INF. 25

Economic Commission for Europe

20 January 2014

Inland Transport Committee

Working Party on the Transport of Dangerous Goods

**Joint Meeting of Experts on the Regulations annexed to the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)
(ADN Safety Committee)**

Twenty-fourth session
Geneva, 27–31 January 2014
Item 4 (b) of the provisional agenda
Special authorizations, derogations and equivalents

Proposed text of a derogation regarding the use of LNG for propulsion for a push boat to be built by Kooiman Marine

Transmitted by the Government of the Netherlands

Attached is the proposed text of possible derogations for a vessel regarding the use of LNG for propulsion.

Decision of the ADN Administrative Committee relating to the push boat to be build by Kooiman Marine (nr. 204)

Derogation No. x/2014 of 31 January 2014

The competent authority of the Netherlands is authorized to issue a trial certificate of approval to the push boat to be built by Kooiman Marine B.V. (shipyard number 204, official ID number not available), as referred to in the ADN, for the use of liquefied natural gas (LNG) as fuel for the propulsion and auxiliary installation.

Pursuant to paragraph 1.5.3.2 of the Regulations annexed to ADN, the above-mentioned vessel may deviate from the requirements of 7.2.3.31.1 and 9.3.2.31.1 until 30 June 2017. The Administrative Committee has decided that the use of LNG is sufficiently safe if the following conditions are met at all times:

1. The vessel has a valid ship's certificate according to the Rhine Vessel Inspection Regulations, based on recommendation 24/2013 of the CCNR.

2. A HAZID study by the recognized classification society[1] shows that the safety level of the LNG propulsion system is sufficient. This study covered, but was not limited to, the following issues:

   - Interaction between cargo and LNG;
   - Effect of LNG spillage on the construction;
   - Effect of cargo fire on the LNG installation;
   - Different types of hazard posed by using LNG instead of diesel as fuel;
   - Adequate safety distance during bunkering operations.

3. The information that LNG is used as fuel is included in the dangerous goods report to traffic management and in emergency notifications;

4. All data related to the use of the LNG propulsion system shall be collected by the carrier. The data shall be sent to the competent authority on request;

5. An evaluation report shall be sent to the UNECE secretariat for information of the Administrative Committee. The evaluation report shall contain at least information on the following:

   (a) system failures;

   (b) leakages;

   (c) bunkering data (LNG);

   (d) pressure data;

   (e) abnormalities, repairs and modifications of the LNG system including the tank;

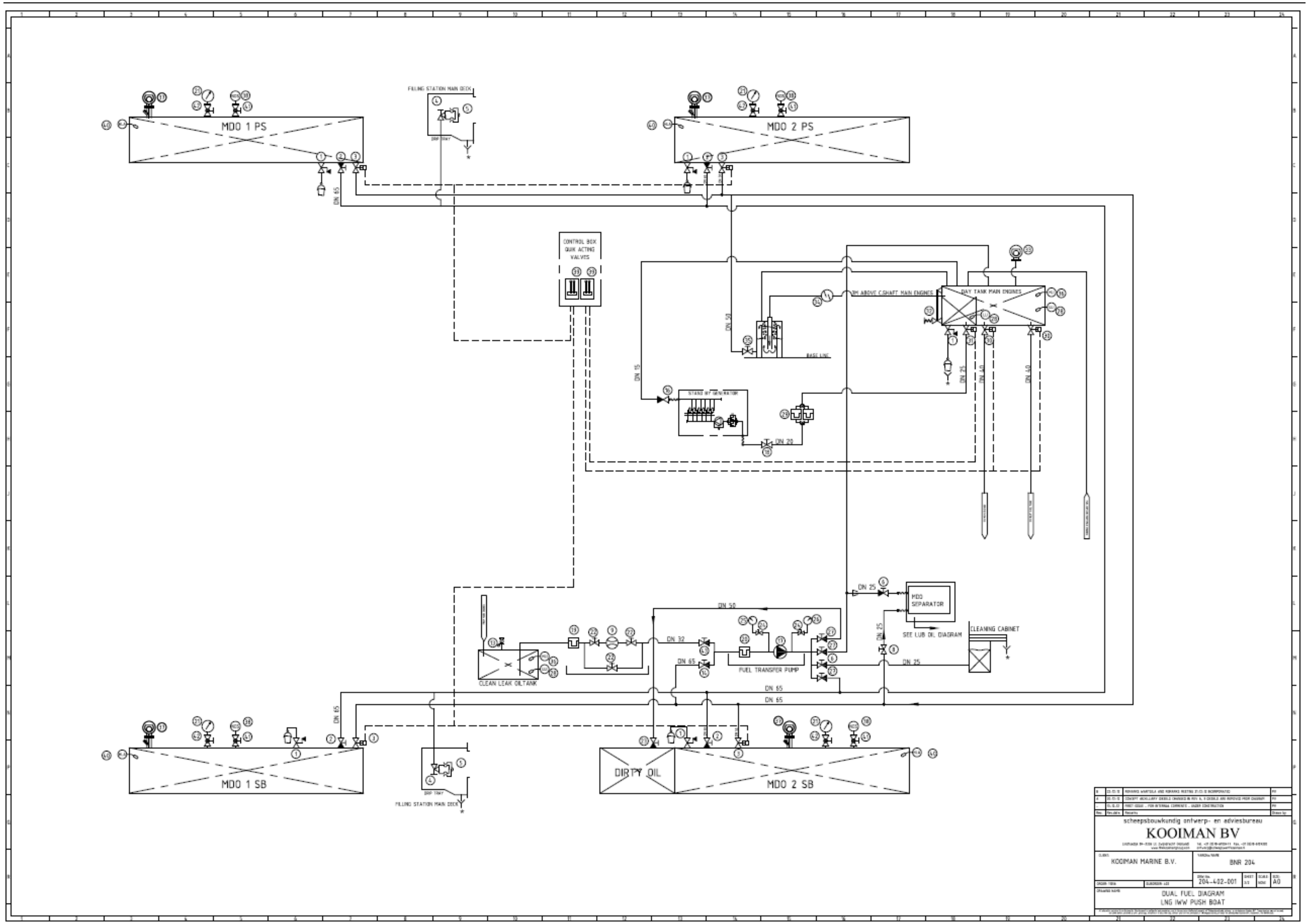
   (f) operational data;

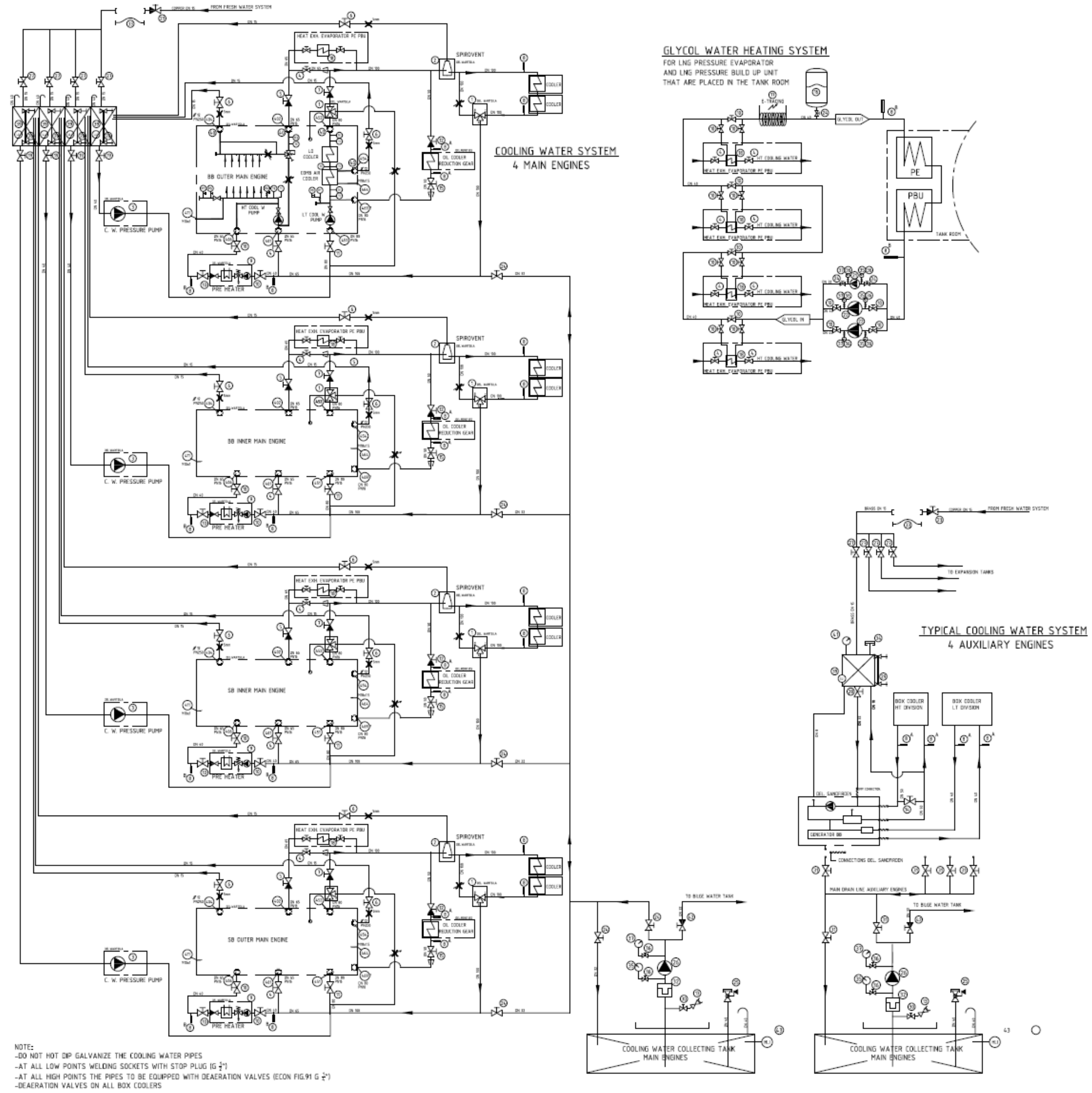
1 Report No. RDS/ENG/130370 (Rev.0) dated 18 April 2013 (available in informal document INF.25 submitted to the twenty-fourth session of the ADN Safety Committee)

(g) inspection report by the classification society which classed the vessel.

Attached documents:

- Annex 1: HAZID Study
- Annex 2: Deviations from IGF Code
- Annex 3: Bunkering procedure
- Annex 4: Crew Training
- Annex 5: Project description
- Annex 6: TNO HAZID Assessment
- Annex 7: CCNR Recommendations


MDO 1 PS
MDO 2 PS
MDO 1 SB
MDO 2 SB
DIRTY OIL
FILLING STATION MAIN DECK
DRIP TRAY
CONTROL BOX
QUIK ACTING
VALVES
DAY TANK MAIN ENGINES
1M ABOVE C.SHAFT MAIN ENGINES
STAND BY GENERATOR
BASE LINE
CLEAN LEAK OILTANK
FUEL TRANSFER PUMP
MDO
SEPARATOR
SEE LUB OIL DIAGRAM
CLEANING CABINET
DN 65
DN 50
DN 32
DN 25
DN 20
DN 15
DN 40
scheepsbouwkundig ontwerp- en adviesbureau
KOOIMAN BV
KOOIMAN MARINE B.V.
BNR 204
204-402-001
A0
DUAL FUEL DIAGRAM
LNG IWW PUSH BOAT



NOTE:
-DO NOT HOT DIP GALVANIZE THE COOLING WATER PIPES
-AT ALL LOW POINTS WELDING SOCKETS WITH STOP PLUG (G 1/2")
-AT ALL HIGH POINTS THE PIPES TO BE EQUIPPED WITH DEAERATION VALVES (ECON FIG.91 G 1/2")
-DEAERATION VALVES ON ALL BOX COOLERS

LABEL CODE	POS	AMOUNT	DESCRIPTION	DIAM.	DELIVERY / MAKE / TYPE	COMMENTS
204 403	43	2	HIGH LEVEL INDICATOR		ECON FIG.8401 S01P/F84	WITH FLANGE ECON FIG.1195
204 403	42	2	GLOBE VALVE NON RETURN	G 1	ECON FIG. 1275 LK	
204 403	41	4	PRESSURE GAUGE	G 1/4"	ECON FIG.3660 #63 0 T/M 1 BAR	
204 403	40	21	FLEX CONNECTIONS		DELIVERY WARTSILA	SEVERAL DIMENSIONS
204 403	39	8	LOW LEVEL INDICATOR		ECON FIG.8401 S01P/F98	WITH FLANGE ECON FIG.1195
204 403	37	5	PRESSURE GAUGE	G 1/4"	ECON FIG.3660 #63 0 T/M 6 BAR	
204 403	36	10	PRESSURE GAUGE VALVE	G 1/4"	ECON FIG.342 G 1/4"	
204 403	35	5	VAC. PRESSURE GAUGE	G 1/4"	ECON FIG.3660 #63 -1 T/M 3 BAR	
204 403	34	4	PRESSURE CAP			MAX 0,6 BAR
204 403	33	2	FLEXIBLE HOSE	15	KOOIMAN	NOT TO BE CONNECTED PERM.
204 403	32	8	STRAINER	32	ECON FIG.1010	STANDARD GRID 1 MM
204 403	31	6	GLOBE VALVE	G 1	ECON FIG.1275	
204 403	30	2	BALL VALVE	G 3/4	ECON FIG.1602	
204 403	29	4	LEVEL GAUGE	G 1/2"	ECON FIG.570	LOWER AND UPPER VALVE
204 403	28	4	GLOBE VALVE	32	ECON FIG.269	90 DEG. ANGLED VALVE
204 403	27	8	BALL VALVE	G 1/2"	ECON FIG.1602	
204 403	26	2	COOL WATER CIRC. PUMP		PM20 0,37 kW 1450 rpm	2 M3/HR AT 3,5 BAR
204 403	25	2	SELF CL. SOUNDING VALVE	40	ECON FIG.724	WITH CAP
204 403	24	11	GLOBE VALVE	32	ECON FIG.275	
204 403	23	2	GLOBE VALVE NON RETURN	G 1/2"	ECON FIG.1275 LK	
204 403	22	2	CIRCULATION PUMP	40	T.B.D.	CAP......M3/HR
204 403	21	1	EM. CIRCULATION PUMP	32	T.B.D.	CAP......M3/HR
204 403	20	4	LEVEL GAUGE	G 1/2"	ECON FIG.570	LOWER AND UPPER VALVE
204 403	19	4	GLOBE VALVE	40	ECON FIG.269	90 DEG. ANGLED VALVE
204 403	18	4	HT / GLYCOL HEAT EXH.	65	DELIVERY WARTSILA	
204 403	17	1	ELECTRIC STAND BY TRACING		TRACING OUTSIDE OF PIPING	STANDBY TO PREVENT FROST
204 403	16	1	ACCUMULATOR	32	DELIVERY WARTSILA	
204 403	15	4	GATE VALVE	50	ECON FIG.317	PN 10 HEIGHT INDICATION
204 403	14	4	SS GATE VALVE	G 1/2"	ECON FIG.3290	
204 403	13	2	QUICK ACTING CONNECTION	20	TYPE T.B.D. AFTER CONSULTING OWNER	
204 403	12	4	GLOBE VALVE NON RETURN	50	ECON FIG.268 LK	PN 16
204 403	11	4	GLOBE VALVE	80	ECON FIG.268	PN 16 (8 HOLES)
204 403	10	24	GLOBE VALVE	40	ECON FIG.268	PN 16
204 403	9	4	ELECTRIC PRE HEATER	40	DELIVERY WARTSILA	
204 403	8B	10	GLASS THERMOMETER	G 1/2"	ECON FIG.1648 INPUT LENGTH 40 MM	0-120° CELSIUS
204 403	8A	24	GLASS THERMOMETER	G 1/2"	ECON FIG.1645 INPUT LENGTH 50 MM	0-120° CELSIUS
204 403	8	8	GLASS THERMOMETER	G 1/2"	ECON FIG.1645 INPUT LENGTH 63 MM	0-120° CELSIUS
204 403	7	4	GLOBE VALVE NON RETURN	80	ECON FIG.268 LK	PN 16 (8 HOLES)
204 403	6	12	GLOBE VALVE	G 1/2"	ECON FIG.250	BRONZE
204 403	5	4	GLOBE VALVE NON RETURN	65	ECON FIG.268 LK	PN 16 (8 HOLES)
204 403	4	6	GLOBE VALVE	65	ECON FIG.268	PN 16 (8 HOLES)
204 403	3	4	C. W. PRESSURE PUMP	G 1 1/2"	DELIVERY WARTSILA	0.25 KW 400V AE 26/2-80
204 403	2	4	SPIROVENT	80	DELIVERY WARTSILA	
204 403	1	8	LT AMOT VALVE	80	DELIVERY WARTSILA	

(LLI) LOW LEVEL INDICATOR
(HLI) HIGH LEVEL INDICATOR
PRESSURE GAUGE WITH VALVE
FLOW DIRECTION
FLEXIBELE CONNECTION
OPEN END
PUMP
GLASS THERMOMETER
GATE VALVE
GLOBE VALVE
GLOBE VALVE NON RETURN
BALL VALVE
BUTTERFLY VALVE
NON RETURN VALVE
QUICK ACTING CONNECTION
QUICK ACTING CONNECTION NON RETURN
SELF CLOSING (SOUNDING) VALVE WITH CAP
ADJUSTABLE RUSTICATER
ORIFICE

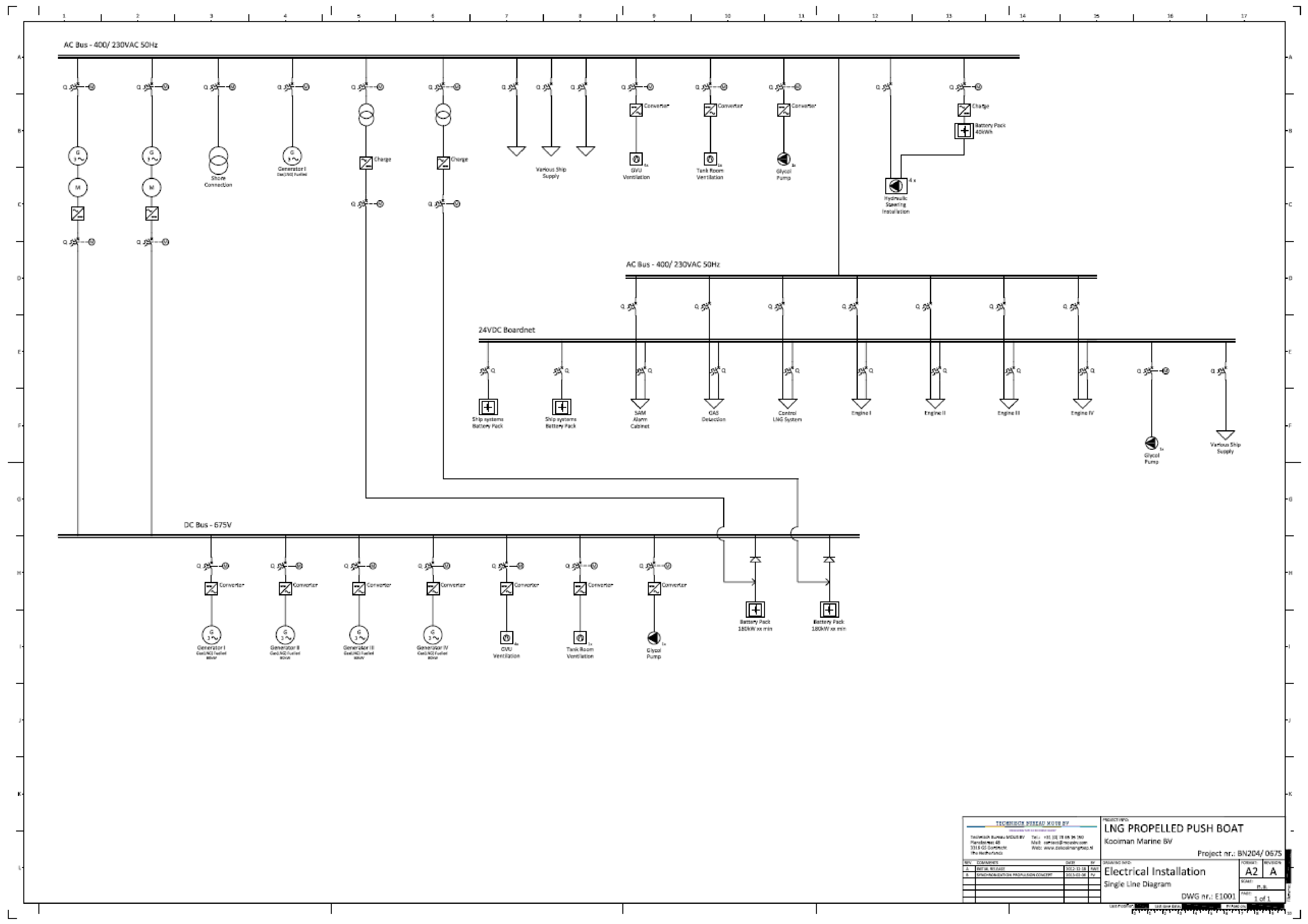
DN	O.D.	WALL	MATERIAL
[MM]	[MM]	[MM]	[-]
—	10	1	COPPER
—	18	1.5	COPPER
—	12	2.0	STEEL HYDR. PIPE
—	16	2.0	STEEL HYDR. PIPE
—	18	2.0	STEEL HYDR. PIPE
—	20	2.5	STEEL HYDR. PIPE
—	22	2.0	STEEL HYDR. PIPE
—	25	3.0	STEEL HYDR. PIPE
20	26.9	2.65	STEEL
25	33.7	3.25	STEEL
32	42.4	3.25	STEEL
40	48.4	4.0	STEEL
50	60.3	3.6	STEEL
65	76.1	3.6	STEEL
80	88.9	3.6	STEEL
100	114.3	3.6	STEEL

