MI2013-11

MARINE INCIDENT
INVESTIGATION REPORT

November 29, 2013

Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board is to prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

MARINE INCIDENT INVESTIGATION REPORT

Vessel type and name:	LNG Tanker, "LNG ARIES"
Vessel number (IMO number):	7390193
Gross tonnage:	95, 084 tons
Incident type:	Loss of control (blackout)
Date and time:	Around 12:37, December 3, 2012 (Local time, UTC+9 hours)
Location:	Off the Southeast of the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port 120˚true, 100 meters from the Toden-Ogishima LNG Berth Light in Kawasaki City, Kanagawa Prefecture (approximately 35˚28.2'N, 139˚44.4'E)

October 10, 2013

Adopted by the Japan Transport Safety Board

Chairman Norihiro Goto
Member Tetsuo Yokoyama
Member Kuniaki Shoji
Member Toshiyuki Ishikawa
Member Mina Nemoto

SYNOPSIS

< Summary of the Incident >

The LNG tanker, LNG ARIES, with 32 crew members in addition to the master and the chief engineer, was loaded with 125,469 m^3 of liquefied natural gas (LNG) in Qatar. Around 12:37, December 3, 2012, while she was coming alongside the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port, for the purpose of discharging the LNG, she lost her electric power, which disabled the operation of the main turbine (main engine) and subsequent lost of control.

With the escort of four tug boats, she was berthed at the Toden-Ogishima LNG Berth with no casualties.

< Probable Causes >

While LNG ARIES was coming alongside the Toden-Ogishima LNG Berth, her main boilers were operating in the gas burning mode. A gas leakage detector installed at a fuel gas pipe then emitted a signal indicating an increased gas concentration. The burning of the boil off gas of the LNG then stopped; consequently, the flame failure occurred in the main boilers. In order to suppress steam consumption, the stand-by diesel generator was made to bear the load on one of the two turbine generators. After the air circuit breakers for the one of the two turbine generators was opened, causing the electrical trips of the air circuit breakers for the stand-by diesel generator and the remaining active turbine generator. Finally, the electric power of LNG ARIES was lost. It is probable that the electric power loss in LNG ARIES caused the incident.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Incident

The LNG tanker, LNG ARIES, with 32 crew members in addition to the master and the chief engineer, was loaded with 125,469 m^3 of LNG in Qatar. Around 12:37, December 3, 2012, while she was coming alongside the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port, for the purpose of discharging the LNG, she lost her electric power, which disabled the operation of the main turbine (main engine) and subsequent lost of control.

With the escort of four tug boats, she was berthed at the Toden-Ogishima LNG Berth with no casualties.

1.2 Outline of the Incident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board appointed an investigator-in-charge (from the Yokohama Office) and another investigator to investigate the incident, on December 4, 2012.

The Board later appointed another marine accident investigator as an additional investigator-in-charge.

1.2.2 Collection of Evidence

Interviews and collection of the written replies to the questionnaires: December 26, 2012 and January 24, 2013

Collection of the written reply to the questionnaires: February 18, 2013

1.2.3 Comments of Parties Relevant to the Cause

Comments on the draft report were invited from parties relevant to the cause of the incident.

1.2.4 Comments from Flag State

Comments on the draft report were invited from the flag State.

2 FACTUAL INFORMATION

2.1 Events Leading to the Incident

According to the statements of the master and the chief engineer of LNG ARIES (hereinafter referrerd to as “the Vessel”) and the manager in charge of the management company (MOL LNG Transport (Europe) Limited: (hereinafter referred to as “the Management Company) to manage the Vessel, and according to the written reply to the questionnaire of the Management Company (hereinafter referred to as “the Reply”), the events leading to the incident were as follows.

1) The Vessel, with 32 crew members in addition to the master and the chief engineer, was loaded with 125,469 m^3 of liquefied natural gas (hereinafter referred to as “LNG”) at the port of Ras Laffan in Qatar, left the port with an even keel of 11.35 meters on November 15, 2012. In addition, she was bunkered at the port of Fujairah in the United Arab Emirates, and then,

on November 17, left the port for the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port.

2) The Vessel needed to cool down her LNG unloading pipe[*1] to prepare for the LNG discharge before entering into the Keihin Port, and started the cool down process at slightly before 09:30, December 3, when a pilot of Tokyo Bay came aboard the Vessel.
3) The chief engineer burned the boil off gas of the LNG (hereinafter referred to as "BOG") vaporizing in the cargo tanks and the BOG vapored by the pipe cool down process, together with heavy fuel oil, in the main boilers. He then operated the main boilers in the gas burning mode to stop the burning of heavy fuel oil and burn only the BOG in the boilers, because large quantity of BOG had been vapored and steam consumption was decreasing due to the lowering of the revolution speed of the main engine to enter into the port.
4) The Vessel reached the waters off the Toden-Ogishima LNG Berth at around 11:53, stopped her main engine, and then was towed to the Berth by two tug boats, one at the bow and the other at the stern. While she was towed, at around 12:02 a gas leakage detector installed at one of the fuel gas pipes (double pipes that prevents gas leakage from the main-boiler fuel gas pipe to the outside) emitted a warning signal that indicated the increase of gas concentration. Then, the burning of BOG stopped in the main boilers; consequently, the flame failure occurred in there.
5) The chief engineer, at around 12:12, (a) ignited the fuel oil burners in the main boilers, (b) started the stand-by diesel generator and closed the air circuit breaker (hereinafter referred to as "the ACB") for the generator in order to make the generator bear the load of No.2 turbine generator of the two active turbine generators and thereby suppress steam consumption, and then (c) opened the ACB for No.2 turbine generator.
6) While the Vessel operated No.1 turbine generator and the stand-by diesel generator in parallel to increase steam pressure in the main boilers, at around 12:37, roughly 100 meters southeast of the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port, the ACBs for the generators tripped (automatically stopped), and then the electric power of the Vessel was lost. The Vessel was unable to operate the main turbine (main engine) and became loss of control.
7) With the escort of four tug boats, the Vessel was berthed at the Toden-Ogishima LNG Berth. She was then towed by the tug boats, and finally anchored in the harbor.
8) When the Vessel lost her electric power, the emergency diesel generator was automatically started, but its ACB was not closed. The chief engineer tried in vain to manually close the ACB. Then, the ACB was bypassed, and the generator was directly connected to the bus bar to light the inside of the Vessel. After lighting onboard was secured, the stand-by diesel generator was inspected, and failure of a diode on the main switchboard was found. Finally, the defective diode was fixed.
9) The Vessel operated the stand-by diesel generator to activate the main boilers. After they were started and the steam pressures returned to within the normal range, the turbine generators were operated to warm up the main turbine. At around 13:30, December 5, the main turbine became operable again.

[*1] Cooling down the LNG unloading pipe: the LNG unloading pipe is cooled down before the discharge of LNG to prevent abrupt evaporation of the low-temperature LNG that passes through the pipe lines and to prevent abrupt generation of thermal stress due to the low-temperature LNG.

The incident occurred at around 12:37, December 3, 2012, at around 120°true, 100 meters from the Toden-Ogishima LNG Berth Light in Section 2 of Kawasaki Quarter, Keihin Port.

(See Figure 1, "Location of the Incident.")

