 'Too High Steam Pressure Switch' and the Surplus Steam Relay.

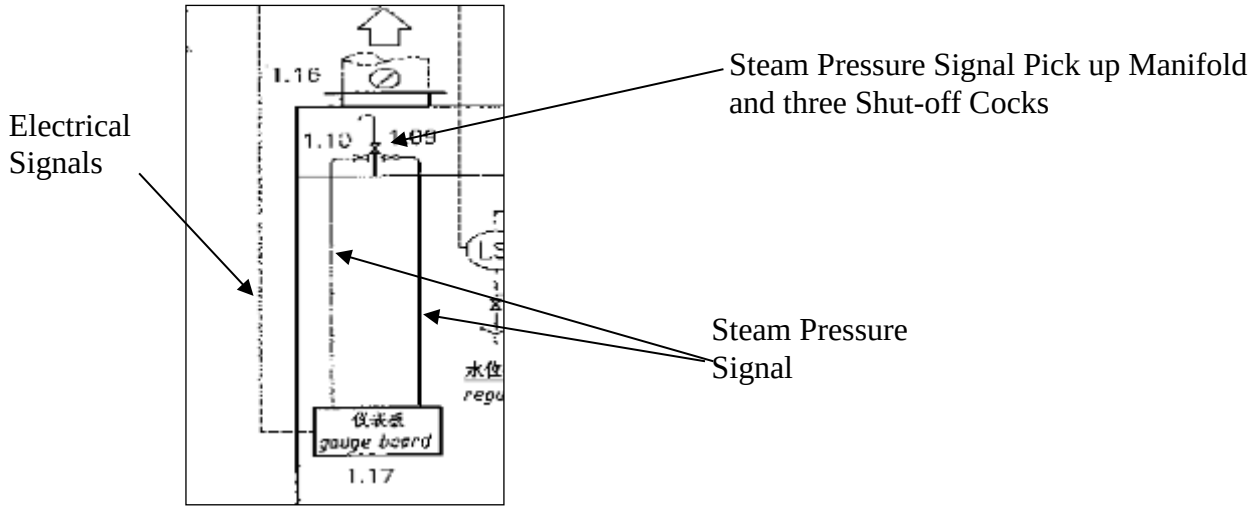


Fig. 12 The designed arrangement of steam pressure signal pick up according to boiler maker

5.10 After the explosion, the actual arrangement of the steam pressure signal pickup and distribution of the boiler on board the CRC Rong Hai had been blown apart (Fig. 13) and could not be traced.

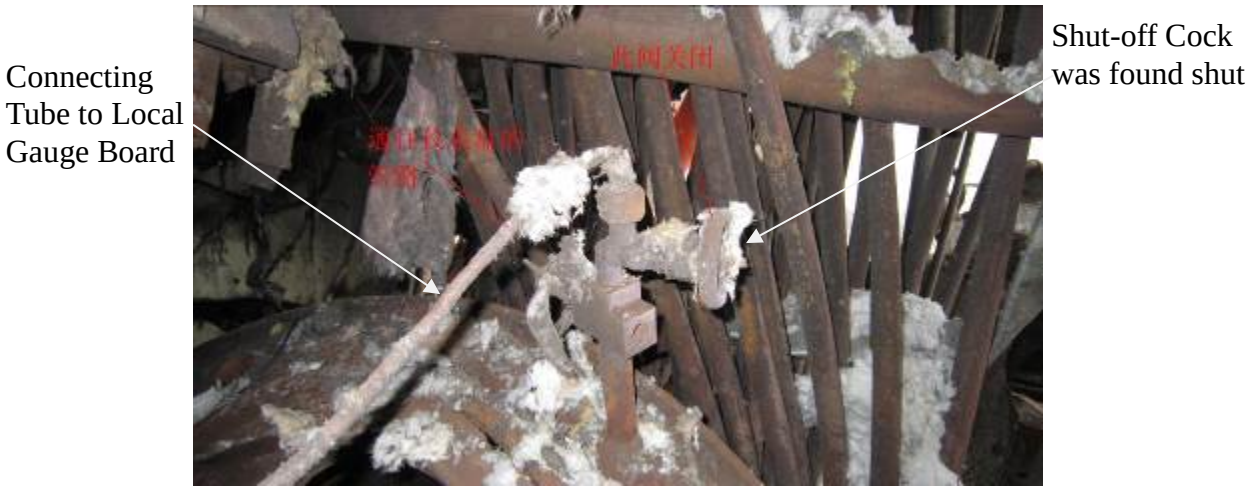


Fig. 13 The ruin of the Steam Pressure Signal Pickup after explosion

Attempt was made to confirm the actual piping arrangement of the steam pressure signal pickup of the vessel by referencing to her sister ship managed by the same ship management company. It was found in the sister ship that the steam pressure signal pickup and distribution arrangement was different from the design as given in the maker's Boiler System Schematic diagram. The arrangement in the sister ship was shown in the Fig. 14 and Fig. 15.