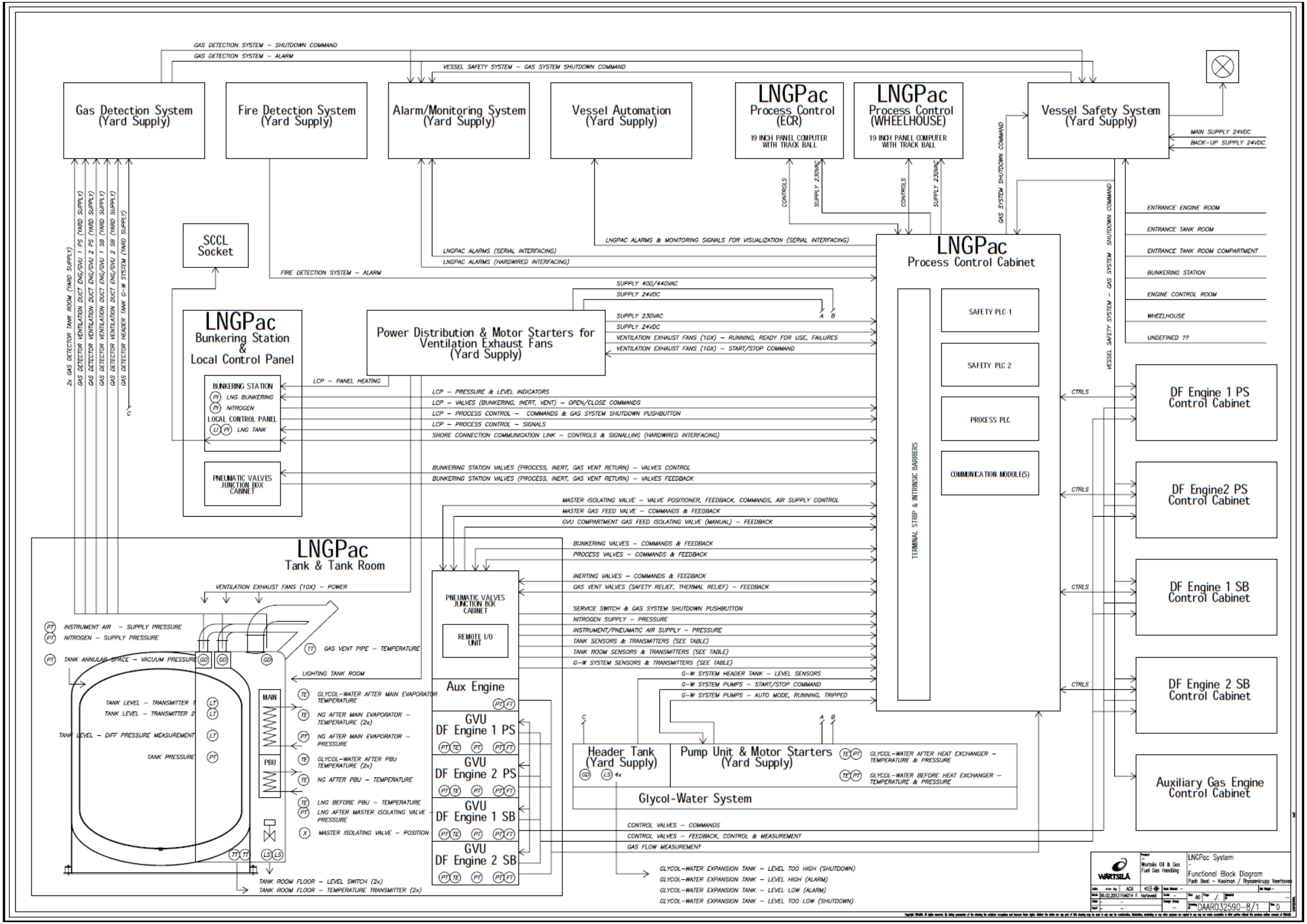
APPROVED	DATE
VEERHAVEN	-
WARTSILA	-
LLOYDS	-

Rev.	Rev.date	Remarks	Drawn by
A	23-12-12	COMMENTS WARTSILA LT AMOT VALVE (MAIL 21-12-12) INCORPORATED	PV
-	19-12-12	FIRST ISSUE - FOR INTERNAL COMMENTS - UNDER CONSTRUCTION	PV

scheepsbouwkundig ontwerp- en adviesbureau
KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.
YARDNo/NAME: 204
ORDER: 1956 | SUBORDER: 403
DRW.-No. 204-403-001 | SHEET: 1/1 | SCALE: NONE | SIZE: A0
DRAWING NAME: COOLING WATER DIAGRAM
LNG IWW PUSH BOAT


AC Bus - 400/ 230VAC 50Hz
Shore Connection
Generator I
Charge
Various Ship Supply
Converter
GVU Ventilation
Tank Room Ventilation
Glycol Pump
Battery Pack 40kWh
Hydraulic Steering Installation
24VDC Boardnet
Ship systems Battery Pack
SAM Alarm Cabinet
GAS Detection
Control LNG System
Engine I
Engine II
Engine III
Engine IV
DC Bus - 675V
Generator II
Generator III
Generator IV
Battery Pack 180kW xx min
LNG PROPELLED PUSH BOAT
Kooiman Marine BV
Project nr.: BN204/ 0675
Electrical Installation
Single Line Diagram
DWG nr.: E1001
A2
A
1 of 1



GAS DETECTION SYSTEM – SHUTDOWN COMMAND
GAS DETECTION SYSTEM – ALARM
VESSEL SAFETY SYSTEM – GAS SYSTEM SHUTDOWN COMMAND
Gas Detection System (Yard Supply)
Fire Detection System (Yard Supply)
Alarm/Monitoring System (Yard Supply)
Vessel Automation (Yard Supply)
LNGPac Process Control (ECR)
19 INCH PANEL COMPUTER WITH TRACK BALL
LNGPac Process Control (WHEELHOUSE)
19 INCH PANEL COMPUTER WITH TRACK BALL
Vessel Safety System (Yard Supply)
MAIN SUPPLY 24VDC
BACK-UP SUPPLY 24VDC
CONTROLS
SUPPLY 230VAC
GAS SYSTEM SHUTDOWN COMMAND
VESSEL SAFETY SYSTEM – GAS SYSTEM SHUTDOWN COMMAND
ENTRANCE ENGINE ROOM
ENTRANCE TANK ROOM
ENTRANCE TANK ROOM COMPARTMENT
BUNKERING STATION
ENGINE CONTROL ROOM
WHEELHOUSE
UNDEFINED ??
2x GAS DETECTOR TANK ROOM (YARD SUPPLY)
GAS DETECTOR VENTILATION DUCT ENG/GVU 1 PS (YARD SUPPLY)
GAS DETECTOR VENTILATION DUCT ENG/GVU 2 PS (YARD SUPPLY)
GAS DETECTOR VENTILATION DUCT ENG/GVU 1 SB (YARD SUPPLY)
GAS DETECTOR VENTILATION DUCT ENG/GVU 2 SB (YARD SUPPLY)
GAS DETECTOR HEADER TANK G-W SYSTEM (YARD SUPPLY)
SCCL Socket
LNGPAC ALARMS & MONITORING SIGNALS FOR VISUALIZATION (SERIAL INTERFACING)
LNGPAC ALARMS (SERIAL INTERFACING)
LNGPAC ALARMS (HARDWIRED INTERFACING)
FIRE DETECTION SYSTEM – ALARM
LNGPac Process Control Cabinet
TERMINAL STRIP & INTRINSIC BARRIERS
SAFETY PLC 1
SAFETY PLC 2
PROCESS PLC
COMMUNICATION MODULE(S)
SUPPLY 400/440VAC
SUPPLY 24VDC
SUPPLY 230VAC
SUPPLY 24VDC
VENTILATION EXHAUST FANS (10X) – RUNNING, READY FOR USE, FAILURES
VENTILATION EXHAUST FANS (10X) – START/STOP COMMAND
Power Distribution & Motor Starters for Ventilation Exhaust Fans (Yard Supply)
LNGPac Bunkering Station & Local Control Panel
BUNKERING STATION
LNG BUNKERING
NITROGEN
LOCAL CONTROL PANEL
LNG TANK
PNEUMATIC VALVES JUNCTION BOX CABINET
LCP – PANEL HEATING
LCP – PRESSURE & LEVEL INDICATORS
LCP – VALVES (BUNKERING, INERT, VENT) – OPEN/CLOSE COMMANDS
LCP – PROCESS CONTROL – COMMANDS & GAS SYSTEM SHUTDOWN PUSHBUTTON
LCP – PROCESS CONTROL – SIGNALS
SHORE CONNECTION COMMUNICATION LINK – CONTROLS & SIGNALLING (HARDWIRED INTERFACING)
BUNKERING STATION VALVES (PROCESS, INERT, GAS VENT RETURN) – VALVES CONTROL
BUNKERING STATION VALVES (PROCESS, INERT, GAS VENT RETURN) – VALVES FEEDBACK
MASTER ISOLATING VALVE – VALVE POSITIONER, FEEDBACK, COMMANDS, AIR SUPPLY CONTROL
MASTER GAS FEED VALVE – COMMANDS & FEEDBACK
GVU COMPARTMENT GAS FEED ISOLATING VALVE (MANUAL) – FEEDBACK
BUNKERING VALVES – COMMANDS & FEEDBACK
PROCESS VALVES – COMMANDS & FEEDBACK
INERTING VALVES – COMMANDS & FEEDBACK
GAS VENT VALVES (SAFETY RELIEF, THERMAL RELIEF) – FEEDBACK
SERVICE SWITCH & GAS SYSTEM SHUTDOWN PUSHBUTTON
NITROGEN SUPPLY – PRESSURE
INSTRUMENT/PNEUMATIC AIR SUPPLY – PRESSURE
TANK SENSORS & TRANSMITTERS (SEE TABLE)
TANK ROOM SENSORS & TRANSMITTERS (SEE TABLE)
G-W SYSTEM SENSORS & TRANSMITTERS (SEE TABLE)
G-W SYSTEM HEADER TANK – LEVEL SENSORS
G-W SYSTEM PUMPS – START/STOP COMMAND
G-W SYSTEM PUMPS – AUTO MODE, RUNNING, TRIPPED
LNGPac Tank & Tank Room
VENTILATION EXHAUST FANS (10X) – POWER
INSTRUMENT AIR – SUPPLY PRESSURE
NITROGEN – SUPPLY PRESSURE
TANK ANNULAR SPACE – VACUUM PRESSURE
GAS VENT PIPE – TEMPERATURE
LIGHTING TANK ROOM
TANK LEVEL – TRANSMITTER 1
TANK LEVEL – TRANSMITTER 2
TANK LEVEL – DIFF PRESSURE MEASUREMENT
TANK PRESSURE
MAIN
PBU
GLYCOL-WATER AFTER MAIN EVAPORATOR TEMPERATURE
NG AFTER MAIN EVAPORATOR – TEMPERATURE (2x)
NG AFTER MAIN EVAPORATOR – PRESSURE
GLYCOL-WATER AFTER PBU TEMPERATURE (2x)
NG AFTER PBU – TEMPERATURE
LNG BEFORE PBU – TEMPERATURE
LNG AFTER MASTER ISOLATING VALVE PRESSURE
MASTER ISOLATING VALVE – POSITION
TANK ROOM FLOOR – LEVEL SWITCH (2x)
TANK ROOM FLOOR – TEMPERATURE TRANSMITTER (2x)
PNEUMATIC VALVES JUNCTION BOX CABINET
REMOTE I/O UNIT
Aux Engine
GVU DF Engine 1 PS
GVU DF Engine 2 PS
GVU DF Engine 1 SB
GVU DF Engine 2 SB
Header Tank (Yard Supply)
4x
Pump Unit & Motor Starters (Yard Supply)
GLYCOL-WATER AFTER HEAT EXCHANGER – TEMPERATURE & PRESSURE
GLYCOL-WATER BEFORE HEAT EXCHANGER – TEMPERATURE & PRESSURE
Glycol-Water System
CONTROL VALVES – COMMANDS
CONTROL VALVES – FEEDBACK, CONTROL & MEASUREMENT
GAS FLOW MEASUREMENT
GLYCOL-WATER EXPANSION TANK – LEVEL TOO HIGH (SHUTDOWN)
GLYCOL-WATER EXPANSION TANK – LEVEL HIGH (ALARM)
GLYCOL-WATER EXPANSION TANK – LEVEL LOW (ALARM)
GLYCOL-WATER EXPANSION TANK – LEVEL TOO LOW (SHUTDOWN)
CTRLS
DF Engine 1 PS Control Cabinet
DF Engine2 PS Control Cabinet
DF Engine 1 SB Control Cabinet
DF Engine 2 SB Control Cabinet
Auxiliary Gas Engine Control Cabinet
WÄRTSILÄ
Wärtsilä Oil & Gas Fuel Gas Handling
LNGPac System
Functional Block Diagram
Push Boat – Kooiman / Thyssenkrupp Veerhaven
26.02.2013
F. Hartevelt
A0
DAAR032590-8/1
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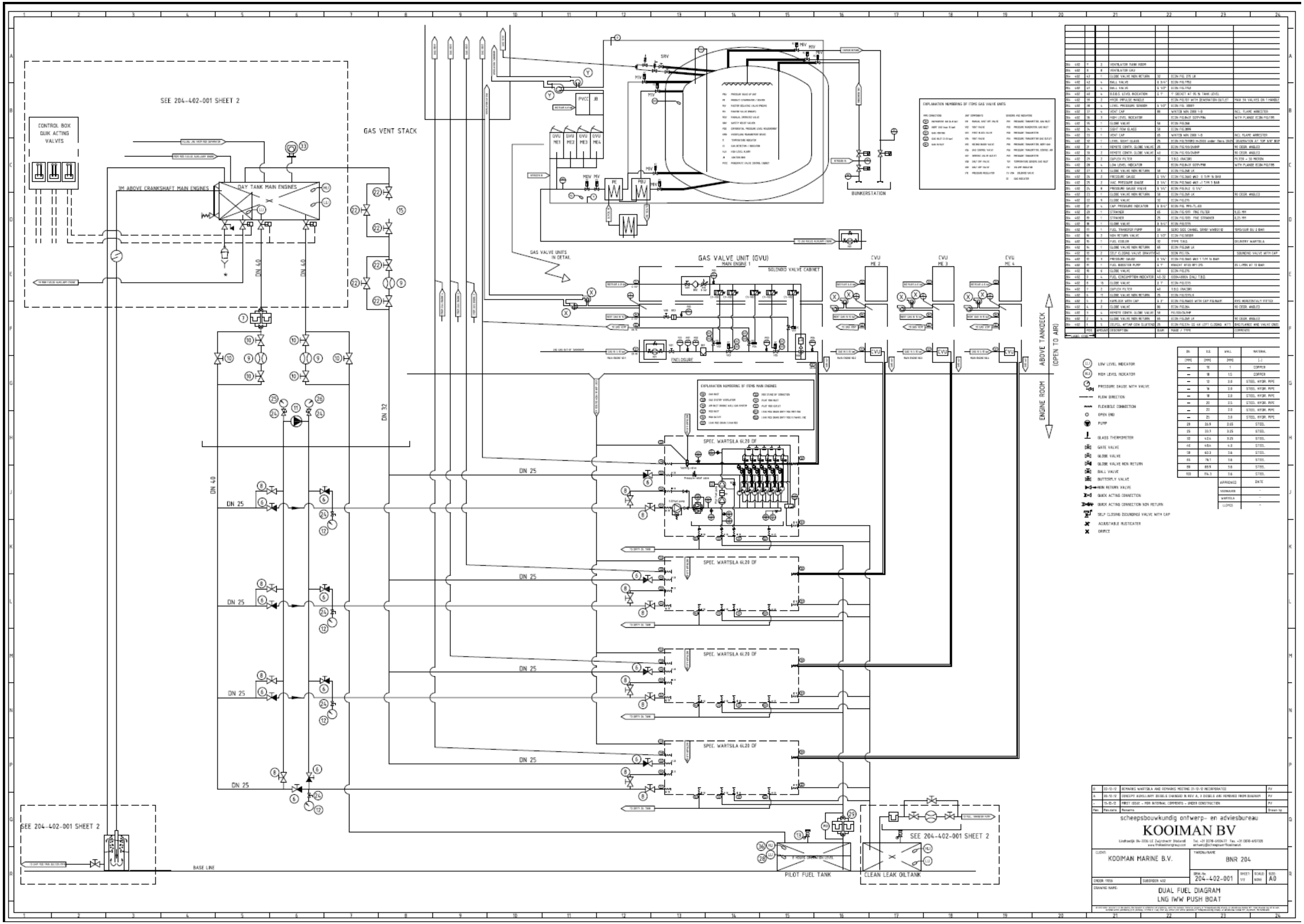