2.2 Injuries to Persons

There were no casualties.

2.3 Damage to Vessel

Vessel and other facilities were not damaged.

2.4 Crew Information

(1) Gender, Age, and Certificate of Competence

1) Master, male, age 34

Nationality: The Republic of Croatia
Master License issued by the Republic of Croatia
Issued on August 2, 2010
(valid until April 14, 2013)

2) Chief engineer, male, age 42

Nationality: The Republic of Croatia
Chief Engineer License issued by the Republic of Croatia
Issued on May 11, 2009
(valid until January 13, 2014)

(2) Seagoing Experience of Master and Chief Engineer

1) Master

According to the statement of the master, he started working as a seaman in 1996 and was promoted to master in 2010. His career on LNG tankers inaugurated in January 2003, and his career as the master of an LNG tanker inaugurated in July 2010. The first time he boarded on an LNG tanker managed by the Management Company was in March 2008.

2) Chief engineer

According to the statement of the chief engineer, he started working as a seaman in around 1991. He then boarded on vessels such as LNG tankers, chemical tankers, container ships, bulk carriers, and car carriers. His career on LNG tanters inaugurated in around 2002 when he boarded on an LNG tanker as a trainee engineer. The first time he boarded as the chief engineer on an LNG tanker was in August 2008.

2.5 Vessel Information

2.5.1 Particulars of Vessel

IMO number:	7390193
Port of registry:	Majuro (in the Republic of the Marshall Islands)
Owner:	BGT LTD (United States of America)
Management company:	The Management Company (United Kingdom of Great Britain and Northern Ireland)

Gross tonnage:	95, 084 tons
L×B×D:	285.30 m×43.74 m×24.99 m
Hull material:	Steel
Engine:	Steam turbine engine×1
Output:	31,269 kW
Date of laying down:	October 23, 1974
Classification Society:	American Bureau of Shipping

2.5.2 Cargo Information

LNG is consisting primarily of methane (CH_4). It is a clear and colorless liquid, and its volume is condensed and reduced to 1/600 when it is cooled to −162°C under atmospheric pressure.

The cargo tanks of the Vessel were cold storage tanks; however, LNG temperature in the tanks gradually increases due to the heat entering from outside. In order to avoid LNG temperature rises, LNG tankers use a low duty compressor (hereinafter referred to as "the L/D Comp.") to send the BOG, which evaporated due to the heat entering from the outside during voyage, to the main boilers and then the BOG was burnt in the main boilers. The Vessel used the steam generated by the burning of the evaporated gas for propulsion and power generation to maintain the LNG temperature and pressure in the cargo tanks.

2.5.3 Hull Information

The Vessel was docking bridge type and a Moss type LNG tankers[*2] with the ocean going. The Vessel was equipped with five independent spherical cargo tanks, each of which could contain about 25,260 m^3 of LNG. The tanks were mounted in a center line from bow to stern, and the upper half of each tank was exposed above the upper deck.

The cargo tanks were numbered from the bow to the stern, No.1, No.2, No.3, No.4 and No.5 respectively. The tank in the stern was Cargo Tank No. 5. Between Cargo Tanks No. 2 and No. 3, a manifold, which could be connected to a cargo loading arm from the land, was mounted.

(See Figure 2, "General Arrangement.")

2.5.4 Information on Engine Room Equipment

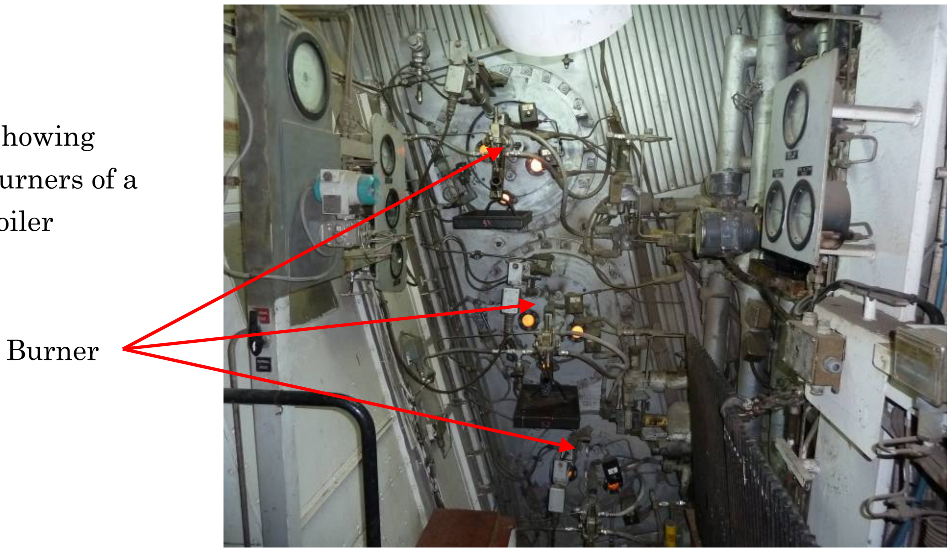
(1) Main Boilers

The Vessel was equipped with two double-drum (D-type) water-tube boilers. Each boiler consisted of a steam drum mounted in the upper part of it, and of a water drum mounted in the lower part. The former was connected to the latter via multiple water tubes. Three laterally-facing burners were installed longitudinally to each boiler. A fuel oil burner is installed in the center of each burner, and the burners surrounding the fuel oil burner were gas burners. Three modes were selectable: (1) The fuel oil burning mode in which only fuel oil is burned; (2) the dual burning mode in which both fuel oil and BOG are burned simultaneously; and (3) the gas burning mode in which only BOG is burned.

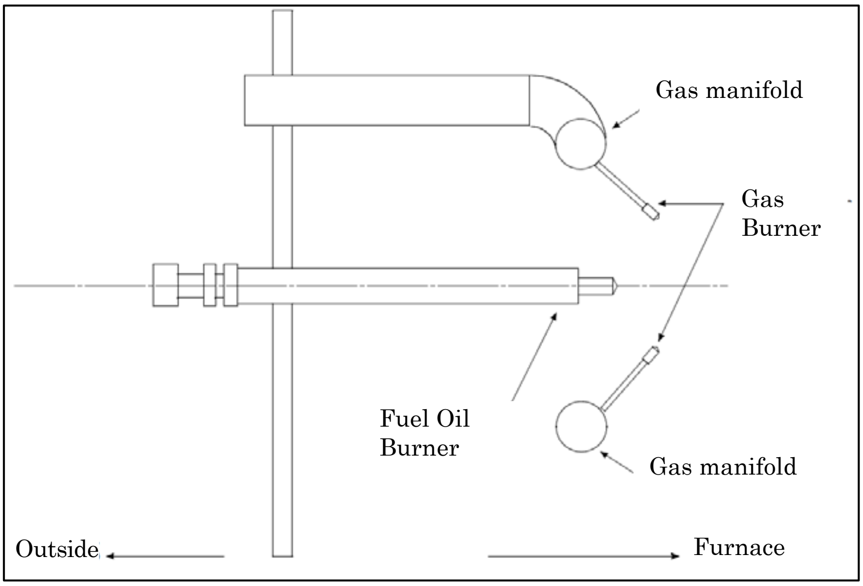
The steam generated in the main boilers was used to operate the main turbine (main engine) as well as the turbine generators, and to heat various parts.