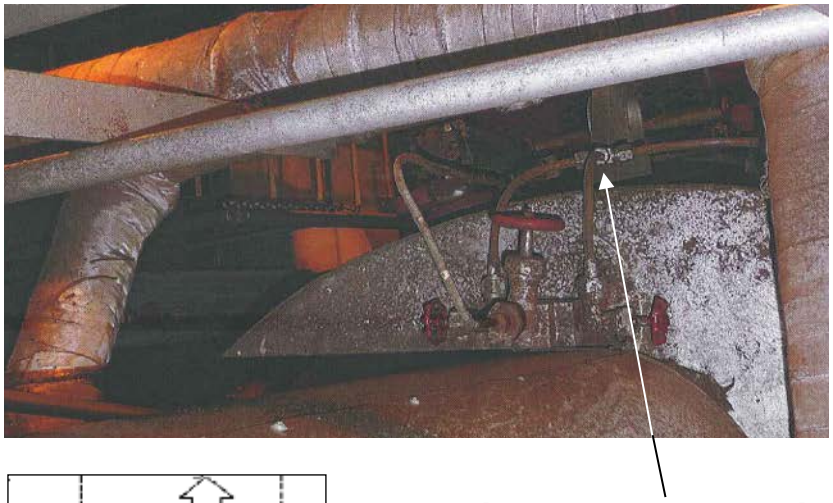


Fig. 14
The Steam Pressure Signal Pickup and Distribution Arrangement in a sister ship of CSC Rong Hai

The Steam Pressure Signal Pickup tubing for the local Steam Pressure Gauge was connected to tubing for the pressure transducers

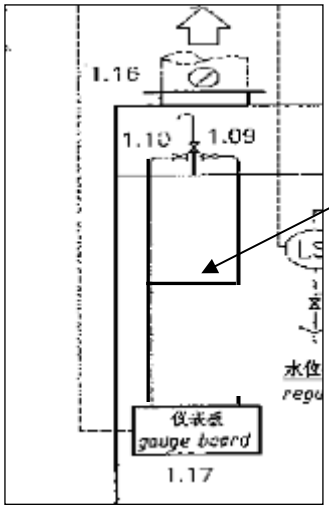


Fig. 15
The schematic of the Steam Pressure Signal Pickup and Distribution Arrangement in a sister ship of CSC Rong Hai

The tubing for the local steam pressure gauge was connected to the tubing for the pressure transducers were joined before the shut-off cocks on the manifold i.e. the local steam pressure gauge was fed by the same steam pressure signal as for the steam pressure transducers.

It was likely that the tubing arrangement for the steam pressure signal distribution in the vessel "CSC Rong Hai" is similar to her sister ship, i.e. not in accordance with the design of the boiler manufacturer.

Probable causes of the boiler explosion

5.11 In this accident, the boiler was totally destroyed. The Ship Superintendent and the shipyard staff who were at the boiler side were killed and no other person could tell how the accident took place. The causes of the accident could only be deduced from the statements and the environmental evidences.

5.12 The structural members of the boiler had been inspected during the boiler survey on 25th February 2012 and the Class Surveyor made no comment on the structural aspect

of the boiler. It was unlikely that the explosion was caused by inherent structural failure of the boiler.

5.13 There were no complaints about the function of the burner unit, it was unlikely that the explosion was due to the failure in the combustion control system.

5.14 The boiler might have exploded due to over-pressure despite all the over-pressure protections installed as described above (Para. 5.3 to 5.7). From the outline of the events (Para. 4.8 to Para 4.16), all the steam pressure control and over-pressure protection systems were made non-operational:

i) Although the electrical circuitry of the automatic combustion control and over-pressure protective systems of the boiler were independent, their steam pressure signal came from a single connecting tube via shut-off cocks fitted on the steam pressure signal pickup manifold. From the ruin of the steam pressure signal pickup after the explosion (Fig. 13), a shut-off cock was found to be in a closed position. Coupling with the other evidences that the alarm systems were also not working indicated that the shut-off cocks might all have been closed before the explosion occurred. (Closing all the shut-off cock would cut off all the steam pressure signals and thus making all the steam pressure control and over pressure protection systems non-functional.)