SEE 204-402-001 SHEET 2
CONTROL BOX
QUIK ACTING
VALVES
GAS VENT STACK
3M ABOVE CRANKSHAFT MAIN ENGINES
DAY TANK MAIN ENGINES
DN 40
DN 32
DN 25
GAS VALVE UNITS
IN DETAIL
GAS VALVE UNIT (GVU)
MAIN ENGINE 1
SOLENOID VALVE CABINET
ENCLOSURE
CVU
ME 2
ME 3
ME 4
GVU
ME1
ME2
ME3
ME4
PVCC
JB
SRV
MIV
MDV
PE
PBU
BUNKERSTATION
SPEC. WARTSILA 6L20 DF
ABOVE TANKDECK
(OPEN TO AIR)
ENGINE ROOM
PILOT FUEL TANK
CLEAN LEAK OILTANK
BASE LINE
LOW LEVEL INDICATOR
HIGH LEVEL INDICATOR
PRESSURE GAUGE WITH VALVE
FLOW DIRECTION
FLEXIBLE CONNECTION
OPEN END
PUMP
GLASS THERMOMETER
GATE VALVE
GLOBE VALVE
GLOBE VALVE NON RETURN
BALL VALVE
BUTTERFLY VALVE
NON RETURN VALVE
QUICK ACTING CONNECTION
QUICK ACTING CONNECTION NON RETURN
SELF CLOSING (SOUNDING) VALVE WITH CAP
ADJUSTABLE RESTRICTOR
ORIFICE
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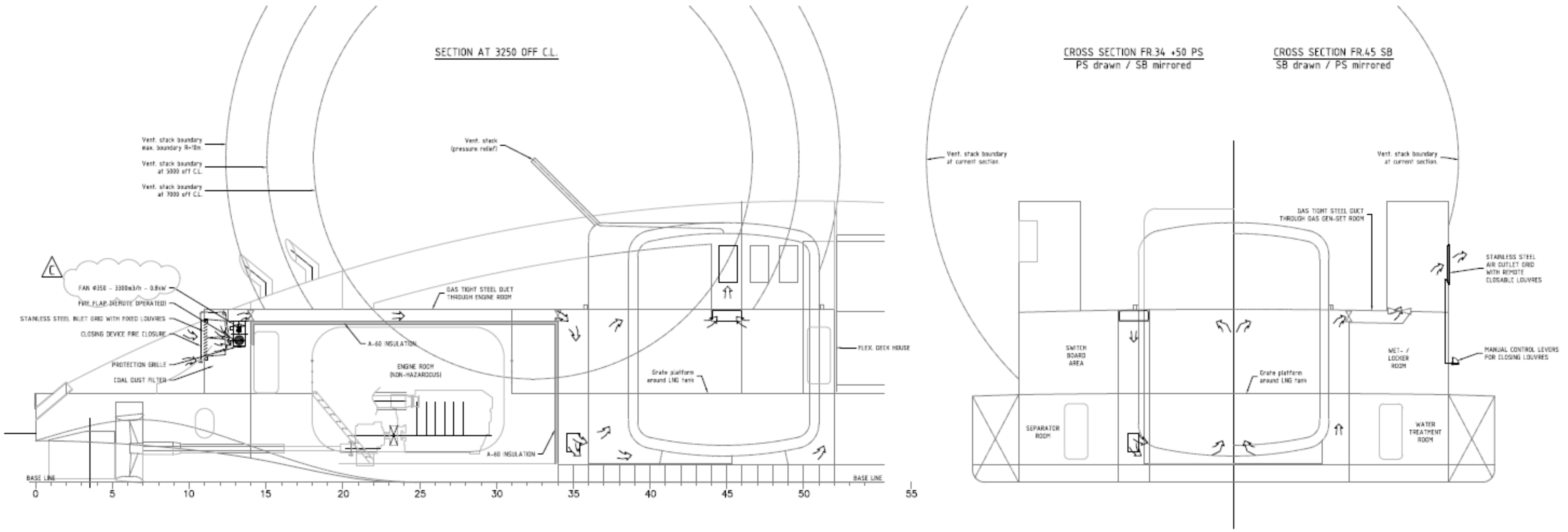
KOOIMAN BV
CLIENT:
KOOIMAN MARINE B.V.
BNR 204
204-402-001
A0
DUAL FUEL DIAGRAM
LNG IWW PUSH BOAT

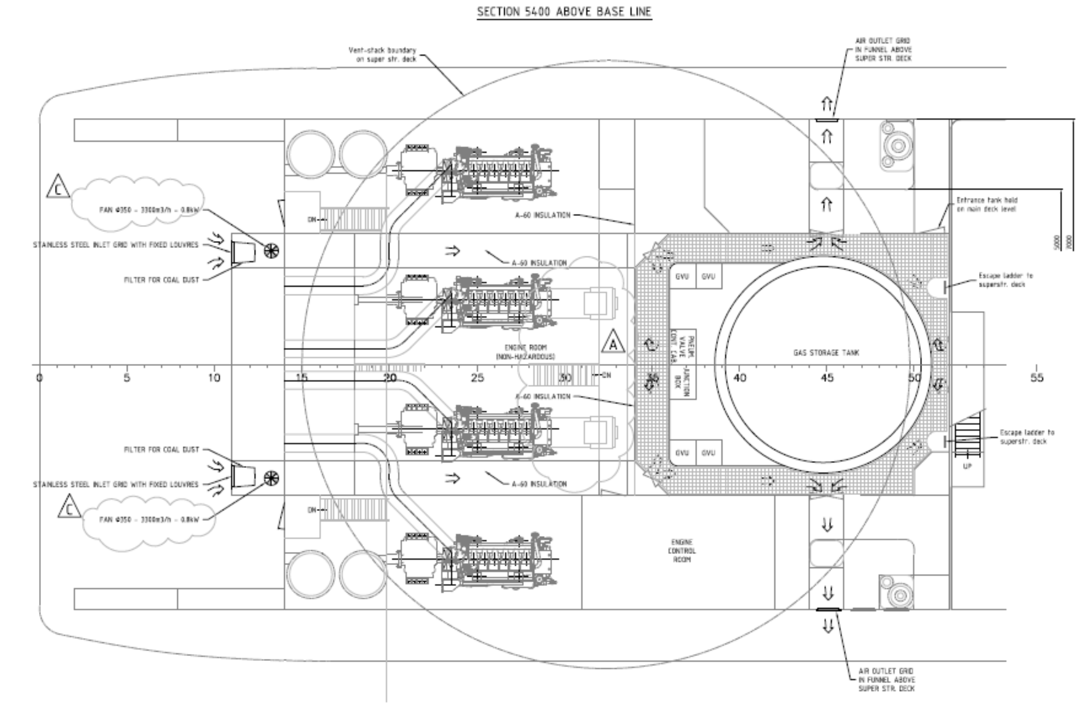
Kooiman Marine BV – Yard no. 204

HAZARD IDENTIFICATION STUDY (HAZID) REPORT

Inland Waterways Dual Fuelled Pushboat

Report No.: RDS/ENG/130370
Rev No: 0
Date: 18 April 2013





<u>Tank hold (compartment)</u>

Space tank hold (compartment) 209m3
Fan cap. 2x Φ350 - 2x 1650/3300m3/h - 2x 0.15/0.8kW
Air changes min. 15x/h max. 31x/h

Vent. inlet: In aft side super structure.
2x Inlet grid with filter (2x 0.36m2 filter per grid).

Filter flow: 1.2/2.4m/s (Pres. drop <60/<70Pa)

Vent. outlet: Grid in funnel (0.72m2) above super str. deck.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	06-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	GENERATORS ADDED TO MAIN ENGINES	PV
-	20-02-13	FIRST ISSUE ACCORDING GA 204-037-001 REV A	A.S.

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KOOIMAN BV

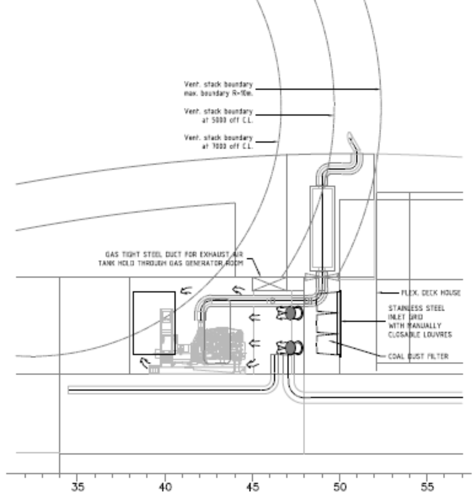
CLIENT: KOOIMAN MARINE B.V.

YARDNo./NAME: BNR 204

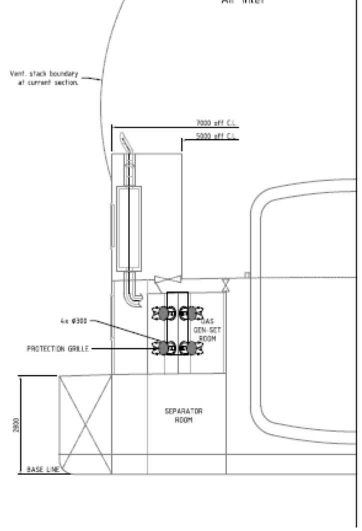
DRW-No.: 204-409-001 | SHEET: 2/5 | SCALE: 1:50 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT
LNG TANK HOLD

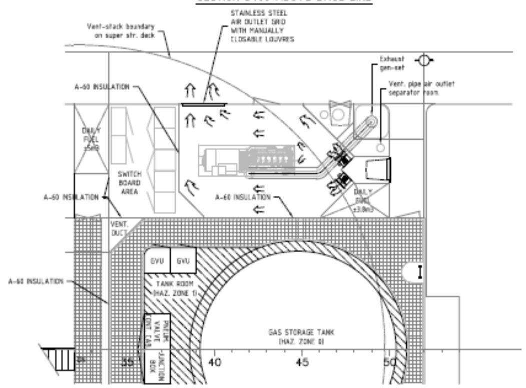
SECTION 4500 OFF C.L.



CROSS SECTION FR.46 PS
Air inlet



SECTION 5400 ABOVE BASE LINE



Ventilation Gas gen-set room "Gas-safe" principle

Min. 30 air changes per hour
Space is 49 m3 x 30 = 1463m3/h
Combustion air = 850m3/h
Total ventilation required = 2313m3/h

Ventilation amount and arrangement subject to CFD calculation

Fan cap. 2x Φ300 (=2x 1250/2500m3/h double speed fans) (2x0.55kW max)
and redundant extra 2x Φ300 (=2x 1250/2500m3/h double speed fans)
In total 4 fans installed. Fans in explosion proof execution

Vent. inlet: 1x Inlet grid with filter (3x 0.36m2).
Air flow filter: 1.3 m/s (Pres. drop <60Pa)

Vent. outlet: Grid in side wall superstructure (2.16m2) at main deck level.

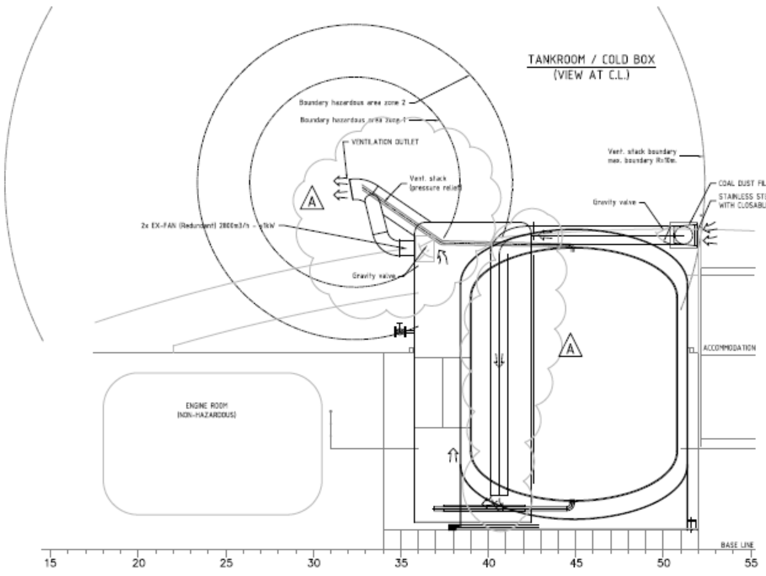
Rev.	Rev.date.	Remarks	Drawn by
C	15-03-15	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-15	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
-	20-10-13	FIRST ISSUE ACCORDING GA 204-010-001 REV A	A.G.

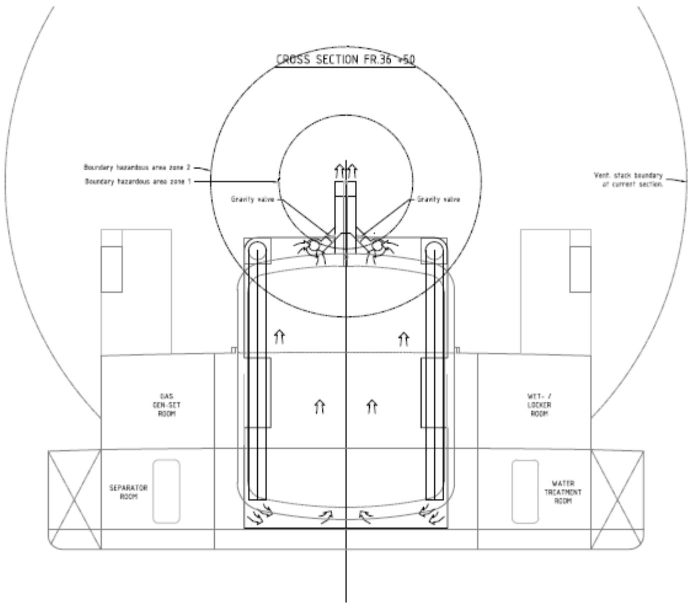
scheepsbouwkundig ontwerp- en adviesbureau

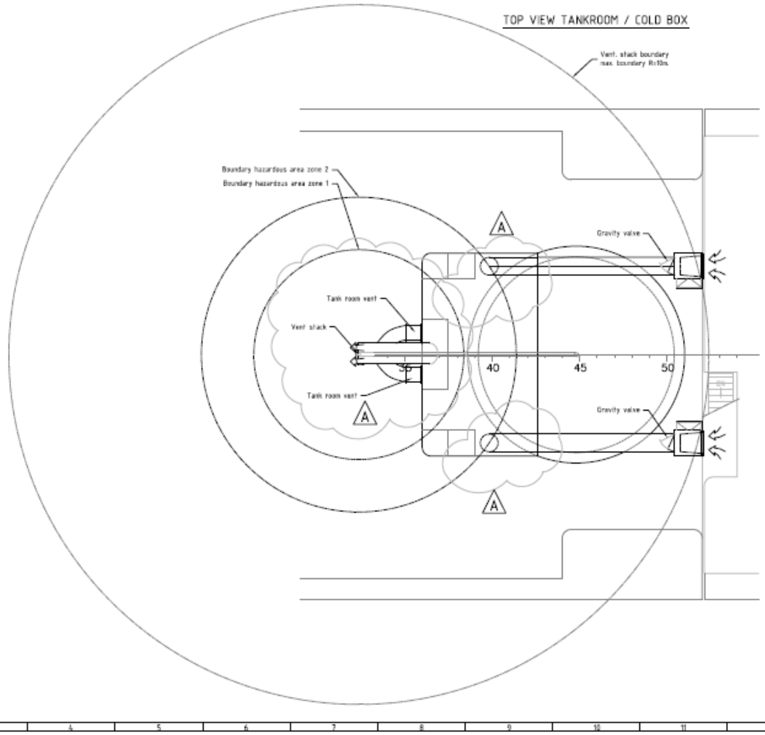
KOOIMAN BV

Client: KOOIMAN MARINE B.V.
Yard no./name: BNR 204
Drw.no.: 204-409-001 | Sheet: 1/1 | Scale: 1:50 | Size: A0

Drawing name: VENTILATION CONCEPTS LNG PUSH BOAT
GAS FUELED GENERATOR ROOM







Tank ROOM

Min. 30 air changes per hour
Space is 96 m3
Total ventilation required 2880m3/h

Fan cap. 1x Ø350 - 3300m3/h = 0.8kW
and redundant 1x Ø350 - 3300m3/h = 0.8kW extra
In total 2 fans installed Fans in explosion proof execution

Ventilation exhaust equiped with gravity valve that closes when fan is stopped

Vent. inlet: 2x Inlet grid with filter (1x 0.36m2 filter per grid).
Air flow per filter: 1.75m/s (Pres. drop <60Pa)

Vent. outlet: Around vent. stack. (Blow-off)

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	VENT STACK AND TANK ARRANGEMENT CHANGED	PV
-	20-11-12	FIRS ISSUE ACCORDING GA 204-031-001 REV A	A.S.

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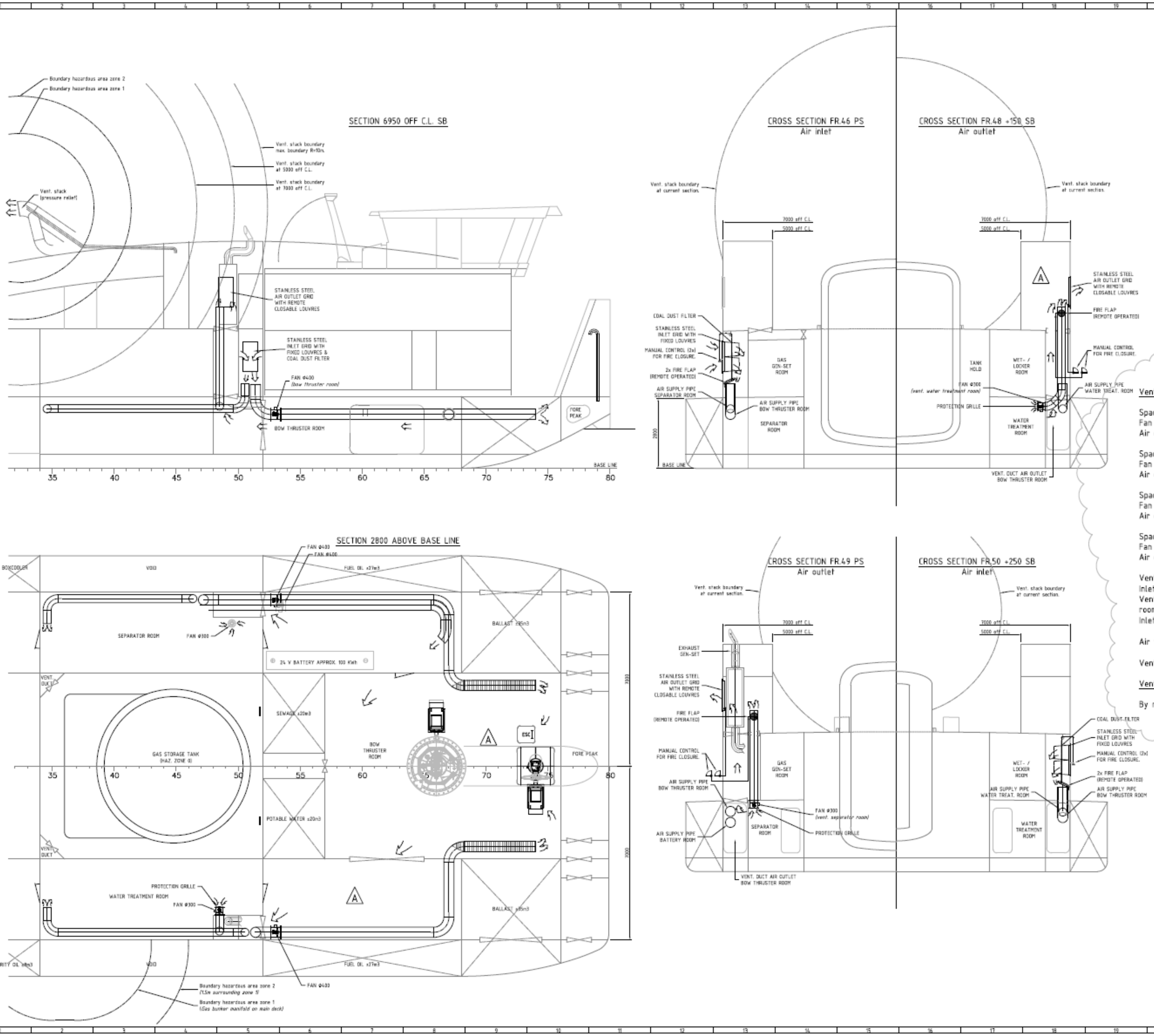
KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.	YARDNo/NAME: BNR 204
ORDER: 1806 / SUBORDER: 409	DRW-No. 204-409-001 · SHEET: 4/6 · SCALE: 1:50 · SIZE: A0
DRAWING NAME:	VENTILATION CONCEPTS LNG PUSH BOAT TANK ROOM / (COLD BOX)



Ventilation bow thruster room / separator room / water treat. room

Space bow thruster room 280m3
Fan cap. bow thr. room: 2x Φ400 - 2x 2000/4000m3/h - 2x 0.23/1.1kW.
Air changes bow thruster room min. 7x/h max. 28x/h

Space watertreatment room 90m3
Fan cap. water treatment room: 1x Φ300 - 1250/2500m3/h - 0.11/0.55kW.
Air changes water treatment room: min. 13x/h max. 27x/h

Space separator room 90m3
Fan cap. separator room: 1x Φ300 - 1250/2500m3/h - 0.11/0.55kW.
Air changes separator room: min. 13x/h max. 27x/h

Space battery room 85m3
Fan cap. battery room 1x Φ400 - 2000/4000 m3/h -0.23/1.1kW.
Air changes battery room: min. 23x/h max. 47x/h

Vent. inlet SB = Air supply bow thruster room & water treatment room.
Inlet grid with filter (2x0.36m2 filter per grid).
Vent. inlet PS = Air supply battery room, bow thruster room & separator room.
Inlet grid with filter (3x0.36m2 filter per grid).