[*2] Moss type LNG tankers: LNG tankers equipped with independent spherical cargo tanks. Each cargo tank is independent of the ship hull and supported by the top of a cargo-tank supporting member called a skirt. The bottom of the skirt is welded to walls in the hold.

Photo showing three burners of a main boiler



Layout of the Fuel Oil Burner and the Gas Burners



(2) Main Turbines

The main turbine was composed of a High Pressure turbine and a Low Pressure turbine. Steam accelerated through nozzles was blown to turbine rotor cascades to rotate the rotor. This mechanism, known as a turbine stage, was installed to each of the High Pressure and Low Pressure turbines. The turbines, which rotate at high speeds, were decelerated by reduction gears to rotate the propeller. The steam was sent to either the High Pressure turbine or the astern turbine to determine the propeller rotation direction, and the amount of the steam was increased or decreased to change the propeller rotation speed.

(3) Generators

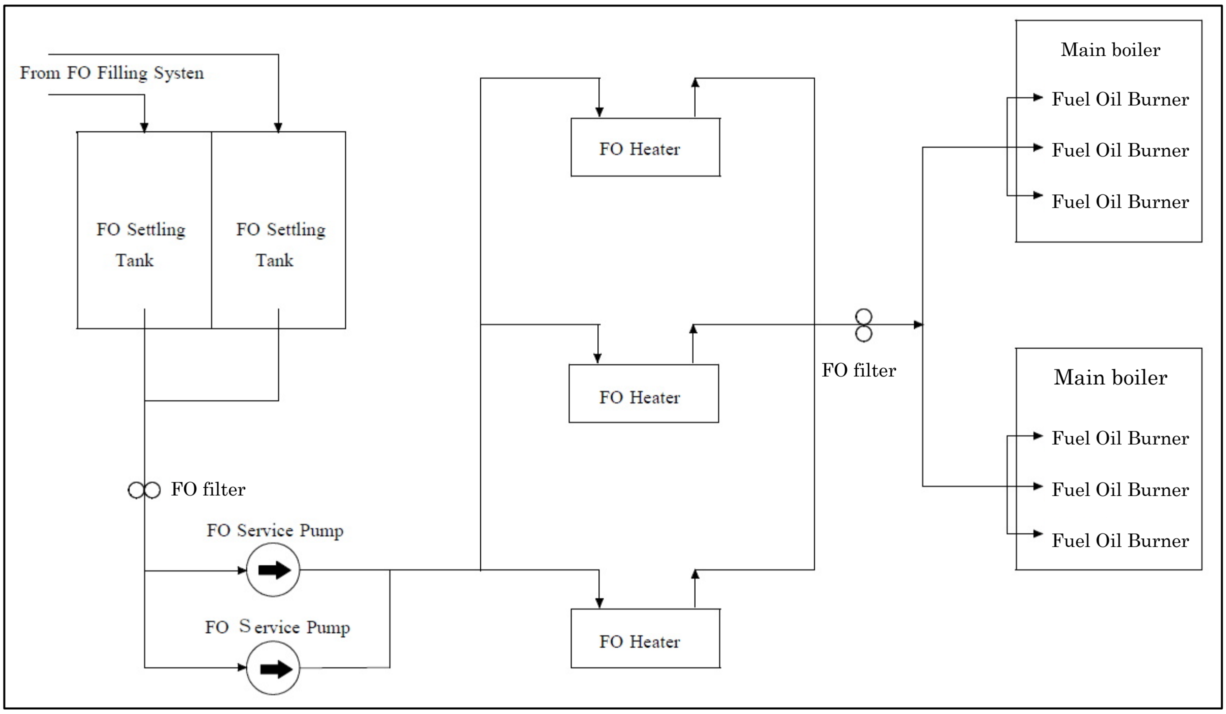
The Vessel was equipped with two 2,500-kW turbine generators, one 1,500-kW stand-by diesel generator, and one 254-kW emergency diesel generator. Usually, the turbine generators were used. The stand-by diesel generator was used in cases such as when high power was required and when the Vessel entered a dock. The emergency diesel generator was supposed to automatically operate and the ACB for the generator was also supposed to be automatically closed in the event that the electric power of the Vessel was lost.

(See Photos 1 and 2 Stand-by Diesel Generator [the port side], Photo 3 Emergency Diesel Generator [diesel engine], Photo 4 Emergency Generator [generator], Photo 5 Emergency Switchboard, and Photo 6 ACB for the Emergency Diesel Generator.)

2.5.5 Information on the Main-Boiler Fuel System

(1) Fuel Oil System

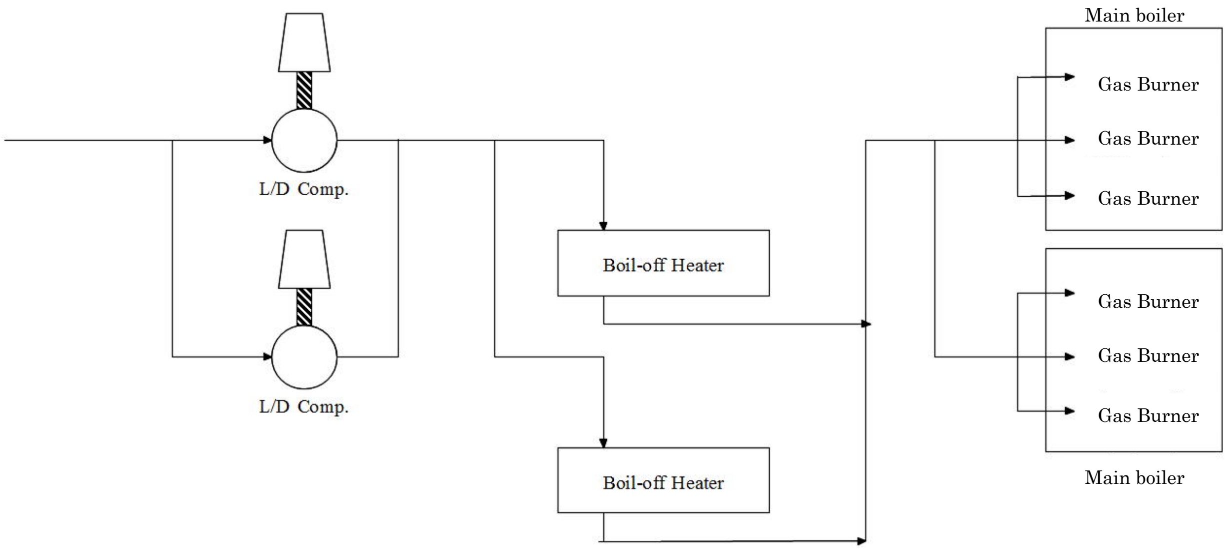
Fuel oil stored in the fuel tank on the Vessel was supplied to FO settling tanks via FO supply pumps. The fuel oil was then suctioned and pressurized by an FO service pumps via an FO filter. Subsequently, the fuel oil was heated to a preset temperature by FO heaters, and then supplied to the fuel oil burners in the main boilers.