ii) Even if the tubing arrangement for the steam pressure signal distribution in the vessel "CSC Rong Hai" followed her sister ship, both shut-off cocks were required to be closed so that no reading could be shown at the local steam pressure gauge and to disable the alarming system. (Note: The small fluctuation of steam pressure on the pressure gauges during the starting of the boiler was due to the expansion of water in the connecting tubes when the boiler was heated up. However, the real pressure in the boiler could not be shown unless the shut-off cock was leaking.) The crew and the shipyard staff were not aware of the closure of the shut-off cocks for the sensor lines. This had caused the steam pressure readings for the boiler to show faulty readings and the failure to activate the over pressure alarms

iii) The boiler could still be protected when the steam pressure inside the boiler exceeded the setting of from over-pressure by the duplex safety valve. However, on 2nd March 2012, in order to meet the sailing schedule, the Ship Management

Department Manager of the shipping company asked the shipyard to gag one of the valves in the duplex safety valve. The repeating leakage of the safety valves and the jointing areas had been linked to the excessive pressure inside the boiler. Owing to poor communication, the decision to gag but end up later in the blanking of the inlet to the duplex safety valve by the shipyard staffs had taken away the last safety protection left in the boiler.

5.15 From the analysis above, the explosion was caused by a series of human errors including: negligence of duties, incompetency and poor communication between various parties.

5.16 Negligence of duties.

i) Negligence of duty of the shipyard

The hydraulic test of the boiler was carried out by the shipyard staffs. They were in-charge of the whole operation which included the duty to reset the boiler to its original state after the hydraulic test had been carried out. The shut-off cocks on the steam pressure signal pickup manifold appeared to be closed. The management quality assurance team of the shipyard also appeared to have failed to monitor the progress of the work of their staffs and that work has been carried out according to the procedures and requirements of the shipyard.

ii) Negligence of duty of crew-in-charge

The crew-in-charge had not carried out his duties in accordance with the Safety Management Manual of the shipping company. It required him to check all the settings in the boiler including the shut-off cocks between the steam pressure signal pickup manifold and the local gauge board before starting the boiler after a major overhaul. Apparently, such a check had not been carried out and the cocks were found still closed when the boiler started to fire up.

iii) Negligence of duty of the Chief Engineer

In the Safety Management Manual of the shipping company, the Chief Engineer was required to be on the scene when the boiler was being commissioned. On that evening when the explosion took place, the commissioning was left to the crew-in-charge.

iv) Negligence of duty of the Ship Superintendent

a) The Ship Superintendent did not monitor the work of the shipyard on the boiler;

b) The Ship Superintendent should not allow a safety valve with no type approval certificate to be installed on the boiler;

c) On 02 March, the Ship Superintendent did not carry out the instruction of the Ship Management Department Manager to restore the function of the safety valve.

v) Negligence of duty of the Ship Management Department Manager

In the company's Safety Management Manual, one of the functions of the management of the shipping company was to ensure the ship's safety and pollution prevention operations were in accordance with the related international conventions, rules & regulations of the flag State, codes & standards. However, when the Captain of the vessel called the Ship Management Department Manager for help in the morning of 02 March, he decided to gag the 'leaking' safety valve and suggested to let the ship set sail with only one safety valve operational on the boiler. Regulation 32.1, Chapter II-1 of SOLAS Convention required that every steam boiler shall be provided with not less than two safety valves of adequate capacity. Gagging one of the valves in the duplex safety valve would render the boiler failed to comply with the SOLAS requirement.

5.17 Incompetency and inexperience of the Ship Superintendent and the crew in-charge of the boiler

i) The crew in-charge (fourth engineer) of the commissioning of the boiler might not be experienced enough for the job;

From the sea service records of the fourth engineer as shown in table 1, he had only a total of 12 months of engineering experience (from September 2010 to October 2011) at sea. He served as the fourth engineer for about 2.5 months after he joined CSC Rong Hai in January 2012. It was quite doubtful that he had the necessary experiences to take full charge to commission a boiler before then.

Ship type	Gross Tonnage	Power (kW)	Rank:	Date of Engagement	Date of Discharge	Sea Time (Months)
Bulk Carrier	12863	5656	Trainee	5.9.2010	16.5.2011	8.5

General Cargo	1997	1286	Motorman	19.5.2011	23.8.2011	3
Bulk Carrier	27737	7648	Trainee Fourth Engineer	5.9.2011	29.10.2011	2.5
					Total:	12

Table 1 Training and experience of the Fourth Engineer

ii) The Ship Superintendent was graduated from a technical college and specialized in industrial automation. From his working experiences as listed in table 2, he did not have the experience in boiler operation and commissioning.