Air flow over filters filter: 0.63/2.9m/s (Pres. drop <60/<95Pa)

Vent. outlet: Grid in funnel (0.72m2) above super str. deck.

Ventilation fore peak

By natural ventilation. Vent. openings in push horns.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	STAND BY GENERATOR AND ITS EXHAUST REMOVED	PV
-	20-12-12	FIRS ISSUE ACCORDING GA 204-051-001 REV A	A.S.

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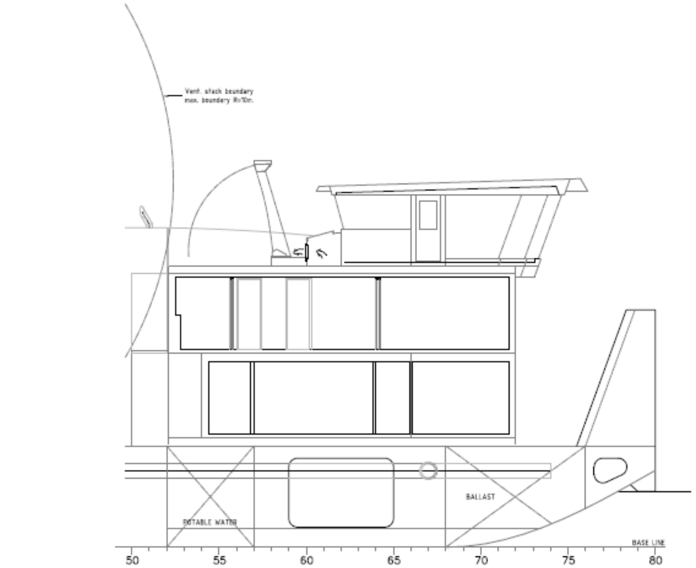
KOOIMAN BV

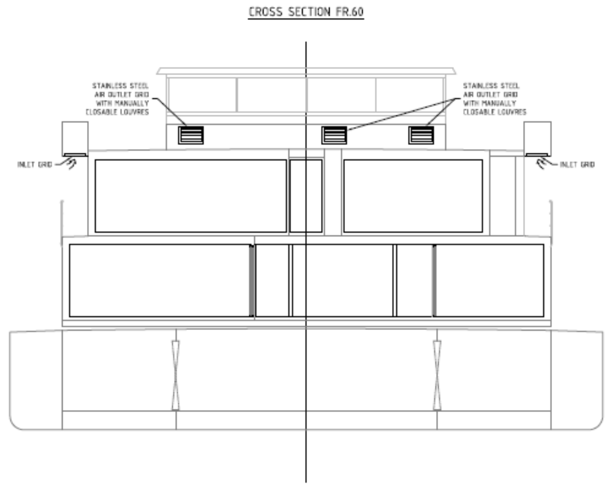
CLIENT: KOOIMAN MARINE B.V.

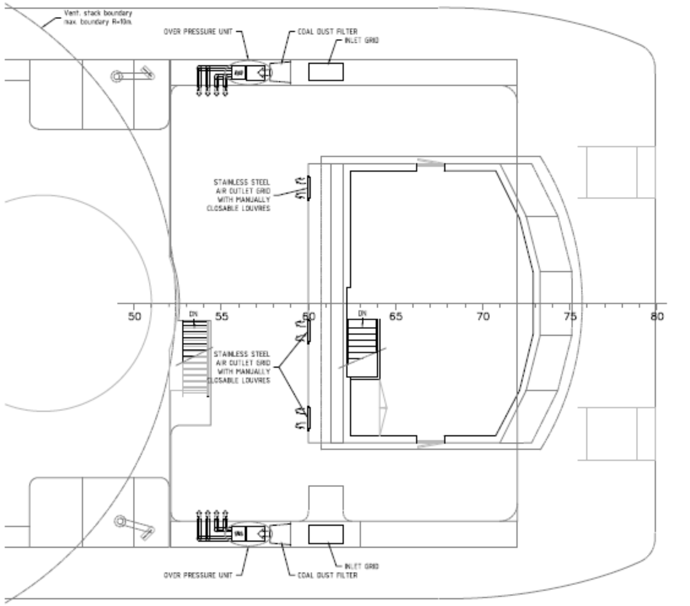
YARDNo./NAME: BNR 204

DRW-No.: 204-409-001 | SHEET: 5/5 | SCALE: 1:50 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT FORE SHIP







Accommodation

C

Over pressure unit (with fan, heater, gas detector and gravity valve.) in extended boxes
SB + PS.
Air supply through ducts above ceiling to all accommodation spaces.

Air intakes equiped with gravity valve that closes when fan has stopped.

Vent. inlet: In bottom side extended boxes of flexible superstructure.
2x Inlet grid with filter (1x 0.36m2 filter per grid).

Vent. outlet: Grid behind wheelhouse.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-19	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-19	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
-	20-03-13	FIRS ISSUE ACCORDING GA 204-031-001 REV A	A.S.

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KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.	YARDNo./NAME: BNR 204			
	DRW-No. 204-409-001	SHEET: 6/6	SCALE: 1:50	SIZE: A0
DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT ACCOMMODATION				

Technical Report Document Page

Report no.: RDS/ENG/130370	☐ Open distribution ☒ Distribution – Kooiman BV/LR only

Rev. no.:	Prepared by	Reviewed by	Approved by	Date
0	Paul Stanney	Willemien Verdonk	Bas Joormann	18 April 2013

Title:

Inland Waterways Dual Fuelled Pushboat
Hazard Identification Study

Client: Kooiman Marine BV

Client specification:

Kooiman Marine BV is proposing to build a Dual Fuel Pushboat burning traditional oil fuel and Liquefied Natural Gas. To minimise safety risks and to comply with Lloyd's Register's and Inland Waterways Rules for unconventional arrangements a HAZID of the proposed design has been undertaken.

Summary:

This report details the findings of the Hazard Identification (HAZID) Study of a Dual-Fuel Inland Waterways Pushboat.

Representatives from Lloyd's Register EMEA, Kooiman Marine BV, Wärtsilä, TNO, Mous BV and ThyssenKrupp Veerhaven BV were present during the study which was facilitated by Lloyd's Register over two and a half days between the 19th and 21st of March 2013 in Rotterdam.

The level of safety of the Dual Fuel system was compared to that of existing Inland Waterways vessels using fuel oil and the prescriptive requirements of Lloyd's Register's Rules and Regulations for the Classification of Inland Waterways Ships and the Rules and Regulations for Classification of Natural Gas Fuelled ships.

The study results indicate that provided the recommendations in Section 5.7 are satisfactorily resolved and implemented then subject to the normal general design and construction requirements, the proposed arrangements do not pose any risks defined as 'high risk' in the Risk Matrix in Appendix 2. The design is considered suitable for Classification by Lloyd's Register.

TABLE OF CONTENTS

1. ABBREVIATIONS

ACH	Air Changes per Hour
BS	British Standards
RVIR	Rhine Vessels Inspection Regulations
CFD	Computational Fluid Dynamics
ESD	Emergency Shut Down
HAZID	Hazard Identification
ISO	International Standards Organisation
IGC	International Code for the Construction of Ships Carrying Liquefied Gases in Bulk
LNG	Liquefied Natural Gas
LR	Lloyd’s Register Group, Marine
N_2	Nitrogen
P&ID	Piping and Instrumentation Diagram
PBU	Pressure Build Up unit
SME	Subject Matter Expert
ToR	Terms of Reference

2. EXECUTIVE SUMMARY

This report details the findings of the Hazard Identification (HAZID) Study on the design of a Dual-Fuel powered Inland Waterways Pushboat.

Representatives from Lloyd's Register EMEA, Kooiman, Wärtsilä, TNO, Mous.BV and ThyssenKrupp Veerhaven B.V. were present during the study which was facilitated by Lloyd's Register Marine over two and a half days between the 19th and 21st of March 2013.

The use of dual fuel (oil fuel and LNG) propulsion on seagoing ships is becoming increasingly common. Lloyd's Register has Rules for these vessels and draft statutory guidelines are in place.

The Pushboat reported here has a conventional four main engine plus auxiliary engine machinery arrangement. The main engines have a double walled gas fuel piping system similar to that fitted on various seagoing ships. This system has been approved by Lloyd's Register for use in a conventional gas safe engine room.

The HAZID concentrated on the specific issues raised by the use of dual fuel on Inland Waterways vessels. These issues are mainly concerned with the smaller scale and draft of inland Waterways vessels and the collision risks and danger from fixed structures.

The HAZID identified a number of possible scenarios that could endanger the vessel or be harmful to personnel. The main issues identified related to:

- Design and support of the vertical LNG tank.
  LNG tanks are normally of the 'horizontal type', supported on two saddle supports. This minimises the stresses imposed on the tank structure. The tank proposed for the Pushboat is a double walled vertical tank, with the outer tank supported on a skirt bolted to the bottom structure. No double bottom is fitted in way of the tank. The inner tank is supported inside the outer tank on a circumferential ring. This arrangement imposes additional bending loadings on the inner and outer tank walls. The inner tank is designed in accordance with the IGC Code for Type C tanks but the overall design is considered novel. The tank design is to be approved by Lloyd's Register.

- For collision and grounding protection for sea going ships, Lloyd's Rules require that LNG tanks are located inboard of the B/5 line and more than B/15 or 2m above the base line of the vessel. The inner (actual) LNG tank on the Pushboat is inboard of the B/5 line and 1360mm above the baseline. The outer (second barrier tank) is 760mm above base line The inner (actual) C-type LNG tank is situated more than B/15 (B<18m) above base line and the 760mm of the second barrier tank is less than B/15 but was considered sufficient protection for the tank on an inland waterways vessel because this complies with the ADN Rules for the location of cargo tanks carrying hazardous substances.

- The tank is mounted in the middle of the Pushboat, behind the accommodation. The tank structure and support arrangements must be suitable for the maximum anticipated collision loading. This analysis must be part of the tank design/support calculations. The collision loads as defined in the I.G.C. code may not be applicable because they were defined for sea going vessels. Collision loads (accelerations) and capacity to absorb expected collision energy (as defined in AND) must be further investigated and submitted for review.

- The top of the outer tank together with the top of the 'tank connection space' is exposed and therefore vulnerable to damage. The top of the tank is lower than the bridge and is therefore partly protected from frontal damage. Two vertical steel plates on either side of the tank provide some protection from the side. The outer tank is 18mm thick steel at the top and this was considered to provide sufficient protection for the inner tank against falling objects - grabs e.t.c. as the thickness of the outer tank exceeds the thickness of the hold bottom plating on barges used on the waterways. The most vulnerable components are the tank safety valves within the 'tank connection space' and this area should be reinforced.

- The proposed location of the bunker station is on the superstructure deck. Details of the bunkering system (procedure, deck protection, truck or bunker station) were not available at the HAZID. The bunkering system is an important safety consideration on LNG fuelled ships and must form the basis of a future workshop.

- Overfilling of the LNG tank during bunkering is considered a possible cause of failure and release of LNG. An independent high-high alarm, clearly identified as such and causing closure of the tank filling valve should be fitted.

- The LNG pressure build up, gas conditioning and main engine room systems are similar to those approved by Lloyd's Register for use on seagoing ships. Similar systems have also been approved for use on Inland Waterways cargo vessels. The HAZID addressed these systems regarding issues of particular relevance to an Inland Waterways Pushboat but accepted the systems in principle without detail analysis at this time.

- . The main engines have a double walled gas fuel piping system similar to that fitted on various seagoing ships. This system has been approved by Lloyd's Register for use in conventional gas safe engine rooms. The arrangement in the main engine room of the Pushboat was therefore only considered with regard to particular issues relevant to the Pushboat.

- The auxiliary engine room systems had not been designed at the time of the HAZID. It is likely that a single walled 'zero pressure' type system will be fitted. Gas and ventilation systems will be designed such that the auxiliary engine room complies with gas safe engine room requirements. The arrangements will be the subject of future discussion.

Twenty four items for further consideration have been identified and these are listed in Appendix 1. after the worksheets. The responses to these items will further improve the design from a safety risk perspective.

3. INTRODUCTION

Kooiman Marine BV is proposing to build a Dual-Fuel Pushboat, using traditional fuel oil and LNG as fuel.

The proposed design is at an early stage and has the following overall features:

- LNG is stored in a single type 'C' tank (IGC designation) of novel vertical design.
- The tank is insulated and protected by an outer tank of substantial thickness.
- The inner tank is supported on a circumferential ring within the outer tank. The outer tank is supported on a skirt at the base, bolted to the single bottom structure of the pushboat.
- The tank is located just behind the accommodation and bridge of the pushboat.
- The LNG tank and associated cold box supplies methane gas to four main and one auxiliary duel fuel engine. Each engine has its own gas valve unit and can run independently from the other engines.
- The main engines are LR Type Approved and have double walled gas supply piping. The auxiliary engine supplier had not been decided at the date of the HAZID. The auxiliary engine is to be of LR approved type. The installation of the auxiliary engine will require detailed analysis of the engine room and ventilation arrangement and this is not addressed in this HAZID.
- The main propulsion and essential auxiliary systems are conventional inland waterways systems and did not form part of the HAZID.

Lloyd's Register (LR) has been engaged by Kooiman Marine BV to carry out a Hazard Identification Study of the proposed LNG dual fuel propulsion package. This HAZID was carried out as part of the initial phase which, together with approval of preliminary plans will form the basis for an 'acceptance in principle' of the system by Lloyd's Register.

The principle objective of the HAZID is to demonstrate an equivalent level of safety as required by the RVIR, and to increase confidence that safety related aspects of the design are appropriate. Further objectives are covered in Section 5 and detailed in the Terms of Reference (ToR) Appendix 3.

The following codes and standards, or parts thereof, were considered relevant for this design:

- Lloyd's Register Rules and Regulations for the Classification of Inland Waterways Ships, November 2008 and notices.
- Lloyd's Register Rules and Regulations for the Classification of Ships, July 2012.
- Lloyd's Register Rules and regulations for the Classification of Natural Gas Fuelled Ships, July 2012.
- IEC 60079-1: Electrical apparatus for explosive gas atmospheres – Part 10: Classification of Hazardous areas
- IMO Resolution MSC.285(86) Interim Guidelines for Natural Gas-Fuelled engine installations in ships. (IGF Code) (version 1 June 2009)
- International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and amendments.

4. DESIGN DETAILS

Details of the proposed design are shown in the reference documents listed in Table 1 below. The documents were made available to the study attendees prior to the study and were provided as hard copies during the study.

For reference purposes the vessel general arrangement, machinery arrangement and diagrammatic plan of the fuel gas arrangements are included as Appendix 4 of this report.

Additional information was made available to the attendees at the opening PowerPoint presentation.

The overall process design, based on details in the reference documents, is summarised below.

Gas supply system

The Gas supply system is a package for storing LNG, controlling the supply pressure in the tank, vaporizing the LNG into Methane Gas and supplying the gas to the engines at suitable pressure and quantity.

The system consists of an LNG storage tank, cold box (vaporizer & PBU), gas valve units, bunkering station, control & monitoring system and piping & instrumentation.

LNG Storage Tank

The LNG storage tank is a vacuum insulated pressure vessel with double walls. Pearlite insulation fills the space between the two walls. Both vessels are constructed from 304L austenitic-stainless steel. The outer vessel protects the inner tank from external impact and is designed as secondary containment in case of failure of the inner tank.

Cold box

The Cold box is a gastight space that is welded to the outer tank. It contains the LNG vaporizer and PBU, all tank connections and all tank valves. This space is monitored to detect gas leakage using gas detectors. The room is provided with a mechanical induced draft ventilation system (under pressure type) with a capacity of at least 30 air changes per hour.

PBU (Pressure Build-up Unit)

The pressure build up unit pressurises the LNG storage tank, in order that LNG will flow to the vaporizer.

Vaporizer

The function of the HP vaporizer is to vaporize LNG to Methane gas. Heat is supplied from the engine cooling system via the Glycol system.

Gas valve units

Four gas valve units are fitted, one for each engine. They are located in separate gas tight enclosures within the overall structure of the cold box but are not accessible from within the cold box. The function of the gas valve units is to condition and control the methane gas supply to the engines. The Methane supply pressure to the main engines is 4-6 bar. For the auxiliary engine it is assumed that a separate GVU will be fitted. The methane pressure will be reduced to less than 1 bar before supply to the engine.

Bunkering Station

The Bunkering Station is designed for receiving LNG from shore, truck, or bunker barge. The details remain to be decided.

Table 1: Reference Documents

Plan no.	Description
204-051-001 rev. C	General arrangement vert. tank concept.
204-035S-001 rev.F	Propulsion concept – shaft generators, aux. on LNG and battery
E1001 rev.B	Electrical Installation single line diagram
DAAR032590-8/1 rev.0	LNGPac System Functional block diagram.
204-402-001 rev.B	Dual fuel diagram
204-403-001 rev.A	Cooling water diagram
204-409-001 6 sheets rev. C	Ventilation concepts
DAARxxxxxx (preliminary)	LNGPac System P&I drawing
	Wärtsilä 20DF Product Guide

5. THE HAZARD IDENTIFICATION STUDY

5.1 Objectives HAZID

The objectives of the HAZID were to identify:

1. Hazards and how they can be realised (i.e. the accident scenarios – What can go wrong and how?);

2. The consequences that may result;

3. Existing measures/safeguards that minimise leaks, ignition and potential consequences, and maximise spill containment; and

4. Recommendations to eliminate or minimise safety risks.

5.2 Study Team and Attendance

The study was facilitated by Paul stanney from Lloyd’s Register over two and a half days between March 19th and 21st 2013. The HAZID Study team consisted of a range of Subject Matter Experts (SMEs) with knowledge and experience of the design. Team members, a summary of their qualifications, experience and attendance at each node of the study are detailed in Table 2 below.

TNO was invited as an independent observer in the study team. TNO will give its view on the HAZID study in a separate document.

Table 2: HAZID Team Members and Attendance

First name	Last name	Company	Position	Prof. qualifications.	Experience
Paul	Stanney	LR	Machinery Specialist	BSc Mech. Eng. DOT 2nd cert.	25 years plan approval experience of LNG systems. Facilitator for low flash point fuels inc. gas turbines
Willemien	Verdonk	LR	Senior Surveyor in charge	M.Sc Naval Architecture/Marine Engineering	3 years Marine systems design FPSO and 7 years plan approval Machinery department Rotterdam DSO. Two years plan approval LNG fuelled ships in Inland Waterways Ships.
Liviu	Porumb	LR	Surveyor-Elec. & control	B.Sc Electrical Engineering	3 years Electrical designer in marine industry. 5 years Plan approval and Port Surveyor in Rotterdam office.
Rene	Van de Velde	LR	Surveyor in charge IWW	B.Sc. Marine Engineering (Merchant Marine)	In service surveys-New construction Certification IWW vessels. 18 years LR 10 years marine engineer-6 years ship repair.
Kees	De Visser	LR	Surveyor Elec. & control	Bsc Electrical	Trainee surveyor
Alex	Vredeveldt	TNO	Senior Scientific Naval Architect	Msc Naval Architecture	TNO structural expert
Mattijs	Breel	LR	Senior Surveyor	Bsc Mechanical Engineering	10 years at Stork Werkspoor (diesel engines) and 11 years plan approval Machinery department Rotterdam DSO. Two years plan approval LNG-fuelled engines
Bas	Joormann	LR	IWW Product Manager	B.Sc. Naval Architecture	20 Years of IWW experience in The Netherlands Shipping Inspectorate, and 4 years with Lloyd’s Register
Berend	Boneschansker	Thyssen Krupp Veerhaven	Senior Manager Nautical & Technical Services	B.Sc. Marine Engineering (Merchant Marine)	10 years Thyssen Krupp Veerhaven
Bram	Krujjt	Wärtsilä Netherlands B.V.	Director Inland Waterways	B.Sc. Mechanical Engineering	Over 10 year Wärtsilä Netherlands B.V.
Rinus	Kooiman	Kooiman	Director	B.Sc.Naval Architecture	Over 30 years experience Shipyard Kooiman, Kooiman Holding and Kooiman Marine B.V.
Peter	Vrolijk	Kooiman design office	Project Manager	B.Sc.Naval Architecture	10 years project manager and naval architect Kooiman
André	De Wijs	Mous.B.V.	Project Manager	MBO Electrical Engineering	Project Manager
Koen	Vonk	Wärtsilä Netherlands B.V.	Development Manager	MSc Naval Architecture	Over 10 year Wärtsilä Netherlands B.V.
Sander	Van Gool	ThyssenKrupp Veerhaven B.V.	Superintendent	B.Sc. Marine Engineering (Merchant Marine)	Over 10 years Thyssen Krupp Veerhaven
Jonatan	Byggmàstar	Wärtsilä Oil &	Project Engineer	M.Sc Process Engineering	2 years development engineer Wärtsilä Oil & Gas

		Gas			
Frank	Harteveld	Wärtsilä Netherlands B.V.	Gen. Sales Manager	B.Sc. Energy Distribution	Bakker Sliedrecht, Bennex, Roll-Royce and Wärtsilä
John	Penninga	Wärtsilä Netherlands B.V.	Account Manager	Technician Naval Engineering	Over 10 year Wärtsilä Netherlands B.V.