Fuel oil system

(2) BOG System

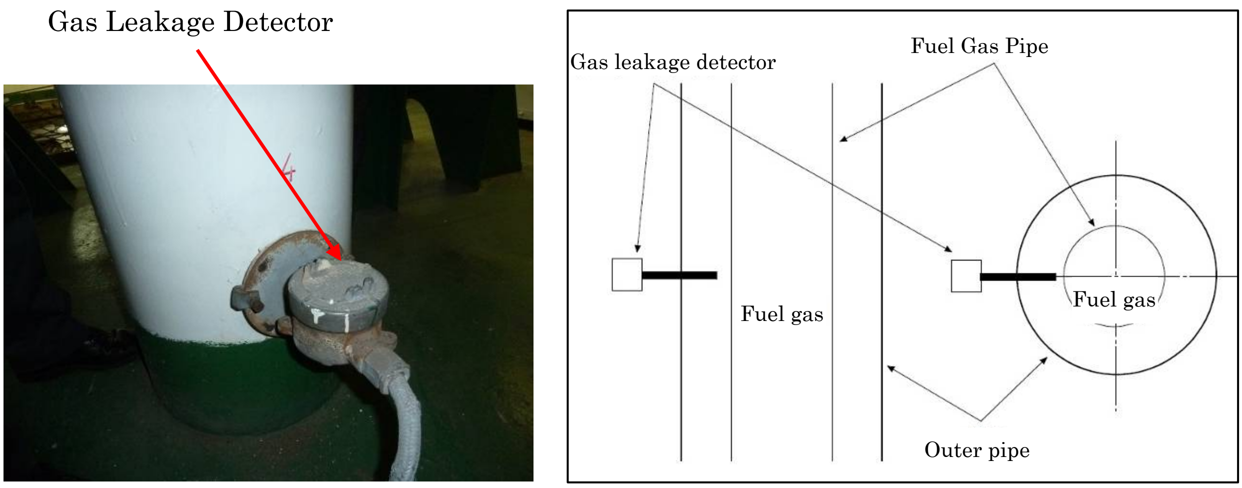
L/D Comps extracted the BOG generated in the cargo tanks by the heat entering from the outside or by cooling down the LNG unloading pipe. The BOG was then heated by boil-off heaters and supplied to the gas burners of the main boilers.



BOG system

Each fuel gas pipe that connects a cargo tank to one of the main boilers was a double pipe. The pipe was enclosed by a wider pipe (outer pipe) to prevent serious accidents caused by BOG leakage (which is caused by factors such as damage to the fuel gas pipe). A gas leakage detector was installed between the outer and fuel gas pipes. The gas leakage detector was supposed to emit an alarm when BOG concentration increased due to BOG leakage caused by factors such as damage to the fuel gas pipe. Also, the gas leakage detector was supposed to cause the burning of BOG in the main boilers to stop.

(See Photo 7 Gas Leakage Detector Monitoring Equipment.)



Gas leakage detector

2.6 Events Leading to the Electric Power Loss and Loss of Control of the Vessel

According to the statements of the chief engineer and the manager in charge of the Management Company to manage the Vessel, and to the Reply, it was the events below that led to the electric power loss and loss of control of the Vessel.

2.6.1 Gas Leakage from a Fuel Gas Pipe

While the Vessel was coming alongside the LNG Berth, a gas leakage detector installed at a fuel gas pipe emitted a warning signal indicating that the gas concentration had exceeded 37%, which is the low flammable limit (LFL). The detector caused the burning of BOG in the two main boilers to stop, which occurs flame failure in the main boilers as the gas burning mode was in operation.

2.6.2 Electric Power Loss in the Vessel

After the flame failure occurred in main boilers, the chief engineer immediately ignited the fuel oil burners in the main boilers and operated the boilers in the fuel oil burning mode so as to raise the steam pressure. In order to suppress steam consumption, he decided to stop one of the turbine generators. Therefore, he started the stand-by diesel generator and closed the ACB for the generator, made the stand-by diesel generator bear the load of No.2 turbine generator, and then opened the ACB for No.2 turbine generator.

After the ACB for the stand-by diesel generator was closed and the ACB for the No.2 turbine generator was opened, the operation of the generator became unstable. About five or six minutes later, the ACBs for the stand-by diesel generator and No.1 turbine generator tripped, and electric power of the Vessel was lost.

2.6.3 Loss of Control of the Vessel

Since the electric power was lost on the Vessel, the main boilers tripped, which decreased the steam pressure. The amount of steam required for the operation of the main turbine (main engine) could not be obtained, and this disabled the Vessel.

2.6.4 Operation Failure of the Emergency diesel Generator

The emergency diesel generator and its ACB were supposed to automatically operate in response to the loss of the Vessel's electric power. When the incident occurred, the emergency diesel generator was automatically started, but the ACB was not closed. Accordingly, the chief engineer tried in vain to manually close the ACB.

2.7 Restoration of the Electric Power of the Vessel

According to the statements of the chief engineer and the manager in charge of the Management Company to manage the Vessel, and according to the Reply, the electric power of the Vessel was restored as follows.

2.7.1 Emergency Operation of the Emergency Diesel Generator

After the electric power of the Vessel was lost, the ACB for the emergency generator was bypassed, and the generator was directly connected to the bus bar in order to light the inside of the Vessel. The generator was then started to obtain electric power such as for lighting.

2.7.2 Emergency Operation of the Stand-by Diesel Generator

After the lighting was restored on the Vessel, the stand-by diesel generator was operated. However, a load in excess of about 380 kW caused the ACB to trip. Therefore, the chief engineer adjusted the stand-by diesel generator so that power consumption would be suppressed and the main boilers would be operated within a power range that enabled the generator to operate.

2.7.3 Main Boiler Operation

Since the FO heaters of the Vessel could not be used due to the decreased steam pressure, diesel oil, instead of heavy fuel oil, was supplied to the fuel oil burners. In this state, the fuel oil burners were ignited, and the steam pressure gradually increased. Once the heavy fuel oil could be heated, it was supplied to the fuel oil burners instead of diesel oil, in order to further increase the steam pressure.

2.7.4 Turbine Generator Operation

After the steam pressure in the main boilers returned to within a normal range, the turbine generators of the Vessel were started, and the stand-by diesel generator as well as the emergency diesel generator were stopped. The main turbine was then warmed up, and became operable.

2.8 Inspection of Broken Equipment after the Incident

According to the statements of the chief engineer and the manager in charge of the Management Company to manege the Vessel, the inspection of the broken equipment revealed the facts below.

2.8.1 Gas Leakage from Fuel Gas Pipes

The inspection of the gas leakage detectors revealed that there was no damage to the fuel gas pipes. However, a failure was found at the base of the detection unit. An alarm error had activated the warning device (for the increase of gas concentration) and also stopped the burning of BOG in the main boilers to occur a flame failure.

2.8.2 Stand-by Diesel Generator

After the emergency diesel generator of the Vessel was urgently operated and the lighting restored, an attempt was made to operate the stand-by diesel generator and close the ACB for the generator. However, the voltage of the generator did not increase, and the ACB could not be closed. A crew member inspected the main switchboard and found that a diode on the electric circuit was loose. After the diode was fixed, the stand-by diesel generator started to operate, and then the voltage of the generator increased, and it became possible to close the ACB for the generator.

The operation of the stand-by diesel generator on the Vessel continued to restore the main boilers; however, it turned out that a load of around 380 kW caused the ACB to trip.