Period	Duration	Post
8.2005 – 3.2010	5 years	船舶電機員 (Electrician)
2010 - 2012	2 years	船舶現場監修 (Superintendent)

Table 2 Working experience of the Ship Superintendent

iii) The Fourth Engineer as well as the Superintendent on board did not appear to have the experiences to commission a boiler and trouble shoot boiler defects when they occurred. It was quite evident that when they fire-up the boiler, they properly had mistaken the lifting of the boiler safety valves for leakages.

5.18 The shipping company also failed to ensure that the Ship Superintendent attending the docking vessel possessed the necessary knowledge and experience. The training and working experience of the Superintendent (Table 2) revealed that he had little experience with the commissioning and testing of boilers.

5.19 Failure of communication channels between parties involved in the incident.

i) The Ship Superintendent on board did not report the boiler problems to the senior management of the shipping company even though the problems had lasted for four days (26 Feb. to 1 March) and no solution was in sight.

ii) The Ship Management Department Manager and the Shipyard Operation Manager agreed that it was the leaking safety valve to be gagged. However, the shipyard staffs blanked off the inlet side of the duplex safety valve and in the process made all the safety valves not operational.

iii) The Ship Management Department Manager did not appear to have told the Ship Superintendent or the crew-in-charge that he had instructed the Shipyard Operation Manager to blank off the safety valve.

6. Conclusion

6.1 On 02 March 2012 at 2309 hrs, the boiler on board the Hong Kong registered general cargo vessel *CSC Rong Hai* exploded while the vessel was alongside at the Zi Jin Shan Shipyard in Nanjing, China.

6.2 As a result of the accident, a Ship Superintendent, a shipyard staff, two crew members were killed, and seven other crew members were injured. The boiler was decimated. The upper deck and the aft wall of the accommodation deck were ruptured. Structural members in the accommodation areas were distorted.

6.3 The investigation into the accident revealed that the main contributing factors to the accident were:

a) The inlet to the duplex-type safety valve was blanked off prior to the boiler explosion. It was mistakenly blanked off by the shipyard staff on the day of the accident. The instruction given by the Ship Management Department Manager was to gag the leaky safety valve while leaving other intact;

b) The Ship Superintendent, Chief Engineer and crew-in-charge of the boiler did not follow the company's procedures closely to ensure that the boiler was restored to its operating conditions before firing up the boiler. The actions would include the checking of steam pressure signal cocks and the working conditions of the safety and alarm systems prior to starting the boiler;

c) The ship management company of *CSC Rong Hai* did not ensure that the Ship Superintendent assigned to check and operate the boiler after maintenances is competent; and

d) The Chief Engineer should ensure that the crew-in-charge has the necessary experience to take full charge in commissioning a boiler from cold.

6.5 The investigation also identified the following safety factors:

a) The arrangement of the steam pressure signal take off lines from the boiler was not installed in accordance with the design of the boiler manufacturer; and

b) The Ship Superintendent did not report to the management company ashore and asked for their support when repeated problems encountered during raising of boiler steam pressure.

7. Recommendations

7.1 The ship management company of the vessel is required to inform, by means of safety circular etc., to all staffs[2] the findings and the lesson learnt from this accident.

7.2 The ship management company of the vessel is required to review its safety management system and implement appropriate measures, such as crew training, internal audits and reviews, etc., in order to ensure that:

i) staff are competent, experienced and well-trained prior to assigning them for the relevant jobs;

ii) staff should be asked to follow company procedures for the safe operation of all equipment and machinery onboard their ships;

iii) staff should follow manufacturer's instructions in the operation and maintenance of all equipment and machinery on board;

iv) proper culture of communication is to be established between field staff and company staff in that safety becomes the company's top priority; and

7.3 A Merchant Shipping Information Note (MSIN) should be issued to promulgate the lessons learnt from this accident.

[2] Staffs includes personnel responsible for the safety management and operation of ships, both ashore and on board company managed fleet.

8. Submission

8.1 In the event that the conduct of any person or organization is commented in an accident investigation report, it is the policy of the Marine Department to send a copy of the draft report or parts thereof to that person or organization for comments.

8.2 Copies of the draft report have been sent to the following interested parties for comments:

a) The ship management company of the vessel;

b) The Zi Jing Shan Shipyard where the accident happened during repair of the vessel;

c) The China Maritime Safety Administration being the coastal State where the accident happened; and

d) The Shipping Division of the Hong Kong Marine Department, being the flag State of the vessel.

8.3 At the end of the consultation, there was no comment received from them.

Appendix. General Arrangement of MV “CSC Rong Hai”