Participation

First name	Last name	Day1			Day2.		Day3
		Node1	Node2	Node3	Node4	Node5	Node6
Paul	Stanney	√	√	√	√	√	√
Willemien	Verdonk	√	√	√	√	√	√
Liviu	Porumb	√	√	√	√	√	√
Rene	Van de Velde	√			√	√	
Kees	De Visser	√	√	√	√	√	√
Alex	Vredeveldt	√	√	√	√	√	√
Mattijs	Breel	√	√	√	√	√	√
Bas	Joormann	√					
Bram	Kruyt	√	√	√			
Rinus	Kooiman	√	√	√			√
Peter	Vrolijk	√	√	√	√	√	√
André	De Wijs	√	√	√	√	√	√
Koen	Vonk	√	√	√	√	√	√
Sander	Van Gool	√	√	√	√	√	√
Jonatan	Byggmàstar	√	√	√	√	√	
Frank	Harteveld	√	√	√	√	√	
John	Penninga				√	√	

5.3 Study Methodology

The approach taken for the study was a 'Structured What If Technique' using guidance from the following sources on the requirements and best practice for conducting studies:

- BS ISO 31000: 2009, Risk Management – Principles and Guidelines
- BS ISO 31010: 2010, Risk Management – Risk Assessment Techniques

The two BS ISO Standards provide useful information on the overall techniques for hazard identification and risk assessment.

The HAZID technique adopted for this study is a checklist based approach used for identifying scenarios that may lead to releases of material or hazardous events. The technique involves the definition of discrete process sections, termed "Nodes", and the application of guidewords to these Nodes to identify deviations that may lead to a safety or operational problem (Scenario).

For each Node a checklist of possible hazards is used to identify possible scenarios. A study checklist, consisting of a list of HAZID guidewords, was developed prior to undertaking the HAZID, as shown in Table 3 below. These guidewords were based on previous experience and indicate the types of hazards that were thought to be applicable to the types of treatment systems being considered. The list is not exhaustive and the HAZID was not limited to these prompts.

For each item in the list of guidewords the team considered realistic scenarios that could lead to an accident and identified possible causes and outcomes from the accident. After evaluating the potential consequences of accident scenarios, measures that would be expected to be in place for prevention, control and mitigation were identified. If these were thought to be inadequate or insufficient information was available, items for further consideration were raised.

Minutes of the HAZID discussions were recorded on a spreadsheet by the study Scribe and are shown in Appendix 1. During the meetings the minutes were projected onto a screen. This allowed team members to comment on the minutes.

Table 3: Guidewords

Leakage
Rupture
Corrosion
Impact
Fire/Explosion
Structural Integrity
Mechanical failure
Control/electrical failure
Human error
Manufacturing defects
Material selection

The Terms of Reference circulated to team members prior to the HAZID and attached as Appendix 3 provides additional details of the HAZID approach taken.

5.4 Risk Rating

Risks identified during the HAZID were rated in accordance with a risk matrix provided by Lloyd's Register as shown in Appendix 2.

It should be noted that the risk ranking is only based on the assessment of risk to personnel. Low severity consequences that could result in minor injury were excluded from the assessment. This approach helps to ensure that the study team only concentrated on significant risks, which is considered to be an appropriate approach for a HAZID at this stage of design.

5.5 HAZID Study meeting

HAZID Meeting

The HAZID meeting was undertaken between 19th and 21st March 2013 in Rotterdam.

The meeting room was adequately sized for the number of team members and was provided with the required equipment for undertaking the HAZID. Breaks for refreshments and Lunch were provided throughout the meetings.

Study Preparation and References

Prior to commencing the Study a Terms of Reference (ToR) was produced by Lloyd's Register and issued to each of the team members. The ToR provided details of the HAZID approach and study schedule.

Team members were also supplied with the reference documents listed in table 1.

At the start of the meeting a short introductory presentation was given to the study team by the study facilitator providing an overview of the project and HAZID technique, respectively.

Study Nodes

The gas system was split into the Nodes listed in

Table 4 for the study. Prior to considering each node a brief overview of the equipment and its operation was given. This ensured that the team were fully aware of the extent of the Node and its function.

Table 4: Nodes

Node	Description	Study Details				
		Session	Date	Start Time	Finish Time	Duration (Minutes)
1.	LNG tank	1	25/09/2013	09:30	12:30	180
2.	LNG bunkering system	1	25/09/2013	13:30	15:00	90
3.	Hazardous areas	1	25/09/2013	15:30	17:00	90
4.	Fuel system from tank to GVU.	2	26/09/2013	08:00	12:00	240
5.	Engine room systems	2	26/09/2013	13:00	17:00	240
6.	External influences and control.	2/3	27/03/13	13.30	1700	210

The approximate time spent studying each Node is shown in the table. Times include breaks for refreshments but not the lunch breaks.

Consequence Assessment and Risk Assessment Results

For the major safety issues in session1, consequences that could have significant effects on people were rated in accordance with the matrix shown in Appendix 2. Scenarios that had no notable effects on personnel were not rated. This means that the ratings are only relevant to significant hazards related to the design

Overall HAZID Assumptions

The following overall assumptions were made for the HAZID :-

- Personnel involved with operation and maintenance of the LNG fuel system will be competent. It is therefore important that personnel have been trained in the use and maintenance of any new equipment.

- Safety systems will be designed to achieve an appropriate level of reliability. This includes any shutdown system or process alarm.

- Personnel will respond to alarms in sufficient time and will take appropriate action.

- Throughout the study it was assumed that any releases of LNG could find an ignition source and be ignited. The consequences of ignition could result in a number of outcomes, such as a pool fire, jet fire, or explosion. As the outcome will depend upon a number of factors such as release size, location, ventilation and duration before ignition it is not possible in a study of this nature to assess all possible outcomes. The overall assumption has been made that releases could result in a fire or explosion and the severity category of release has been based on the team's judgement.

- Rules, standards, codes and legislation for marine systems will apply where applicable. While a detailed review of applicable rules, standards, codes and legislation was not undertaken as part of the study it was recognised that these are relevant. Where relevant, reference was made to standards and codes during the meeting.

5.6 Items for further consideration

Items for further consideration were generated. A total of 24 considerations were raised in the worksheets. A synopsis is included at the end of the worksheets in Appendix 1.

No specific dates were set for completing these items and the items were assigned to companies rather than individuals. This approach was taken as all of the items should be considered immediately as part of the project schedule.

5.7 Conclusions

The HAZID of the proposed Dual-Fuelled Pushboat identified a number of possible scenarios that could harm personnel and these are detailed below. They concern structural failure of the inner/outer tank and release of LNG into the cold box. The likelihood of occurrence of these scenarios were considered remote, but fall into the medium risk category of the risk matrix by virtue of the consequences of the occurrence. These issues require further work and satisfactory resolution in order to reduce the risk to ALARP (as low as reasonably practicable).

The main issues identified related to:

- Design and support of the vertical LNG tanks – structural loads on the supports of vertical tanks during vessel collision can lead to failures which could release large quantities of LNG in the vessel. Such a release could lead to fire/explosion or structural damage due to low temperature embrittlement. The design of the tank and supports must be capable of withstanding the worst anticipated collision loadings and these loadings must be clearly stated on the design documentation of the tank.

- Side collision from another vessel was considered the most likely scenario that could damage the tank. The ability of the Pushboat side structure in way of the LNG tank to absorb energy in event of collision should be assessed and compared with predicted collision energy curves for Inland Waterways vessels.

- Overfilling of an LNG tank – an overfilling of the LNG tank could lead to tank rupture or release of a two phase LNG/NG release from the vent mast. A release of this type could have very severe consequences. The use of an independent system for preventing overfill of the LNG tank has been recommended.

- Piping or piping component failures within the cold box can only be isolated by operation of the single tank isolating valve. It is recognised that this valve is a high integrity spring fail close valve but it is considered that the possibility of failure of this valve and uncontrolled release of LNG into the cold box must be considered and suitable mitigation provided.

- Failure of the LNG bunkering system - releases from the bunkering connection could lead to a large LNG release. It is important to ensure that the design of the bunkering system is based on best practice and meets regulatory requirements. Details of the bunkering system were not available at the HAZID and will be the subject of future discussion.

Twenty four items for further consideration were also identified. The responses to these items along with details of potential failure scenarios and safeguards identified in the study will further improve the design from a safety risk perspective.

APPENDIX 1. HAZID WORKSHEETS AND SUMMARY OF ACTIONS.

System: LNG storage tank	Drawing: Various	HAZID sheet 1
Area: Node 1	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : LNG storage tank		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
1. Rupture							
1.1 Rupture of inner tank							
1.1.1.	Failure due to material, welding and manufacturing defects (normal service conditions).	Release of LNG	Fire/explosion	LNG tank will be designed in acc. with IGC Code Type C requirements. Double walled, pearlite and vacuum insulated type of tank. Material of inner, outer shell and supporting skirt is AISI 304 stainless steel. Design to be approved by LR, including supporting structure. LNG tank will be built under survey of LR.	Possibility of failure of the inner tank is very low. If failure occurs outer tank will contain leakage. Outer tank is not designed as a pressure vessel but will contain leakage. Excess pressure is vented through a lift plate which is led to the vent mast. The maximum pressure retaining capacity of the outer tank and the relieving capacity of the lift plate vent system and hence the maximum inner tank hole size should be specified. (rec.1)	**L1**	**C**
1.1.2.	Side/bottom impact from jetty or grounding of vessel	Release of LNG from tank	Fire/explosion.	LNG tank will be located B/5 from ship side in acc. with LR Rules. Bottom of LNG (outer- second barrier) tank will be 760 mm above baseline of ship. The Rules require the tank is more than B/15 above baseline ship. ADN Rules require cargo tanks to be 600 mm above baseline.	The arrangement is considered to comply with ADN requirements for gas tankers.	**L1**	**C**

System: LNG storage tank				Drawing: Various	HAZID sheet 1		
Area: Node 1				Revision: 0	Operating Mode: Normal continuous.		
Equipment/Systems : LNG storage tank							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
1.1.3.	Vessel collision	ship to ship ship to shore	Fire explosion	Top of tank is below airdraft of vessel. Location of LNG tank i.a.w. ADN requirements (as above stated).	Yard and TNO are to propose collision loads to LR, based on structural details of the ship and will be discussed separately. Vulnerability of LNG tank is to be investigated in terms of crash-worthiness and ability of side structure to absorb energy. Reference to be made to ADN curves on collision energies. (rec.2)	**L1**	**C**
1.1.4.	Overpressure	Overfilling of tank	Tank rupture	Automatic filling arrangement and level alarms are in acc. with IGC Code (HLA & HHLA) with automatic shutdown of bunkering action (pump, valves). Safety relief valves i.a.w. IGC Code	LNG supply pressure is to be not greater than design pressure of tank. Max filling limits for safety of tank to be defined. Detail of bunkering arrangements are not yet decided and will be the subject of separate meeting.(rec 3.)	**L1**	**C**
1.1.5	Vessel movement.	Angles of inclination in max. damaged condition.	Tank support failure – release of LNG.	Tank support arrangements to comply with ADN requirements for max. angles of inclination.	Maximum damaged condition to be defined. (rec.4)	**-**	**-**
1.1.6	Dropped objects during cargo operations	Damage to top of tank due to 45 ton grab load of cargo (coal…)	Fire/explosion	Outer tank will protect inner tank. Top dish end (18 mm outer shell) is concluded to be able to withstand an accidental dropped load of cargo. Vent pipe connections are protected.		**-**	**-**
1.1.7	Dropped objects	Damage to top of	Fire explosion	Outer tank will protect inner tank.	Top of cold box in way of	**-**	**-**

System: LNG storage tank			Drawing: Various		HAZID sheet 1		
Area: Node 1			Revision: 0		Operating Mode: Normal continuous.		
Equipment/Systems : LNG storage tank							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
	from bridges, accidental (car) & intentional (tiles)	tank and safety-relief valves, due to their location in topside of tankroom.		Top dish end (18 mm outer shell) is concluded to be capable of withstanding these impacts.	pressure relief valves to be strengthened for impact loads. (rec.5)		
1.2 Rupture / collapse of outer tank							
1.2.1.	Failure of inner tank causes outer tank to be pressurised.	Failure of outer tank due to pressure	Release of LNG Fire/expolosion.	Result of analysis of outer tank to be made available.			
1.2.2.	Side/bottom impact	Loss of vacuum	Excessive boil off/relief valves lift	See comments above re. strength of outer tank.			
1.2.3.	Dropped objects.	Loss of vacuum	Excessive boil off/relief valves lift	See comments above re. strength of outer tank.			
1.3 Rupture of connecting pipes.							
1.3.1.	Fretting	Release of LNG into outer tank.	Safety valves lift.	Pipe is assumed to leak before complete failure. Leakage to be vented through breakplate (vacuum loss) and tank pressure will be reduced in by-passing pressure relief valves.			

System: LNG storage tank	Drawing: Various	HAZID sheet 1
Area: Node 1	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : LNG storage tank		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
2. Leakage							
2.1 Leakage from inner tank							
2.1.1.	Fatigue failure in inner tank.	Release of LNG into outer tank.	Loss of vacuum in outer tank. Pressure build up causes breakplate to open and relieve pressure.	Tank pressure will be reduced by by-passing pressure relief valves.	Pipe arrangements for venting to be considered further. Size of pressure relief vent line to be assessed against assumed leak size, which is to be stated. (rec.6)	**L1**	**B**
2.1.2	Fatigue failure from pipe connections.	Release of LNG into outer tank.	Loss of vacuum in outer tank. Pressure build up causes breakplate to open and relieve pressure.	Small leakages will be detected by the loss of vacuum insulation. Tank pressure can be reduced by by-passing pressure relief valves.	Pressure sensor to be fitted for continuous monitoring the vacuum. Arrangements for a leaking LNG tank to be discharged to shore are to be provided. (rec.7)	**L2**	**B**
3. Corrosion/erosion					The inner and outer tanks are 304L stainless steel. Internal/external corrosion and erosion and not expected to be issues over the lifetime of the tank.		
6. Structural integrity					See comment 1.1.1. regarding the design of the tank.		

System: Bunkering system.	Drawing: Various	HAZID sheet 2
Area: Node 2	Revision: 0	Operating Mode: Alongside.
Equipment/Systems : Bunkering system		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
1. Rupture					LNG Bunkering system has not been finalized yet and will have to be addressed at a later stage when details are known. (rec.8)		
1.1. Rupture of bunker pipework	.						
1.1.1.	Overpressure	Release of LNG	Fire explosion. Structural failure of boat due to embrittlement of steel structure.	Stainless steel drip-tray for containment of hose contents	Failure and leakage of bunker end connections will be protected with drip trays. Breakaway self sealing coupling will be fitted. Additional water protection to drain LNG from ship's deck. may be considered.		
1.2 Rupture of supply hose.							
1.2.1.	Chafing/over extension.	Spill of LNG via pipe connections or other fittings	Fire explosion.		Failure of bunker hose is considered unlikely. Breakaway self sealing couplings will reduce spill.		
1.3. Failure of bunker lines in cold box.	Expansion/ contraction due to cooling down.	Spill of LNG in cold box.	Fire/explosion	Expansion bends are arranged in cryogenic piping system. (not flexible hoses or expansion pieces)			

System: Bunkering system.			Drawing: Various		HAZID sheet 2		
Area: Node 2			Revision: 0		Operating Mode: Alongside.		
Equipment/Systems : Bunkering system							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
1.2 Tank rupture due to high pressure				*To be discussed as control item in Node 6..*			
1.2.1.	Overfilling of tank	Release of LNG.	Fire/explosion	Tank high level and high-high level alarms and shutdowns will be in accordance with the I.G.C.	The importance of an independent high-high level alarm solely with a safety function to close the bunker supply valve was recommended.		
1.2.2.	Failure of pressure relief	Release of LNG	Fire explosion.	Two pressure relief valves will be fitted in accordance with the I.G.C. code. The relief valves must operate in the vapour phase – see comments above re. high liquid level alarms.			

System: LNG systems	Drawing: Various	HAZID sheet 3
Area: Node 3	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : Ventilation and Hazardous areas.		

ITEM	Comment
1. LNG tank	Tank is zone 0. Pressure relief valves i.a.w. the IGC code are fitted. They relieve to a mast located 6m above the working area and gangways. The outlet is 10m away from air intakes or open decks. The tank safety relief vent exhausts horizontally for rain but a deflector will be placed to direct the vent gases upwards into the vertical direction. The ventilation outlet from the cold box is arranged around the relief valve outlet at the vent mast to help disperse the vent gases of the tank pressure relief waste pipe. The vent mast is not 6 m. above the superstructure (weather) deck as required by the Rules. It is situated 4.87 m. above the bunker station deck. Restrictions for personnel will apply in for this area. Electrical equipment on the superstructure deck is to be of approved gas safe certified type.
2. Cold box	Cold box is zone 1. This is ventilated at 30 air changes per hour by 2 fans (one redundant) discharging up the vent mast from a location at the top of the cold box. Air inlet of the ventilation system is situated at the forward end of the tankroom (refer to plan no. 204-409-001 sh.4 of 6) and outside the 10 m. sphere from the relief valves outlet at the vent mast.
3. GVU	The gas valve units are located within the cold box structure but are not accessible from within the cold box. They are accessible from outside the cold box through bolted covers with a bolt spacing in accordance with Rule-requirements Part 4, Ch.2, Sec. 11.2.1 for gas-tight zones. The gas valve units are zone 1. Ventilation air for the GVU is the same as the ventilation air for the double walled pipes in the engine room. The ventilation air for each engine and GVU is separate. The fans are duplicated. Air is drawn in through dust screens from outside the engine room and led to the outer pipe of the double walled pipe around the engine. It then passes through the outer pipe into the GVU room and thence through single walled pipe ends in the tankroom. This ventilation air will be taken out by dedicated exhaust fans in the tankroom discharging in a separate vent pipe to the high level vent.
4. Tank hold	The tank hold is considered gas safe, because the tank is double-walled and the cold box is completely gastight below the deck. Air is drawn in at the aft end of the vessel outside the 10m radius of the vent mast. The exhaust is also outside the 10m radius of the vent mast.

5. Auxiliary Engine	The gas supply piping inside the aux. engine room to the gas-fuelled engine is single-walled. This may be accepted for a very low pressure gas supply system, provided a satisfactory CFD analysis is carried out to demonstrate, that any gas leaks are immediately dispersed by the forced ventilation air flow. The analysis is to demonstrate that no stagnant area's are present inside this engine room for a possible build-up of gas. Further reference is made to IEC

Room	60079-10 standard. Ventilation rates are to be based on maximum gas supply pressure (expected 2 bar) to the GVU and leak rates of gas-fuelled engine. Arrangements are to be approved by LR. Ventilation inlet to the aux. engine room is to be taken from a gas safe area. Ventilation exhaust of aux.engine room is concluded to be gas safe due to redundant forced ventilation applied and situated in a gas safe area. Ventilation fans are to be of an explosion safe type.
6. Safe spaces	Air is drawn into the gas safe spaces of the vessel through inlets in gas safe areas.