The upper limit of the power of the stand-by diesel generator was determined to be 380 kW on the Vessel, and the main boilers, turbine generators, and main turbine were restored. On December 15, the Vessel went out of Tokyo Bay, and the stand-by diesel generator was further inspected. The inspection revealed that the air side of the air inter cooler of the stand-by diesel generator was soiled and clogged, and that the 3-way temperature control valve of the cooling fresh water system was jammed.

Soiling of the air side of the air condenser of the stand-by diesel generator

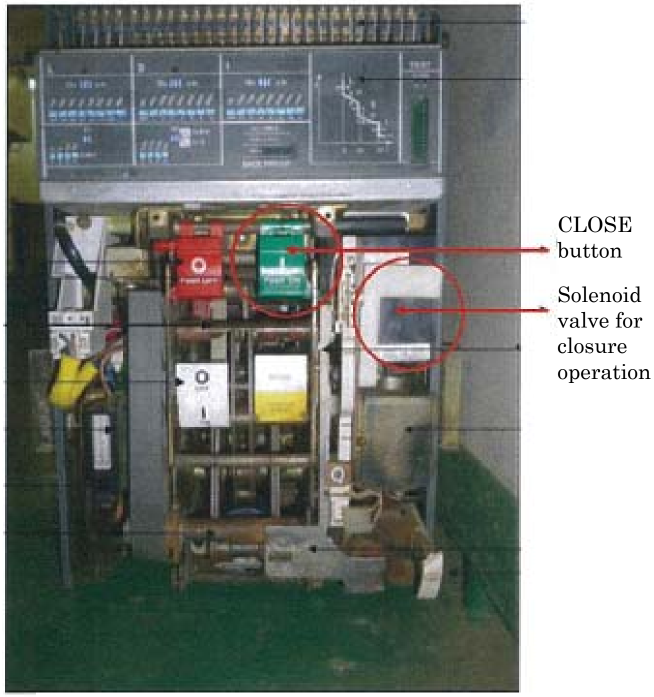
2.8.3 Failure of the ACB for the Emergency Diesel Generator

After the Vessel went out of Tokyo Bay, the ACB for the emergency diesel generator was inspected; consequently, the revealed abnormality was as follows.

(a) damage to a plastic part in the internal linkage mechanism behind the CLOSE button of the ACB,

(b) operation failure of the spring as well as the solenoid valve for the closure operation, and

(c) The melting of a fuse on the electric circuit in the emergency switchboard and the failure of a relay on the circuit.



ACB for the emergency diesel generator

(The ACB is removed from the generator)

Damage to a plastic part in the internal linkage mechanism

Damage to the solenoid valve for closure operation

Damage to the ACB for the emergency diesel generator

2.9 Condition and Maintenance of Equipment

According to the statements of the chief engineer and the manager in charge of the Management Company to manage the Vessel, the condition and maintenance of the equipment on the Vessel were as follows.

2.9.1 Gas Leakage Detectors

Prior to the incident, the gas leakage detectors of the Vessel had not detected any gas leakage, emitted a warning, nor caused the burning of BOG to stop.

2.9.2 Stand-by Diesel Generator

The Maintenance System for the Vessel specify what maintenance needs to be performed on the stand-by diesel generator according to the working hours of the generator, so the crew members performed that maintenance. However, the timing of the maintenance was not based on any term, but on the working hours of the generator. Since the total working hours of the generator were about 1,500 hours, the air side of the air inter cooler was not inspected nor cleaned.

On the Vessel, the stand-by diesel generator was operated weekly on a trial basis. During each operation, the ACB was closed to exert a load on the generator. However, the load was only about 250 kW.

2.9.3 Emergency Diesel Generator

Every month, the emergency diesel generator was operated for about two hours on a trial basis, with a load exerted on it. The generator was operated without any problems about 10 days prior to the incident.

2.10 Gas Burning Mode in the Main Boilers during Berthing

According to the statements of the chief engineer and the manager in charge of the Management Company to manage the Vessel, the conditions relating to the gas burning mode during the berthing of the Vessel were as follows.

The burning mode of the main boilers had been determined by the amount of the vapored BOG or by a request from the Charterer or Shipper. On the other hand, since the LNG unloading pipe had been cooled down while the Vessel had come alongside the port of shipment or discharging, large quantity of BOG had been vapored. Accordingly, the vapored BOG needed to be burned in the main boilers, and excess steam needed to be condensed into water by the heat exchanger.

On the Vessel, the cooling down of the LNG unloading pipe, which had usually been performed before her entry into port, ended around the time when a harbor pilot boarded the Vessel. In response to this, the amount of the vapored BOG decreased; therefore, during the berthing of the Vessel, the main boilers would have to be operated in the dual burning mode. However, during the incident, the gas burning mode was selected to operate the main boilers with only BOG. The purposes of this were to maximize the vapored BOG burning.

In the main boilers, it is likely that the fire from the gas burners was blown out. The trips of the main boilers during the berthing of a vessel could disable the vessel, possibly leading to a serious accident. Accordingly, other LNG tanker usually do not operate their main boilers in the gas burning mode during berthing. However, the Management Company had not given any clear and strong instructions to prohibit the gas burning mode during the stand-by-engine mode.

2.11 Management Company

According to the statements of the manager in charge of the Management Company to manage the Vessel, the informationon the Management Company was as follows..

The Management Company engaged in LNG tanker management and it was managing 15 LNG tankers at the time of the incident.

Managers called superintendents (SIs) were responsible for LNG carrier management. The Management Company appointed SI for performing operation and SI for managing technical matters; consequently, they jointly managed the LNG carriers.

2.12 Weather and Sea Conditions

2.12.1 Weather Observed Values

According to the Yokohama Local Meteorological Observatory located about 8.7 km east-northeast of the site of the incident, the weather observed values at around the time of the incident were as follows.

	Weather	Wind direction	Wind speed	Temperature
10:00	Cloudy	North	7.6 m/s	6.4˚C
11:00	Cloudy	North	7.1 m/s	6.7˚C
12:00	Cloudy	North	7.0 m/s	7.2˚C
13:00	Cloudy	North	5.9 m/s	7.6˚C
14:00	Cloudy	North-northwest	5.6 m/s	8.0˚C

2.12.2 Observation by Crew

According to the description of the logbook, when the incident occurred, the weather was cloudy, a force three wind was blowing from the north, the visibility was clear, and the sea was calm.

3 ANALYSIS

3.1 Situation of the Incident Occurrence

3.1.1 Course of the Events

According to Chapters 2.1, 2.5.2, 2.5.4, 2.5.5, and from 2.6 through 2.10, it is probable that the events leading up to and following the incident were as follows:

(1) While the Vessel was coming alongside the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port, her main boilers were operated in the gas burning mode during the course of the incident. Usually, the main boilers are not operated in the gas burning mode during the berthing of the Vessel.

(2) A gas leakage detector installed at a fuel gas pipe on the Vessel emitted a false warning signal indicating an increased gas concentration. The burning of BOG tripped in the main boilers, occurring flame failure in the main boilers.