System: Pressure build up and gas distribution.	Drawing: Various	HAZID sheet 4
Area: Node 4	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : Cold box and GVU		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
1. Rupture							
1.1. Rupture of pipe work in coldbox							
1.1.1	Fretting / fatigue failure of pipe & pipe connections.	Large scale release of LNG	Build up of liquid in cold box.	All seamless stainless steel piping with welded connections. All welds are NDE and certified by LR. Expansion is accommodated by st.steel pipe bends. Pressure rating is 10 bar and no corrosion/erosion is expected. Gas detection / temp. detection fitted. Gas detection causes tank outlet valve to close. Tank outlet valve is spring-loaded to close and pneumatic opened. Valve sealing can be tested by closing 5 valves and checking pressure change in piping. An FMEA has been carried out on valve design and submitted to LR for review. Ventilation outlets of coldbox are to be of adequate size to avoid pressure build-up. Tank outlet valve body is tested to 620 bar. Coldbox is manufactured from 304L material.	The coldbox is designed to accommodate the volume of liquid contained in the pipes and equipment in coldbox. Max. flooding or max. pressure of LNG that can be contained by the coldbox is to be determined. The ventilation pipes are to be sized such that they will prevent a build up of pressure in the coldbox resulting from a ruptured pipe. Sole reliance on the tank outlet valve for controlling flooding is not recommended. (rec.9)		

System: Pressure build up and gas distribution.			Drawing: Various		HAZID sheet 4		
Area: Node 4			Revision: 0		Operating Mode: Normal continuous.		
Equipment/Systems : Cold box and GVU							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
1.2. Internal rupture in PBU and evap. heat exchangers							
1.2.1.	Internal rupture in heat exchanger	Leakage of gas into glycol system.	Pressure build up in glycol system.	Pressure in LNG system must be designed to be higher than in glycol system. Any leakage must always be from LNG system into glycol system.	Gas detection should be fitted in Glycol system header tank or accumulator vessel. (rec.10)		
1.3 Rupture in glycol lines							
1.3.1.	Rupture in glycol lines	Release of glycol	Loss of heating capacity in coldbox and 'freezing up' of heat exchangers. Hazardous area's can be affected.	Loss of glycol medium is detected by low level alarm in expansion tank and consequent closing of tank outlet valve.	Loss of glycol to heat exchangers to be further investigated. Arrangements to prevent freezing of heat exchangers in the event of loss of glycol supply must be provided. (rec.11)		
1.4 Rupture of pipe in GVU.							
1.4.1.	Metal fatigue.	Release of gas into GVU compartment	Possible build-up of combustible gas/air mixture.	GVU Unit is ventilated by 30 air changes per hour. All equipment in GVU is certified safe type. Gas			

System: Pressure build up and gas distribution.			Drawing: Various		HAZID sheet 4		
Area: Node 4			Revision: 0		Operating Mode: Normal continuous.		
Equipment/Systems : Cold box and GVU							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
				detection sensor is fitted. Each engine has its own GVU. Engine will shut down on gas detection.			
2. Leakage							
2.1 Leakage in cold box	Leakage of valve stems	Build up of methane gas	No significant effects are expected due to safeguards mentioned..	Cold box is ventilated at 30 air changes per hour. Gas detection sensor is fitted in top of coldbox, where accumulation of gas is expected.			
2.2 In line leakage through valves	Worn sealing surface	Uncontrolled gas flow.	Uncontrolled effects in gas system.	Valves are tested in service for condition. No hazardous condition is expected from in-line failure of a single valve (other than tank outlet valve –see above comments).	Maintenance regime for all valves to be specified by manufacturer. (rec.12)		
3. Corrosio n/erosion							
3.1 Corrosion	Incorrect material used.	Leakage of LNG	Fire/explosion.	All LNG piping and pipe components are in manufactured from stainless steel. Bo corrosion or erosion is expected in the lifetime of the system.	All materials used in the LNG pipe must be approved by the manufacturer.		
4. Structura l integrity							
4.1 Pipe/com ponent overpress							

System: Pressure build up and gas distribution.				Drawing: Various		HAZID sheet 4	
Area: Node 4				Revision: 0		Operating Mode: Normal continuous.	
Equipment/Systems : Cold box and GVU							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
ure.							
4.1.1.	Locked in piping	Release of LNG	Fire/explosion	Pipework is designed for a pressure of at least 10 bar. Pipes connected to tank are protected by tank relief valves. All other pipes that may be isolated from the tank are protected by thermal relief valves.			
5.Mechanical failure							
5.1. Valves							
5.1.1.	Failure of control system to shut valve	Valves fail to move to safe position	Control of system is lost	All valves are designed to move to closed position. Except vent valves which are to move to open position. All valves are metal to metal seated.			
5.2. Heat exchangers							
5.2.1.	Corrosion				See comments re leakage.		
6. Human error							
6.1	Unauthorized 'pushing of buttons' by operator.	Uncontrolled operation	Release of LNG.	Sufficient training to be provided for personnel in operation of the automated LNG system. Additional training is required for personnel on LNG aspects on properties / behaviour of LNG and handling of	(rec.13)		

System: Pressure build up and gas distribution.	Drawing: Various	HAZID sheet 4
Area: Node 4	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : Cold box and GVU		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
				LNG on board. The LNG system is completely automatic on start-up, normal operation and shut-down. No emergency or reversionary modes are provided. Manual intervention is only required during bunkering.			
7 Manufacturing defects							
7.1 Faulty manufacture	.						
7.1.1.	Faulty manufacture	Failure of material	Release of LNG	Complete gas system and materials are manufactured under LR Survey.	Welding of LNG piping to be further investigated for class. Requirements re. welding and NDE requirements for small bore piping. (rec.14)		
8. Materials							
10.1 Incorrect material							
10.1.1.	Incorrect material selection or incompatible materials	Material failure	Release of LNG	Materials to be manufactured and tested in acc. with LR Rules for Liquefied Gas Ships.			

System: Engine room systems.	Drawing: Various	HAZID sheet 5
Area: Node 5	Revision: 0	Operating Mode: Normal continuous.
Equipment/Systems : Dual fuel/auxiliary engines		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
Main engines							
Main engines have a double wall gas piping arrangement. This is approved by LR for use in gas safe engine rooms. No further analysis of the main engine systems was considered necessary The main engines are required to be built under survey and certification of Lloyd's Register. The engine is to be approved or alternatively hold an LR Type Approval. The Wärtsilä 6L20DF engine is Type Approved by LR (Cert. no.11/00057). Wärtsilä 20 DF is an 'electronically controlled' engine and understood that Engine Control Unit (ECU) is identical to 34DF unit. This ECU holds an LR Type Approval.							
Auxiliary engine							
The make and type of auxiliary engine has not been decided. The engine will be an 80%/20% dual fuel zero pressure engine with single walled piping. The engine room ventilation and arrangement must be specially considered to ensure that the engine room can be considered gas safe in case of single pipe failure. This will need to be the subject of a separate HAZID when details are available.							

System: External influences	Drawing: Various	HAZID sheet 6
Area: Node 6	Revision: 0	Operating Mode: Various.
Equipment/Systems : External influences and control arrangements		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
1.Fire					Further advice on heat ingress for tank above and below deck to be requested for sizing of safety valves. (rec.15)		
1.1. ER fire.	Oil leakage / spray	Engine room fire	Overheating of LNG tank and vapour boil off	Automatic closing of Master Gas valve in supply line to 4 GVU's. A60 insulation at ER bulkhead to tankroom and fixed fire-fighting systems in ER. Two independent fire-fighting pumps are fitted. Water spray to exposed section of tank outside tank hold.			
1.2 Fire in tank hold	Light fixtures or other electrical equipment	Overheating of LNG tank. Excessive boil off.	Tank safety valves lift.	Tank hold is a gas safe space. There is no flammable inventory and no source of ignition other than electrical switchgear. The tank hold is a low fire risk area and no special fire fighting measures are needed.			
1.3 Fire / explosion in cold box	Gas leak.	Build up of gas.	Fire/explosion.	Cold box is vented at 30 air changes an hour. Gas detection is fitted. All electrical equipment in cold box is certified gas safe. A fire/explosion in cold box is extremely unlikely.			
1.4 Fire on deck	Flammable substances on deck igniting.	LNG tank may be heated.	Tank relief valves will lift	Tank structure is mainly enclosed by tank room. Heating effect will be limited. Waterspray system installed to cool the top of the LNG tank.			

System: External influences	Drawing: Various	HAZID sheet 6
Area: Node 6	Revision: 0	Operating Mode: Various.
Equipment/Systems : External influences and control arrangements		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
1.5 Fire in cargo barges	Cargo ignites.	Heating the LNG tank. Igniting the gas or gas/air mixtures from ventilation lines and exhausts.	Tank relief valves will lift.	Tank to be cooled sufficiently to protect tank at max. heat load and avoid opening of pressure relief valves.	If tank relief valves open then flare may form at the vent outlet. Means to control this event must be considered. (rec.16)		
2. Flooding							
2.1 Tank hold flooding	Bottom plating damage.	Tank hold will be flooded.	Heat input into the tank will change.	Control cabinets will not be flooded. Bottom of LNG tank and the suction line is considered to be sufficiently protected against mechanical damage due to flooding.			
2.2 E/R flooding	Bottom plating damage.	Engine room will be flooded.	Loss of power/blackout.	Engine room flooding in a gas fuelled vessel engine room is not considered to pose any additional hazards and concluded to be identical to a normal diesel-fuelled vessel			
2.3 Sinking	Collision	Complete flooding of tank hold	High heat input into tank. Flotation of tank/breakaway from fixings.	Flotation of LNG tank is not considered a hazard. Foundation design is capable to withstand higher dynamic loads. Tank remains attached to bottom of ship and foundation will be designed to accommodate upward forces.	Working conditions of pressure-relief valves to be investigated. Will valve operate in submerged condition. Will relief valve prevent rupture of LNG tank if submerged. (rec.17)		
3.0 Escape							
3.1 Escape	Fire/sinking	Entrapment	Fatality	One exit at main deck level. Two exits at superstructure deck	Tank hold is a low fire risk protected space that is not		

System: External influences				Drawing: Various		HAZID sheet 6	
Area: Node 6				Revision: 0		Operating Mode: Various.	
Equipment/Systems : External influences and control arrangements							
ITEM	**CAUSE**	**HAZARD**	**POTENTIAL EFFECTS**	**SAFEGUARDS**	**RECOMMENDATIOS**	**FI**	**SI**
from tank hold					normally manned.		
3.2 Escape from cold box	Fire/asphyxiation	Entrapment	Fatality	Irregular and temporarily accessed for inspection and maintenance. One exit through a bolted hatch cover on top of coldbox. Two ladders inside for descent/ascent to bottom of coldbox	It was not clear whether access doors or bolted manholes would be provided for access. This is to be finalized. Arrangements are to comply with statutory requirements.Statutory requirements to be checked and communicated. (rec.18)		
4. Alongside /maintenance							
4.1 Vessel maintenance/repairs	Ignition sources by manual-, electric powered tools and welding equipment	Leakage, venting of LNG	Fire/explosion.	Purging and inerting LNG piping in coldbox after the tank outlet valve. Decrease pressure in LNG tank to minimum level. Procedure, to maximise tank holding time.	Proposal to made for preparing the LNG plant for different maintenance/repair scenarios on the vessel. (rec.19)		
4.2 LNG plant maintenance	Replacement of parts/failed components.	Leak of LNG/gas.	Fire explosion.	Purging and inerting LNG piping in coldbox after the tank outlet valve. Decrease pressure in LNG tank to minimum level. Procedure, to maximise tank holding time. Possible transfer of LNG ashore. Inerting of the tank.	A procedure will be produced to state the level of maintenance required and how it is to be performed. (rec.20)		
4.3 Engine repairs and maintenan	Replacement/repair of components.	Leak of LNG/gas.	Fire explosion.	Block & bleed valve arrangement in each gas supply line. Each engine will be disconnected from gas supply			

System: External influences	Drawing: Various	HAZID sheet 6
Area: Node 6	Revision: 0	Operating Mode: Various.
Equipment/Systems : External influences and control arrangements		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
ce				and gas-free during maintenance and repairs.			
4. Commisioning and trials							
4.1	A commissioning and trials procedure will be supplied. Plant will be commissioned by manufacturers and testing and trials witnessed by LR.						
5. Blackout							
5.1.	Blackout will cause loss of power to the LNG system and system will shut down. Backup power is supplied by batteries and the auxiliary generator.						
6. Deadship							
6.1 LNG plant and engine room	Short circuit	Accumulation of undetected methane gas in coldbox and hazardous zones	Fire/explosion on start up.	Portable gas detectors to be available. Ventilation air must be provided before start up of the LNG plant.	Evacuation of vessel and a procedure for the gas-safe restoration of power to be provided. (rec.21)		
6.2 LNG tank	No cooling measures of LNG are available	Pressure build-up in LNG tank and entrapment of liquid LNG pipe sections	Uncontrolled venting.	Relief valves on tank will vent and relief valves on liquid LNG pipelines may vent.	Recovery from deadship condition is considered to be available on call and short notice on inland waterways.		
7.Automatic modes							
	The system is fully automatic. No manual operation is possible. System shuts down on failure of control system.						
7.1							

System: External influences	Drawing: Various	HAZID sheet 6
Area: Node 6	Revision: 0	Operating Mode: Various.
Equipment/Systems : External influences and control arrangements		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
8. Reversionary							
8.1	No reversionary modes are fitted. System shuts down on failure and reverts to oil fuel operation.						
9. Emergency							
9.1	No emergency operation modes are fitted. System shuts down on failure and reverts to oil fuel operation.						
10. Electrical & Control system							
10.1 DC bus	DC bus short-circuit	Short circuit	Black out ship and loss of ventilation, glycol and cooling water pumps	Shut-down of gas outlet valve Main engines will switch to diesel-mode (ECU battery backup 24V) Steering system (24 V backup) and automatic starting of auxiliary diesel driven generator for restoration of ventilation and pumps.	Auxiliary engine room to be gas-safe independent of ventilation after stop of auxiliary dual-fuel engine in order to re-start aux.engine in diesel-mode. (rec.22)		
10.2 AC bus	AC bus short-circuit	Short circuit	Loss of redundancy in ventilation in cold box, GVU, double-walled piping and glycol pumps. Complete loss of pumps and ventilation after 30 min.	Ventilation of cold box, GVU, double-walled piping and glycol pumps is continued. LNG control will remain on UPS supply for 30 min.	This issue is to be reconsidered so that after a single failure in electrical system, uninterupted operation of essential ventilation, pumps and control is maintained. (rec.23)		
10.3 Control	Failure of control system.	System malfunction	Uncontrolled operation.		Failure Mode & Effect Analysis is to be submitted		

System: External influences	Drawing: Various	HAZID sheet 6
Area: Node 6	Revision: 0	Operating Mode: Various.
Equipment/Systems : External influences and control arrangements		

ITEM	CAUSE	HAZARD	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIOS	FI	SI
System					and to include the general design principals for dealing with malfunctions in control system. (rec.24)		

Summary of Actions /Recommendations

No.	Worksheet ref.	Remarks/considerations	Responsibility
1.	Node1./ 1.1.1./1.2.1.	Max. pressure retaining capacity and relieving capacity of the lift plate to be specified.	Wärtsilä
2.	Node1./ 1.1.3.	Collision loadings on tank are to be defined. Energy absorbing ability of ship side structure to be specified. Reference is made to AND curves on collision energy	Wärtsilä, Kooiman, TNO.
3.	Node1./ 1.1.4.	Bunkering arrangements and tank filling limits are to be clarified and assessed at a later date.	Wärtsilä, Kooiman
4.	Node1./ 1.1.5.	Maximum damage condition (heel and trim) to be defined.	Kooiman
5.	Node1./ 1.1.7.	Top of cold box in way of pressure relief valves to be strengthened.	Wärtsilä
6.	Node 1./2.1.1.	Pipe arrangements for venting to be considered further.	Wärtsilä
7.	Node1./ 2.1.2.	Pressure sensor for continuous monitoring of vacuum to be fitted. Arrangements for discharging LNG ashore to be provided.	Wärtsilä
8.	Node2./ 1.	Bunker arrangements to be further considered at a later date.	Wärtsilä/Kooiman
9.	Node4./ 1.1.1.	Maximum flooding height and pressure that can be contained by cold box is to be determined. Ventilation pipes are to be sized such that they will prevent a build up of pressure resulting from ruptured pipe.	Wärtsilä
10.	Node4./ 1.2.1.	LNG leak detection should be fitted in Glycol system.	Wärtsilä/Kooiman
11.	Node4./ 1.3.1.	Arrangements to prevent freezing of heat exchangers in event of failure of Glycol system to be provided.	Wärtsilä/Kooiman
12.	Node4./ 2.2..	Maintenance regime for all gas components to be specified.	Wärtsilä
13.	Node 4./6.1.	Training to be provided for operators	Wärtsilä/Kooiman
14.	Node 4/7.1.1.	Material and survey requirements for welding of small diameter gas pipes to be investigated.	LR
15.	Node6./1.	Further advice on heat ingress from fire for tank above and below deck	LR
16.	Node6.1.5.	Means for controlling flare at vent mast to be considered.	Wärtsilä
17.	Node6./2.3	Working conditions of pressure relief valves when submerged to be investigated.	Wärtsilä
18.	Node6./3.2	Access doors or bolted manholes to the cold box. The arrangements are to be clarified.	Wärtsilä
19.	Node6./4.1	Proposal to be made for preparing LNG plant for different maintenance /repair scenarios.	Wärtsilä
20.	Node6./4.2	A procedure to state level of maintenance required for all gas components to be produced	Wärtsilä
21.	Node6./6.1.	Procedure for the gas safe restoration of power from a deadship to be provided.	Kooiman
22.	Node6./10.1	Auxiliary engine room to be gas safe independent of ventilation in order to re-start aux. engine. In diesel mode. Arrangements are to be considered.	Kooiman
23.	Node6./10.2	Uninterrupted operation of ventilation is required after 30 minutes on U.P.S. Arrangements are to be further considered.	Wärtsilä
24.	Node6./10.3	FMEA to be submitted to deal with malfunctions in control system.	Wärtsilä

APPENDIX 2. RISK RATINGS

Severity

Severity	Description	Likelihood				
		L1	L2	L3	L4	L5
C	Multiple fatalities					
B	Single fatality or multiple major injuries					
A	Major injury					

Likelihood

Code	Description	Chance Per Year	Chance Per Vessel Lifetime
L1	Remote	<10E-6	> 1 in 40,000
L2	Extremely Unlikely	10E-6 to 10E-5	1 in 40,000 to 1 in 4,000
L3	Very Unlikely	10E-5 to 10E-4	1 in 4,000 to 1 in 400
L4	Unlikely	10E-4 to 10E-3	1 in 400 to 1 in 40
L5	Likely	10E-3 to 10E-2	1 in 40 to 1 in 4

Risk Ranking

Code	Description
	Low
	Medium
	High

APPENDIX 3. TERMS OF REFERENCE/SCOPING STUDY

Lloyd’s Register has been contracted by Kooiman Marine BV to carry out a Hazard Identification Exercise (HAZID) on an Inland Waterways Pushboat with dual fuel (diesel oil or LNG) engines. The use of LNG as a fuel for Inland Waterways Vessels is relatively new and novel for this type of boat.

Lloyd’s Register has Rules for Methane Gas (LNG) fuelled ships which require a HAZID to be carried out on the LNG arrangements but these are not primarily intended to be applicable to Inland Waterways Vessels. The object of this HAZID is to ensure that all hazards associated with LNG and methane gas and in particular those relevant to inland waterways vessels are considered and that an equivalent level of safety to a conventional diesel fuelled vessel is achieved.

The HAZID report will form part of the approval documentation required for Classification of the vessel by Lloyd’s Register and acceptance of the vessel by the National Authorities for use on Inland Waterways.

The HAZID will take the form of a round the table discussion by all stakeholders involved in the project. The discussions will be led by a project facilitator using guidewords as detailed below.

Project team

Project facilitator from Lloyd’s Register.
Representatives from :-
Lloyds Register.
Ship owner/operator.
Shipyard.
Port authority.

A full list of attendees will be included in the HAZID report.