(3) The fuel oil burners in the main boilers were ignited to increase the steam pressure in the boilers. In order to suppress the steam consumption, the stand-by diesel generator was started to make it bear the load of No.2 turbine generator. The ACB for the stand-by diesel generator was closed so as the made generator could bear the load on No.2 turbine generator. Subsequently, the ACB for No.2 turbine generator was opened, but the ACBs for the active

stand-by diesel generator and the active No.1 turbine generator tripped. Finally, the electric power of the Vessel was lost.

(4) After the electric power was lost, the emergency diesel generator of the Vessel was automatically started, but its ACB was not closed. A chief engineer tried in vain to manually close the ACB.

(5) Since the electric power of the Vessel was lost, the main boilers tripped, which decreased the steam pressure in them. The decrease of the steam pressure led to a shortage in the amount of steam required for the operation of the main turbine (main engine), and this lost control of the Vessel. With the escort of four tug boats, the Vessel was subsequently berthed at the Toden-Ogishima LNG Berth.

Noted that, later, a crew member bypassed the ACB for the emergency diesel generator to light the inside of the Vessel. The stand-by diesel generator was then operated, restoring the main boilers. Finally, the turbine generators were operated, which made the main turbine operable.

3.1.2 Time, Date, and Location of the Incident

According to Chapter 2.1, it is probable that the incident occurred at around 12:37, December 3, 2012 and at around 120°true, 100 meters from the Toden-Ogishima LNG Berth Light.

3.2 Causal Factors of the Incident

3.2.1 Crew and Vessel Conditions

(1) Crew Conditions

According to Chapter 2.4, it is probable that the master and the chief engineer had a leagal and valid certificates of competency, and that they had experience in working in LNG tankers.

(2) Vessel Conditions

According to Chapters 2.1, 2.8.2, and 2.8.3, at the time of the incident, it is probable that the air side of the air inter cooler of the stand-by diesel generator was clogged; that a load which exceeds 380 kW could not be placed on the generator because the amount of air supply was insufficient when the generator was operated to increase the load; that a diode on an electric circuit on the main switchboard was loose; and that there was a problem with the ACB for the emergency diesel generator and it could not be closed.

3.2.2 Gas Leakage Detector Conditions

According to Chapters 2.1, 2.5.5 (2), 2.8.1, and 2.9.1, gas leakage detectors are devices that detect the increase of gas concentration caused by BOG leakage due to factors such as damage to any fuel gas pipe, and emit a warning signal in response to the gas concentration. At the time of the incident, a gas leakage detector emitted a warning signal that indicated an increased gas concentration, and then the burning of BOG then stopped in the main boilers, indicating flame failure in the main boilers. However, in actuality, no fuel gas pipes were damaged, and the gas concentration had not increased. Therefore, it is probable that the base of the detection unit was defective, and that the warning signal was wrongly emitted because of the defect.

3.2.3 Main Boiler Burning Mode

According to Chapters 2.1, 2.5.4 (1), 2.5.5 and 2.10, it is probable that while the Vessel was coming alongside the Toden-Ogishima LNG Berth, large quantity of BOG was vapored (a) in the cargo tanks due to the heat entering from the outside and (b) by the pipe cooling down process, and that the main boilers were operated in the gas burning mode to maximize the vapored BOG burning. In the gas burning mode of the main boilers, it is somewhat likely that the flames of the gas burners were blown out, and if the main boilers trip during the berthing of the Vessel, she may become lost of control, which could lead to a serious accident. This is why other LNG tankers do not usually operate their main boilers in the gas burning mode during berthing. However, it is probable that the Management Company had not given any clear and strong instructions to prohibit the gas burning mode during the stand-by-engine mode.

3.2.4 Maintenance of the Stand-by Diesel Generator

According to Chapter 2.9.2, specified maintenance was performed on the stand-by diesel generator according to its working hours. However, the timing of the maintenance was based on operational time periods, and the total working hours of the generator were short. Therefore, it is probable that the air side of the air inter cooler of the stand-by diesel generator was not inspected nor cleaned.

3.2.5 Operation of the Stand-by Diesel Generator and the Emergency Diesel Generator

According to Chapters 2.5.4 (3), 2.7.2, 2.8.2, 2.9.2, and 2.9.3, it is probable that the situations was as follows.

(1) Stand-by Diesel Generator

On the Vessel, the turbine generators were usually used, whereas the stand-by diesel generator was used for a short time when high power was required or when the Vessel entered a dock. The stand-by diesel generator was operated weekly on a trial basis. Since the load placed on the generator during the trial operation was low, around 250 kW, no crew members noticed that the air side of the air inter cooler of the stand-by diesel generator was clogged.

(2) Emergency Diesel Generator

The emergency diesel generator was operated for about two hours every month on a trial basis, with a load exerted on it. About 10 days prior to the incident, it was operated for about two hours with a load exerted on it, and no abnormalities were found.

3.2.6 Events Leading to the Loss of Control of the Vessel after Flame Failure in the Main Boilers

According to Chapters 2.6, 2.8.2, and 2.8.3, it is probable that the incidents below occurred.

(1) After occurring flame failure in the main boilers, the fuel oil burners in them were ignited to increase the steam pressure in them. In order to suppress the steam consumption, the stand-by diesel generator was started, and then the ACB for the generator was closed to make it bear the load of No.2 turbine generator. The ACB for No.2 turbine generator was then opened.

(2) The operation of the stand-by diesel generator became unstable, and then the ACBs for No.1 turbine generator and the stand-by diesel generator tripped; accordingly the electric power of the Vessel was lost. It is probable that the unstable generator operation was caused by the lack of air supply due to the clogging of the air side of the air inter cooler of the stand-by diesel generator, the looseness of the diode on the main switchboard, or some other factor.

However, the real cause was not discovered.

(3) Since the electric power was lost in the Vessel, the main boilers tripped, which decreased the steam pressure in them. The amount of steam required for the operation of the main turbine (main engine) could not be obtained, and this lost control of the Vessel.

(4) The emergency diesel generator (for backup) and its ACB were supposed to automatically operate in response to electric power loss. When the incident happened, the emergency diesel generator was automatically started, but the ACB was not closed. In response to this, the chief engineer tried to manually close the ACB. However, due to damage to the ACB, it could not be closed.

3.2.7 Weather and Sea Conditions

According to Chapter 2.12, it is probable that the weather was cloudy, a force three wind was blowing from the north, the visibility was clear, and the sea was calm when the incident occurred.

3.2.8 Occurrence of the Incident

According to Chapters 2.1, 2.6.1, 2.6.2, 2.8 and 2.10, it is probable that the circumstances were as follows.

(1) While the Vessel was coming alongside the Toden-Ogishima LNG Berth in Section 2 of Kawasaki Quarter, Keihin Port, the base of the detection unit became defective. The gas leakage detector installed at a fuel gas pipe emitted a false warning signal indicating an increased gas concentration. The burning of BOG then stopped, occurring flame failure in the main boilers.

(2) Usually, the main boilers were not operated in the gas burning mode during the berthing of the Vessel. However, when the incident occurred, they were operated in the gas burning mode to maximize the vapored BOG burning. In the gas burning mode of the main boilers, it is somewhat likely that the flames of the gas burners were blown out, and if the main boilers trip during the berthing of the Vessel, she may become lost of control, which could lead to a serious accident. This is why other LNG tankers do not usually operate their main boilers in the gas burning mode during berthing. However, it is probable that the Management Company had not given any clear and strong instructions to prohibit the gas burning mode during the stand-by-engine mode.