Applicable codes and standards

LR Rules for Inland Waterways vessels
LR Rules and Regulations for Ships
LR Rules for Methane Gas Fuelled Ships
IEC 60092: Electrical installations in Ships
IEC 60079-1: Electrical apparatus for explosive atmospheres
IMO MSC86(26) Interim Guidelines for gas fuelled ships
IMO MSC Circ285.

Novel or alternative design

The novel design features for this vessel are concerned solely with the LNG storage, processing and distribution systems. The propulsion engines are duel fuel and therefore if the LNG system fails, propulsion and steering can be maintained by switching over to diesel fuel. The conventional machinery arrangements will not form part of this study.

Risk management

The HAZID id scheduled for 2 days and will address the following :-

a) The safety of the shipboard LNG machinery and systems.
b) The safety of shipboard personnel
c) The reliability of essential machinery and systems.

d) The environment.

The procedure will consider the hazards associated with installation, operation, maintenance and disposal, both with the machinery system functioning correctly and following any reasonably foreseeable failure. A single failure of any piece of equipment will be considered.

Procedure for the HAZID

Before the HAZID it is necessary to establish the specific areas and systems that are considered outside the scope of existing Rules, non compliant with existing Rules or that are required to be addressed by stakeholders. An initial assessment of the plans indicates that these areas are :-

a) Tank design and arrangement.
b) Pressure build up and evaporator systems.
c) Bunkering arrangements.
d) Tank venting and ventilation of hazardous areas.
e) Gas valve unit arrangement.
f) Engine room gas related systems.

The following operating modes and ship conditions will be considered

Operational Modes

a) Underway
b) Docking
c) Alongside and maintenance
d) Commissioning and trials.

For the purpose of analysis the systems will be divided into the following Nodes.

Node 1. Storage tank and bunkering arrangement.
Node 2. Ventilation and hazardous areas.
Node 3 Pressure build up and gas distribution systems.
Node 4 Engine room systems
Node 5 External influences e.g. Fire/flooding

Ship conditions

a) Normal operation
b) Blackout
c) Deadship
d) Fire in a single compartment
e) Flooding in a single compartment

Modes of operation

a) Start-up
b) Running
c) Shutdown
d) Automatic
e) Reversionary
f) Emergency

To structure the discussions the following guidewords will be applied :

Leakage

Rupture
Corrosion/erosion
Impact
Fire explosion
Structural integrity
Mechanical failure
Control/electrical failure
Human error
Manufacturing defects
Material selection.

The guidewords will be applied in a systematic manner to the relevant plans and all comments, mitigating measures e.t.c. will be recorded in accordance with the following preliminary schedule.

Day 1.

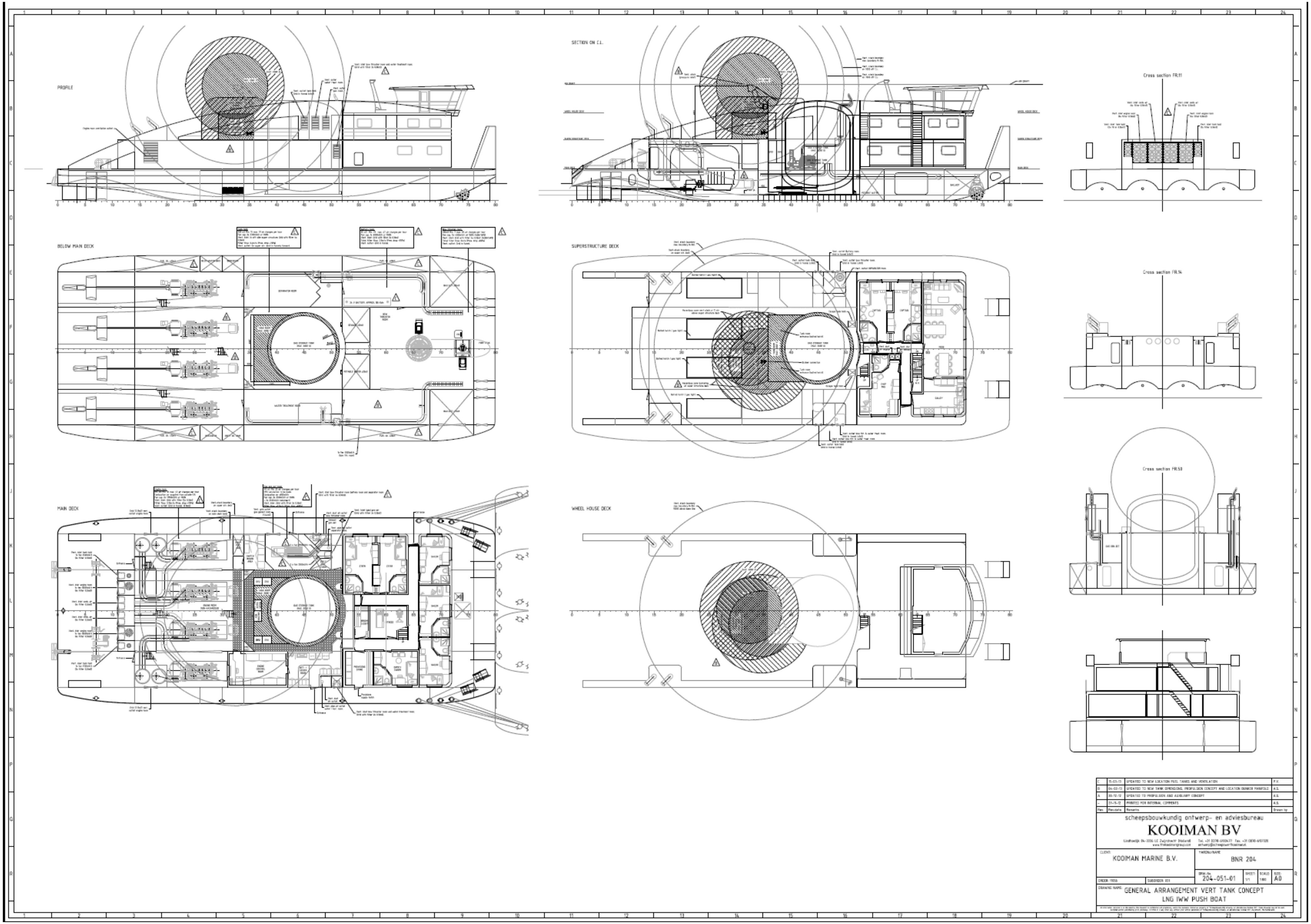
Node 1.
Node 2.

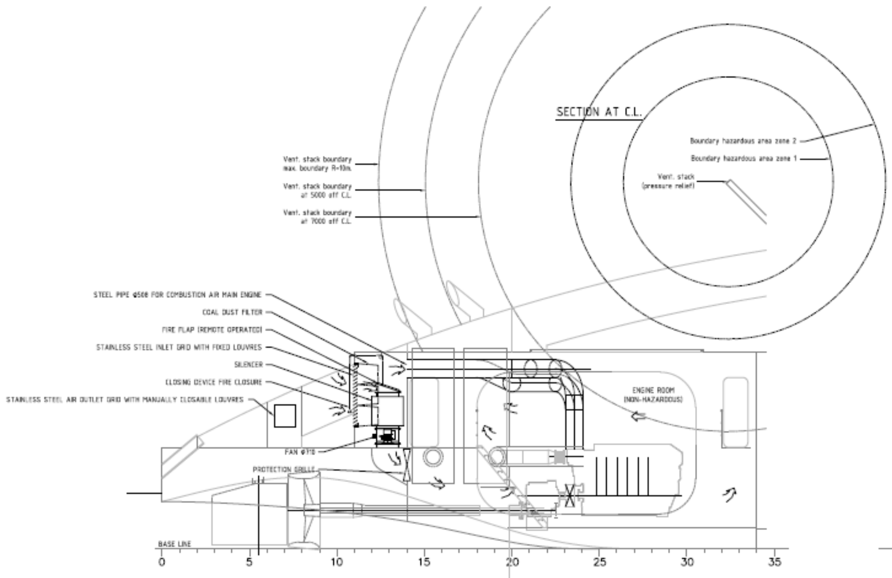
Day2.

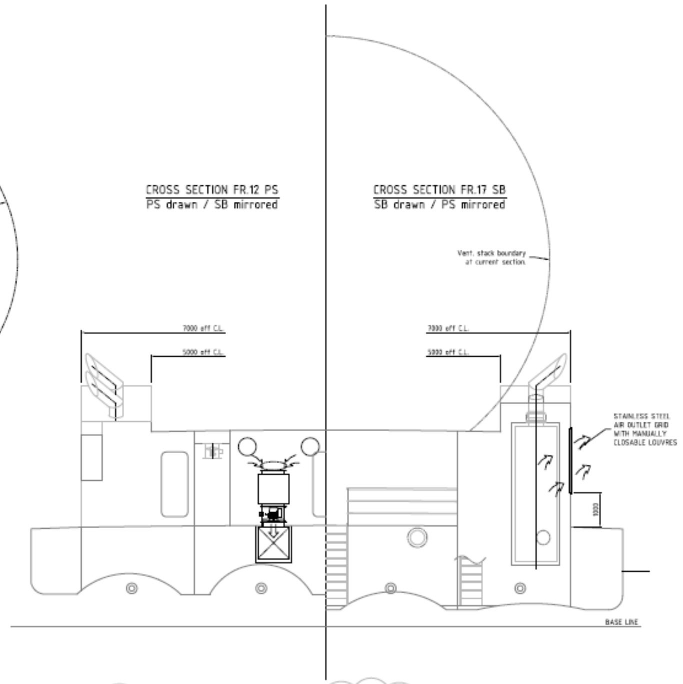
Node 3.
Node 4.
Node 5.

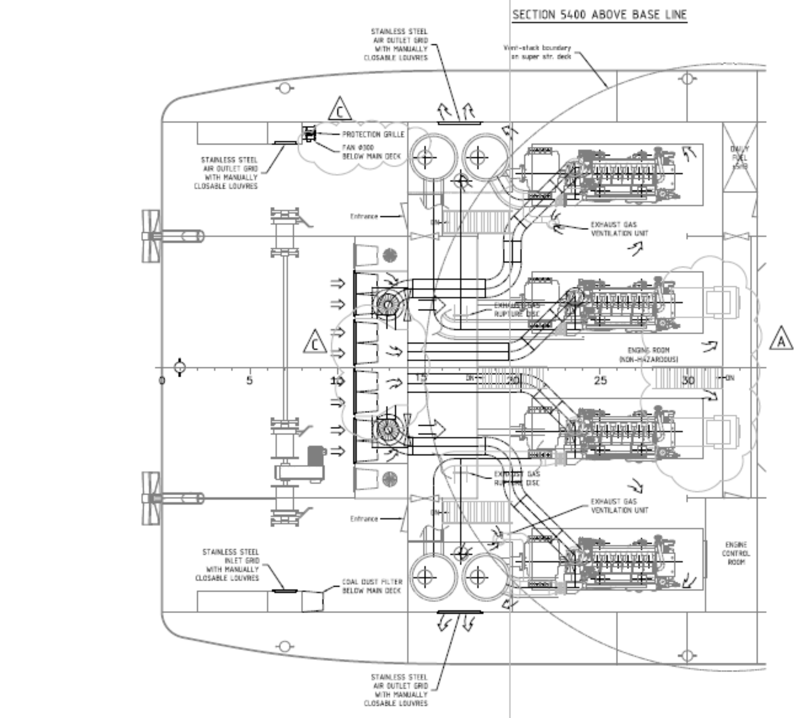
This schedule may need to be amended during the session depending on comments and issues raised.

APPENDIX 4. GENERAL ARRANGEMENT AND SYSTEM PLANS


PROFILE
SECTION ON C.L.
Cross section FR.11
BELOW MAIN DECK
SUPERSTRUCTURE DECK
Cross section FR.14
MAIN DECK
WHEEL HOUSE DECK
Cross section FR.50
C 15-03-13 UPDATED TO NEW LOCATION FUEL TANKS AND VENTILATION P.V.
B 04-02-13 UPDATED TO NEW TANK DIMENSIONS, PROPULSION CONCEPT AND LOCATION BUNKER MANIFOLD A.S.
A 30-12-12 UPDATED TO PROPULSION AND AUXILIARY CONCEPT A.S.
- 27-11-12 PRINTED FOR INTERNAL COMMENTS A.S.
Rev. Rev.date Remarks Drawn by
scheepsbouwkundig ontwerp- en adviesbureau
KOOIMAN BV
CLIENT: KOOIMAN MARINE B.V.
YARDNo/NAME: BNR 204
DRW.-No. 204-051-01
SIZE: A0
DRAWING NAME: GENERAL ARRANGEMENT VERT TANK CONCEPT
LNG IWW PUSH BOAT







Engine room

Space engine room 815m3
Combustion air through steel pipe approx separate from engine room ventilation. (max combustion air 100% load 29308 m3/h)

Fan cap. engine room 2x Φ710 - 2x 8750/17500m3/h - 2x 1.3/6.2kW
Air changes: min. 21x /h max. 43x /h

Vent. inlet: In aft side superstructure.
6x Inlet grid with filter (6x 0.36m2 filter per fan).
Air flow vent filter: 1.13/2.26m/s (Pres. drop <60/75Pa)
Air flow combustion air filter: 1.88m/s (Pres. drop <60/70Pa)

Vent. outlet: Grid in funnel (2.16m2) at main deck level.

Aft peak

Space aft peak: 145m3
Fan cap. 1x Φ300 - 2500m3/h - 0.55kW
Air changes: 17x/h

Vent. inlet: Aft deck inside arc at main deck level.
1x Inlet grid with filter below main deck.
Air flow filter: 1.9m/s - (Pres. drop <75Pa)

Vent. outlet: Grid in funnel (0.36m2) Aft deck inside arc at main deck level.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	GENERATORS ADDED TO MAIN ENGINES	PV
-	20-03-13	FIRST ISSUE ACCORDING GA 204-017-001 REV A	A.S.

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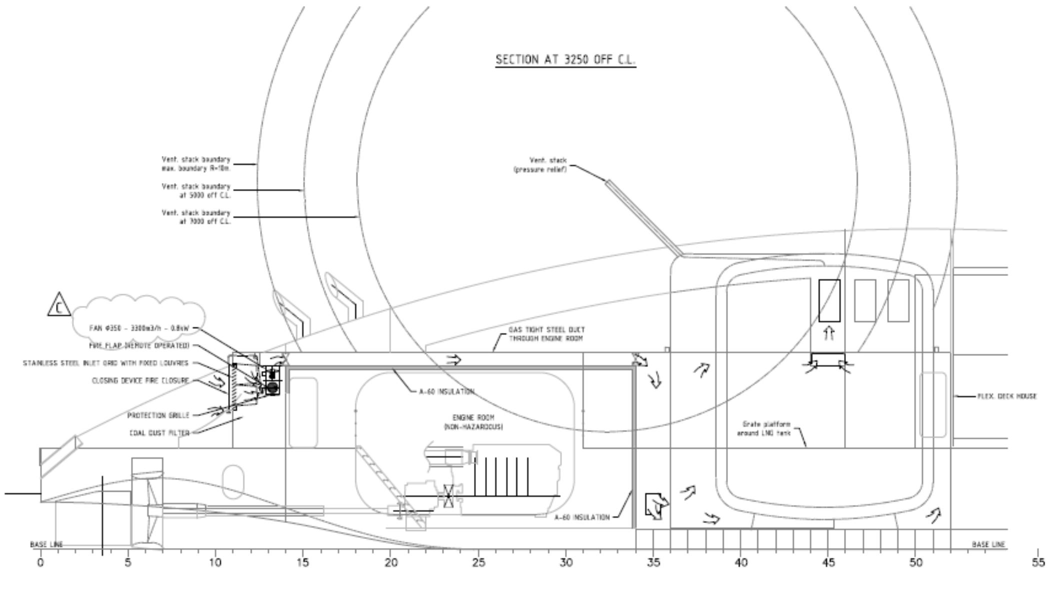
KOOIMAN BV

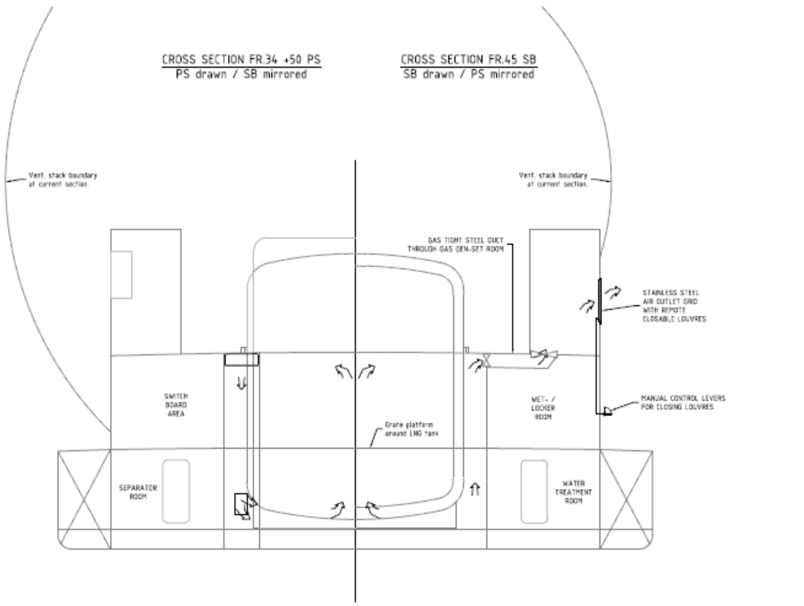
CLIENT: KOOIMAN MARINE B.V.

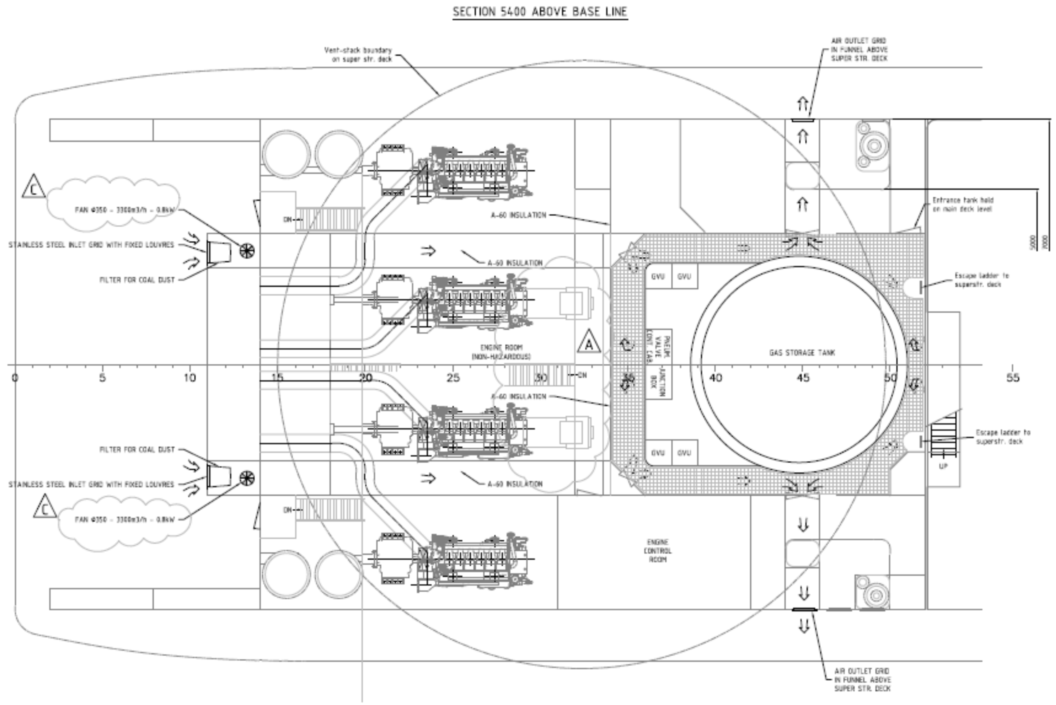
YARDNo/NAME: BNR 204

DRW-No. 204-409-001 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT
ENGINE ROOM / AFT PEAK







Tank hold (compartment)

Space tank hold (compartment) 209m3
Fan cap. 2x Φ350 - 2x 1650/3300m3/h - 2x 0.15/0.8kW
Air changes min. 15x/h max. 31x/h

Vent. inlet: In aft side super structure.
2x Inlet grid with filter (2x 0.36m2 filter per grid).