(3) After occurring flame failure in the main boilers, the fuel oil burners in them were ignited to increase the steam pressure in them. In order to suppress the steam consumption, the stand-by diesel generator was started, and then the ACB for the generator was closed to make it bear the load of No.2 turbine generator. The ACB for No.2 turbine generator was then opened.

(4) The operation of the stand-by diesel generator became unstable, and then the ACBs for the stand-by diesel generator and the remaining active turbine generator tripped. Finally, the electric power of the Vessel was lost; accordingly, this lost control of the Vessel. It is probable that the unstable generator operation was caused by the lack of air supply due to the clogging of the air side of the air inter cooler of the stand-by diesel generator, by the looseness of the diode in the main switchboard, or by some other factor. However, the real cause was not discovered.

(5) The emergency diesel generator (for backup) and its ACB were supposed to automatically operate in response to electric power loss. When the incident happened, the emergency diesel

generator was automatically started. However, due to damage to the ACB, the ACB could not be closed.

(6) With the escort of four tug boats, it was possible to berth the Vessel at the Toden-Ogishima LNG Berth.

4 CONCLUSIONS

4.1 Probable Causes

While the Vessel was coming alongside the Toden-Ogishima LNG Berth, her main boilers were operating in the gas burning mode. A gas leakage detector installed at a fuel gas pipe then emitted a signal indicating an increased gas concentration. The burning of BOG then stopped; consequently, the flame failure occurred in the main boilers. In order to suppress steam consumption, the stand-by diesel generator was made to bear the load on one of the two turbine generators. After the ACB for the one of the two turbine generators was opened, causing the electrical trips of the ACBs for the stand-by diesel generator and the remaining active turbine generator. Finally, the electric power of the Vessel was lost. It is probable that the electric power loss in the Vessel caused the incident.

4.2 Other Discovered Safety-Related Matters

Large quantity of BOG was vapored in the cargo tanks of the Vessel due to heat entering from the outside, and to the cooling down of the LNG unloading pipe. In order to maximize the vapored BOG burning, the main boilers were operated in the gas burning mode (which is not normal practice during berthing) while the Vessel was coming alongside the berth. In the gas burning mode of the main boilers, it is somewhat likely that the flames of the gas burners were blown out, and if the main boilers trip during the berthing of the Vessel, she may become lost of control, which could lead to a serious accident. This is why other LNG tankers do not usually operate their main boilers in the gas burning mode during berthing. However, it is probable that the Management Company had not given any clear and strong instructions to prohibit the gas burning mode during the stand-by-engine mode.

It is likely that the occurrence of the incident could have been avoided if the fuel oil burning mode or the dual burning mode had been selected to operate the main boilers.

The Vessel used the stand-by diesel generator for a short time only when high power was required or when the Vessel entered a dock. In addition, the stand-by diesel generator was operated weekly on a trial basis. However, since the load placed on the generator was low, around 250 kW, no crew members noticed that the air side of the air inter cooler of the stand-by diesel generator was clogged, and the air inter cooler was not inspected nor cleaned. It is somewhat likely that the stand-by diesel generator would have operated normally if the air inter cooler had been inspected and serviced.

5 SAFETY ACTIONS

While the Vessel was coming alongside the Toden-Ogishima LNG Berth, the burning of BOG in the main boilers stopped; consequently, the flame failure occurred. The stand-by diesel generator was made to bear the load of one of the two turbine generators. After the ACB for the one of the two turbine generators was opened, causing the electrical trips of the ACBs for the stand-by diesel generator and the remaining active turbine generator. Finally, the electric power of the Vessel was lost. It is probable that the electric power loss in the Vessel caused the incident.

Large quantity of BOG was vapored in the cargo tanks of the Vessel due to heat entering from the outside, and to the cooling down of the LNG unloading pipe. In order to maximize the vapored BOG burning, it is probable that the main boilers were operated in the gas burning mode (which is not normal practice during berthing) while the Vessel was coming alongside the berth. In the gas burning mode of the main boilers, it is somewhat likely that the flames of the gas burners were blown out, and if the main boilers trip during the berthing of the Vessel, she may become lost of control, which could lead to a serious accident. This is why other LNG tankers do not usually operate their main boilers in the gas burning mode during berthing. However, it is probable that the Management Company had not given any clear and strong instructions to prohibit the gas burning mode during the stand-by-engine mode.

It is likely that the occurrence of the incident could have been avoided if the fuel oil burning mode or the dual burning mode had been selected to operate the main boilers.

The Vessel used the stand-by diesel generator only when high power was required or when the Vessel entered a dock. In addition, the stand-by diesel generator was operated weekly on a trial basis. However, since the load placed on the generator was low, around 250 kW, no crew members noticed that the air side of the air inter cooler of the stand-by diesel generator was clogged, and the air inter cooler was not inspected nor cleaned. It is somewhat likely that the stand-by diesel generator would have operated normally if the air inter cooler had been inspected and serviced.

Accordingly, it is probable that the Vessel must (a) avoid operating the main boilers in the gas burning mode while berthing, a time at which the flame failure in the main boilers could lead to a serious accident, (b) operate the stand-by diesel generator while sufficient load is exerted on it, and (c) be subject to periodical overhaul.

5.1 Safety Actions Taken by the Management Company

The Management Company took the actions below for the Vessel.

(1) Stand-By Diesel Generator

-Replacement of the air inter cooler with a new one

-Inspection and overhaul of the supercharger

-Inspection and maintenance of the cooling fresh water system

(2) Emergency Diesel Generator

-Inspection, such as the switchboard

-Replacement of the ACB with new one

(3) Gas Leakage Detectors

-Replacement of the broken gas leakage detector with a new one

5.2 Accident Prevention Measures Taken

The Management Company took the accident prevention measures given below for the vessels that it manages, including the Vessel.

(1) Regarding the burning mode of the main boilers, the Management Company issued a warning to the vessels that the gas burning mode must be avoided during berthing or sailing in congested sea areas.

(2) The stand-by diesel generator of each vessel must periodically be operated under normal load and be subject to periodic maintenance.
(3) The emergency diesel generator of each vessel must be operated, as is currently done, on a trial basis according to the manual.
(4) The interval for performing the operation tests of the gas leakage detectors was changed from every four months to every two months.

Figure 1 “Location of the Incident”

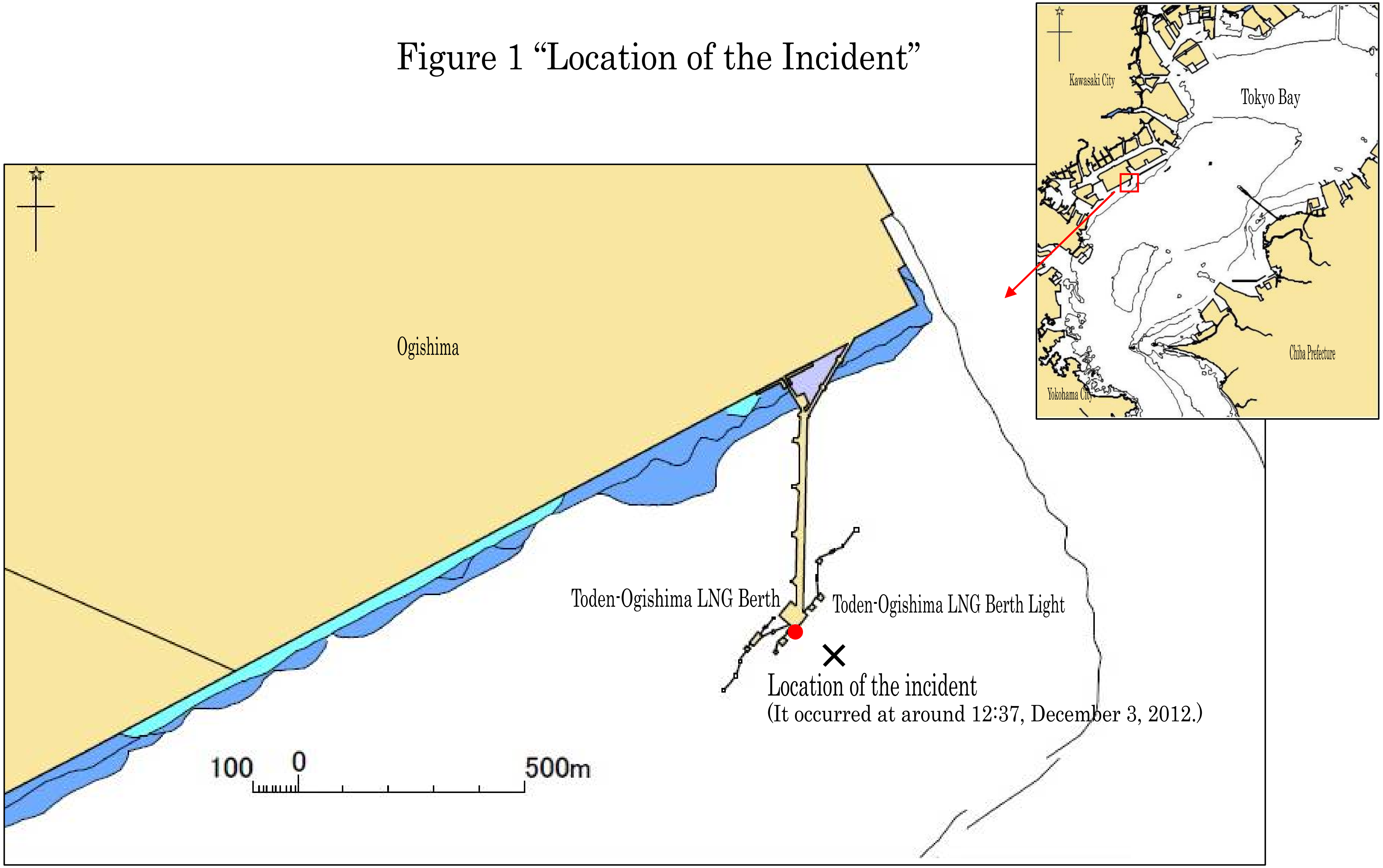


Figure 2 “general Arrangement”

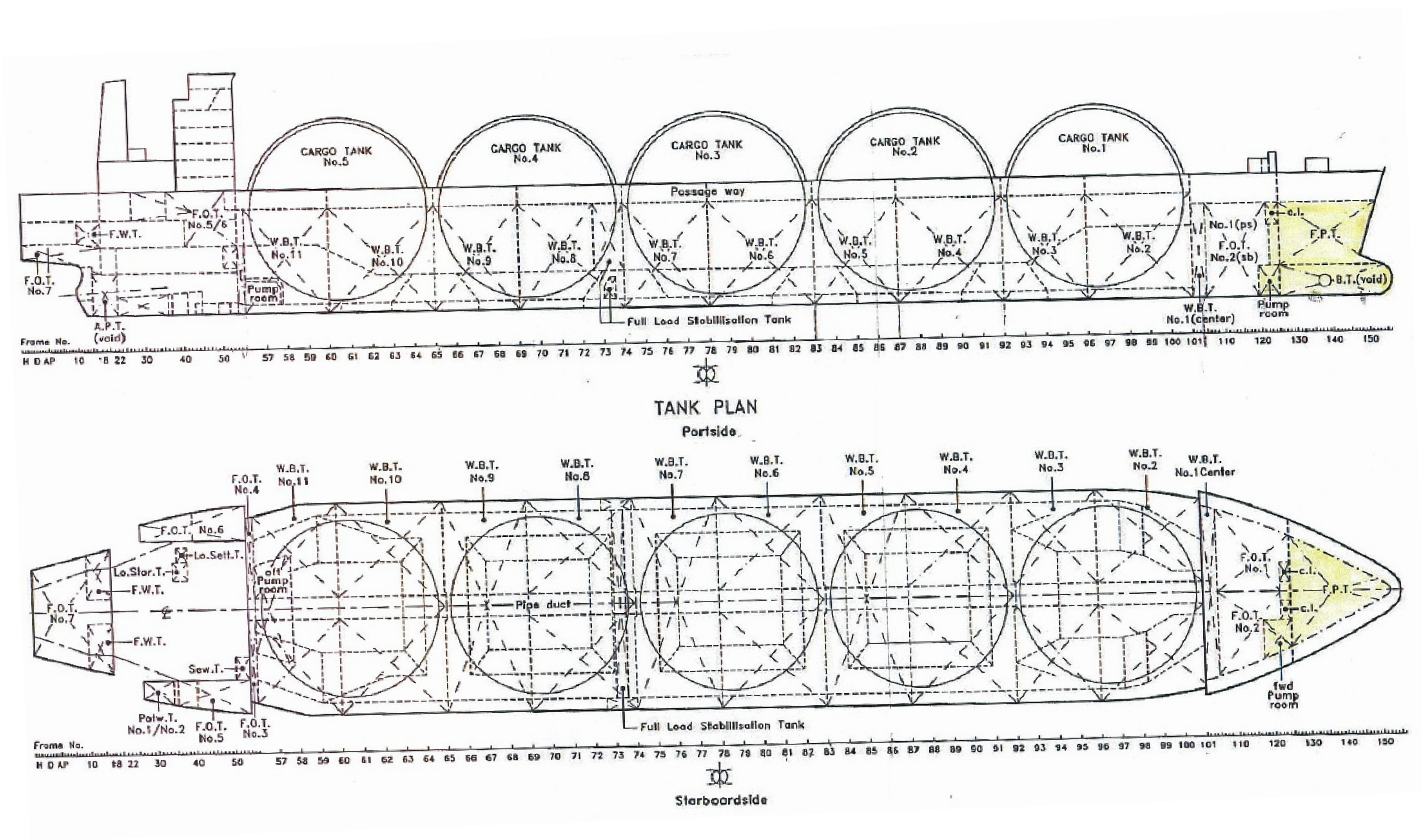


Photo 1: Stand-by Diesel Generator (the port side)

Photo 2: Stand-by Diesel Generator (the port side)

Photo 3: Emergency Diesel Generator (diesel engine)

Photo 4: Emergency Diesel Generator (generator)

Photo 5: Emergency Switchboard

ACB

Photo 6: ACB for the Emergency Diesel Generator

Photo 7: Gas Leakage Detector Monitoring Equipment