Filter flow: 1.2/2.4m/s (Pres. drop <60/<70Pa)

Vent. outlet: Grid in funnel (0.72m2) above super str. deck.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	GENERATORS ADDED TO MAIN ENGINES	PV
-	20-12-12	FIRST ISSUE ACCORDING GA 204-051-001 REV A	A.S.

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KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.

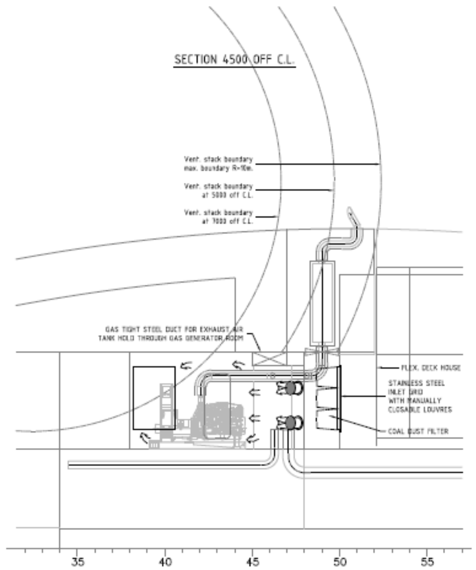
YARDNo./NAME: BNR 204

ORDER: 1856 | SUBORDER: 409

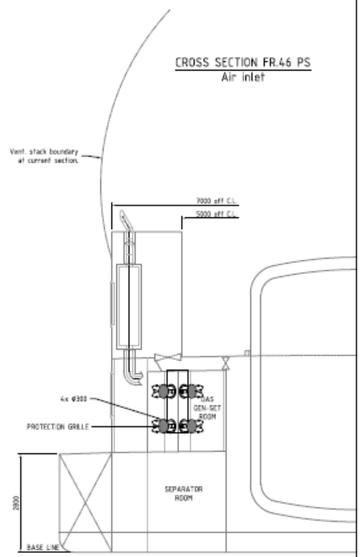
DRW-No.: 204-409-001 | SHEET: 2/5 | SCALE: 1:50 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT
LNG TANK HOLD

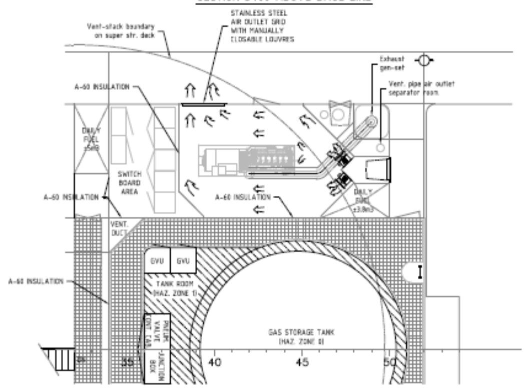
SECTION 4500 OFF C.L.



CROSS SECTION FR.46 PS
Air inlet



SECTION 5400 ABOVE BASE LINE



Ventilation Gas gen-set room "Gas-safe" principle

Min. 30 air changes per hour
Space is 49 m3 x 30 = 1463m3/h
Combustion air = 850m3/h
Total ventilation required = 2313m3/h

Ventilation amount and arrangement subject to CFD calculation

Fan cap. 2x Ø300 (=2x 1250/2500m3/h double speed fans) (2x0.55kW max)
and redundant extra 2x Ø300 (=2x 1250/2500m3/h double speed fans)
In total 4 fans installed. Fans in explosion proof execution

Vent. inlet: 1x Inlet grid with filter (3x 0.36m2).
Air flow filter: 1.3 m/s (Pres. drop <60Pa)

Vent. outlet: Grid in side wall superstructure (2.16m2) at main deck level.

Rev.	Rev.date	Remarks	Drawn by
C	15-03-14	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
-	20-10-13	FIRST ISSUE ACCORDING GA 204-010-001 REV A	A.G.

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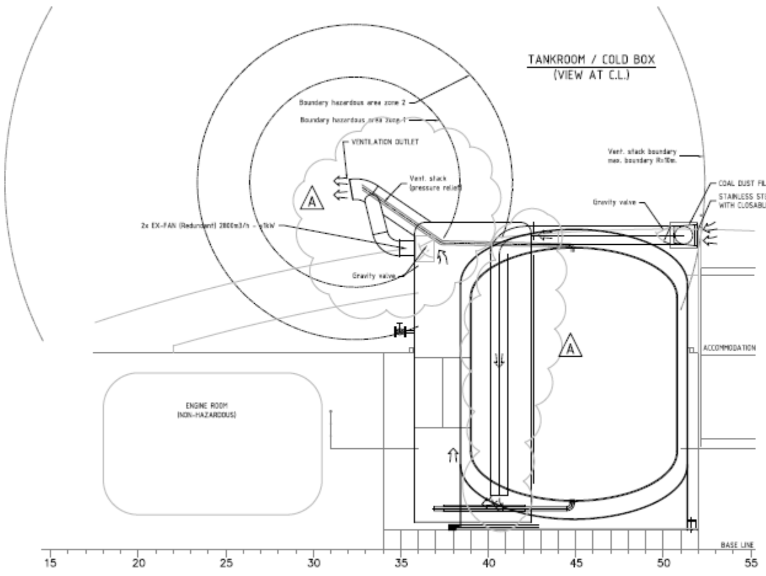
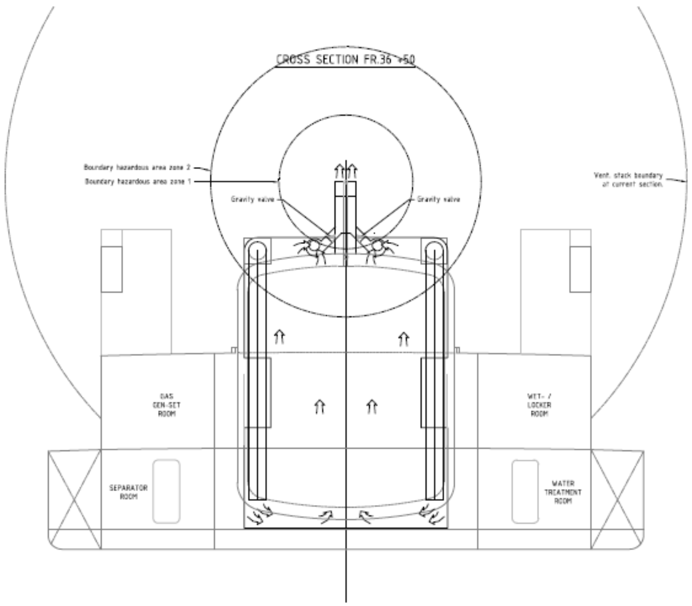
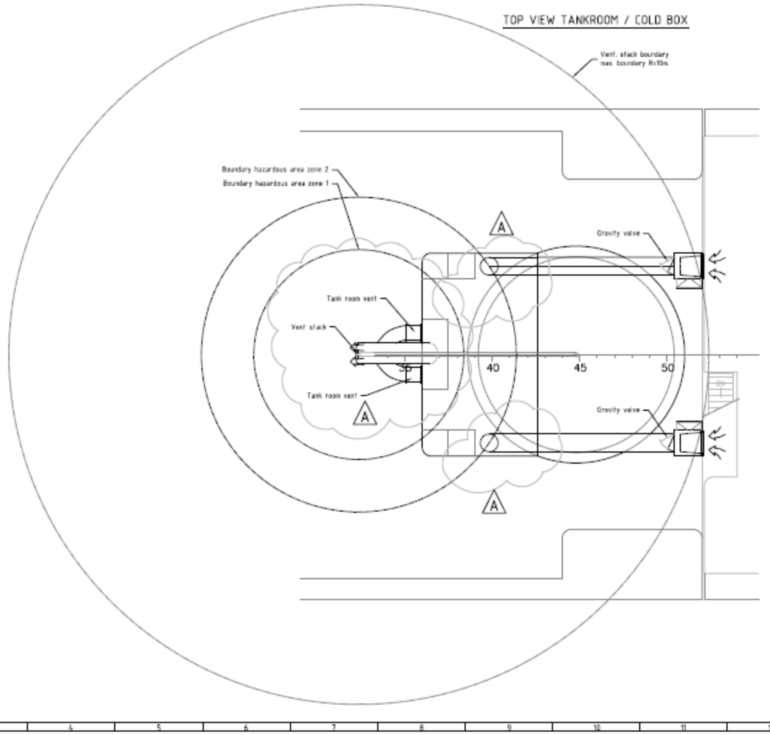
KOOIMAN BV

Client: KOOIMAN MARINE B.V.
Yardno/name: BNR 204
Drw.no.: 204-409-001 | Sheet: 1/1 | Scale: 1:50 | Size: A0
Drawing name: VENTILATION CONCEPTS LNG PUSH BOAT
GAS FUELED GENERATOR ROOM







Tank ROOM

Min. 30 air changes per hour
Space is 96 m3
Total ventilation required 2880m3/h

Fan cap. 1x Ø350 - 3300m3/h = 0.8kW
and redundant 1x Ø350 - 3300m3/h = 0.8kW extra
In total 2 fans installed Fans in explosion proof execution

Ventilation exhaust equiped with gravity valve that closes when fan is stopped

Vent. inlet: 2x Inlet grid with filter (1x 0.36m2 filter per grid).
Air flow per filter: 1.75m/s (Pres. drop <60Pa)

Vent. outlet: Around vent. stack. (Blow-off)

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	04-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	VENT STACK AND TANK ARRANGEMENT CHANGED	PV
-	20-12-12	FIRS ISSUE ACCORDING GA 204-031-001 REV A	A.S.

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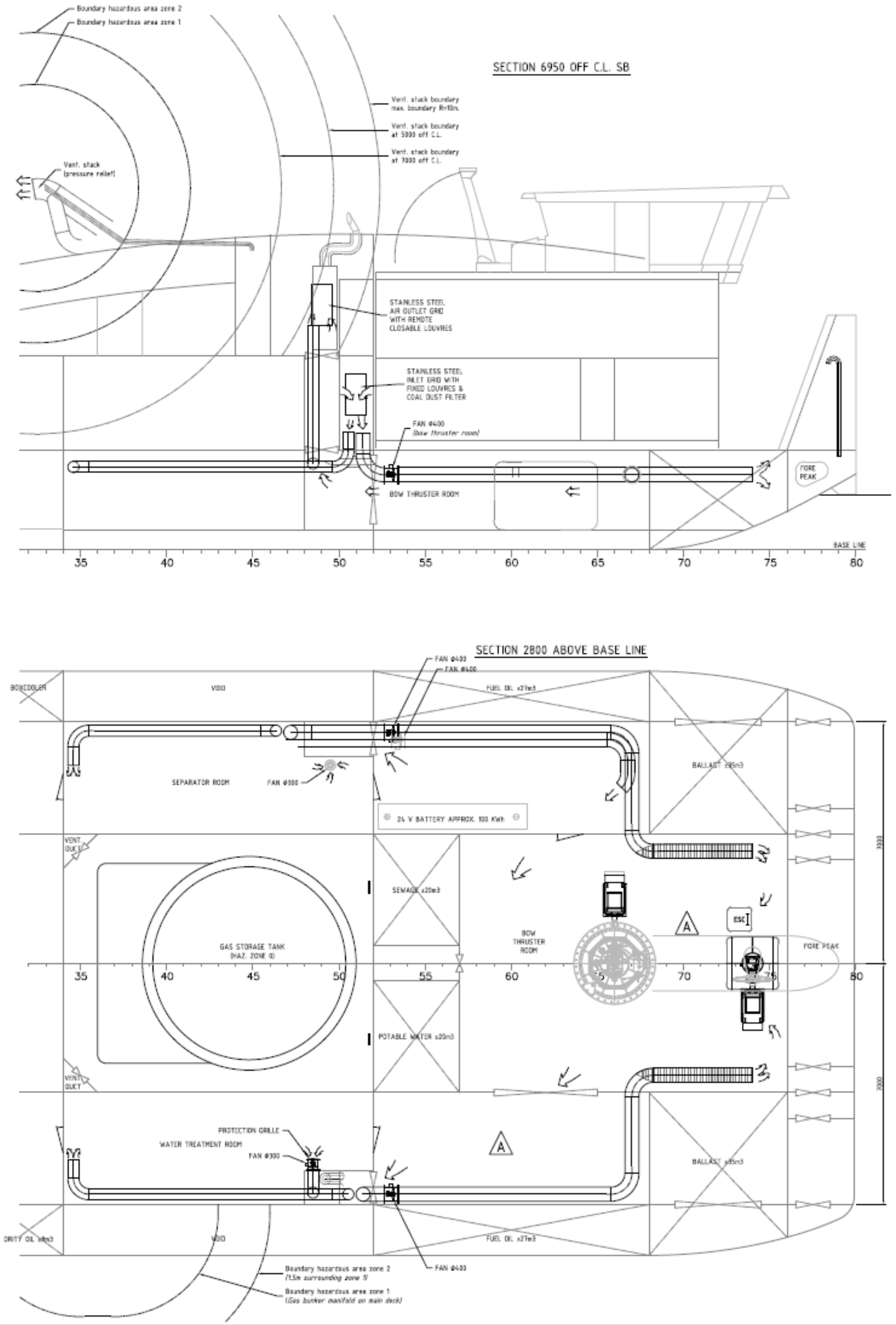
KOOIMAN BV

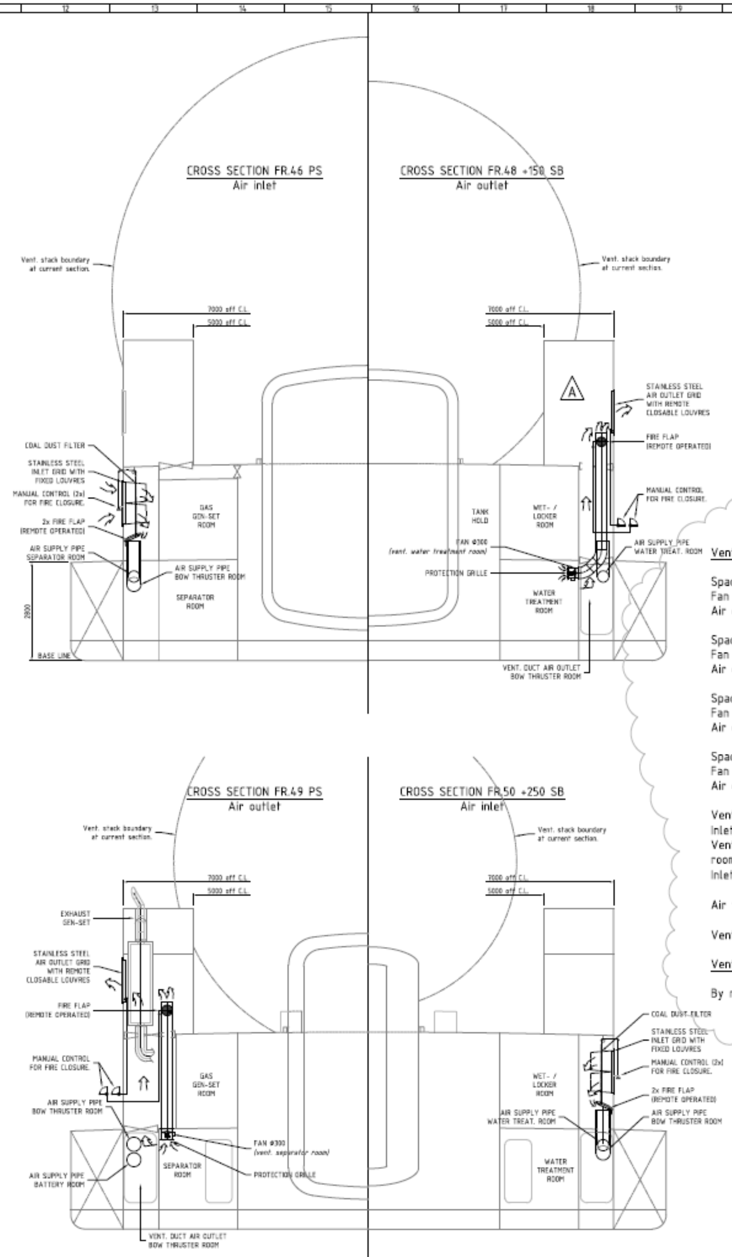
CLIENT: KOOIMAN MARINE B.V.

YARDNo/NAME: BNR 204

DRW-No. 204-409-001 | SHEET 4/6 | SCALE 1:50 | SIZE A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT
TANK ROOM / (COLD BOX)





C

Ventilation bow thruster room / separator room / water treat. room

Space bow thruster room 280m3
Fan cap. bow thr. room: 2x Φ400 - 2x 2000/4000m3/h - 2x 0.23/1.1kW.
Air changes bow thruster room min. 7x/h max. 28x/h

Space watertreatment room 90m3
Fan cap. water treatment room: 1x Φ300 - 1250/2500m3/h - 0.11/0.55kW.
Air changes water treatment room: min. 13x/h max. 27x/h

Space separator room 90m3
Fan cap. separator room: 1x Φ300 - 1250/2500m3/h - 0.11/0.55kW.
Air changes separator room: min. 13x/h max. 27x/h

Space battery room 85m3
Fan cap. battery room 1x Φ400 - 2000/4000 m3/h -0.23/1.1kW.
Air changes battery room: min. 23x/h max. 47x/h

Vent. inlet SB = Air supply bow thruster room & water treatment room.
Inlet grid with filter (2x0.36m2 filter per grid).
Vent. inlet PS = Air supply battery room, bow thruster room & separator room.
Inlet grid with filter (3x0.36m2 filter per grid).

Air flow over filters filter: 0.63/2.9m/s (Pres. drop <60/<95Pa)

Vent. outlet: Grid in funnel (0.72m2) above super str. deck.

Ventilation fore peak

By natural ventilation. Vent. openings in push horns.

Rev.	Rev.date.	Remarks	Drawn by
C	15-03-13	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	06-03-13	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
A	04-03-13	STAND BY GENERATOR AND ITS EXHAUST REMOVED	PV
-	26-02-13	FIRS ISSUE ACCORDING GA 204-037-001 REV A	A.S.

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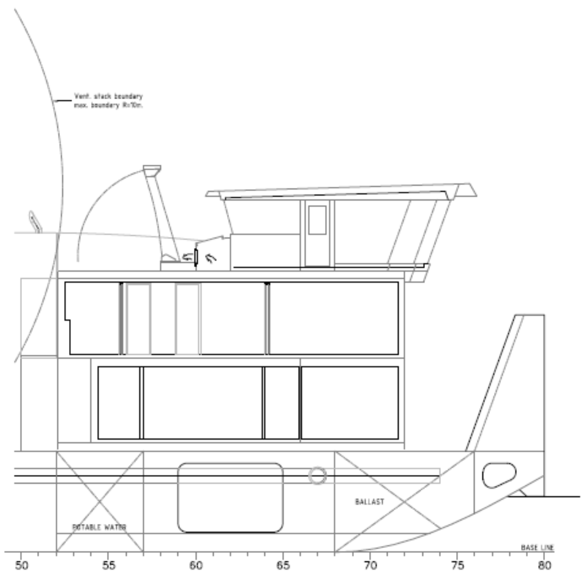
KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.

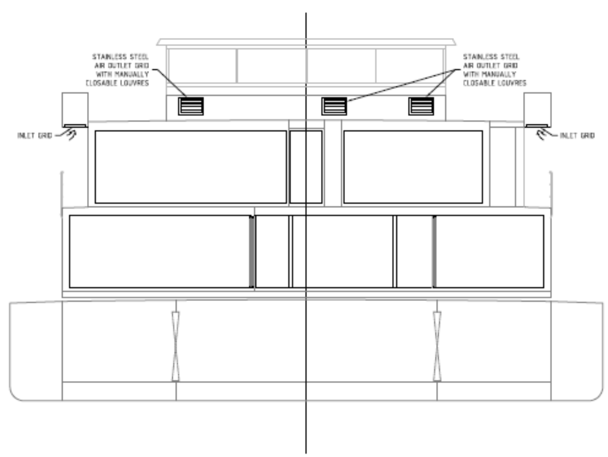
YARDNo/NAME: BNR 204

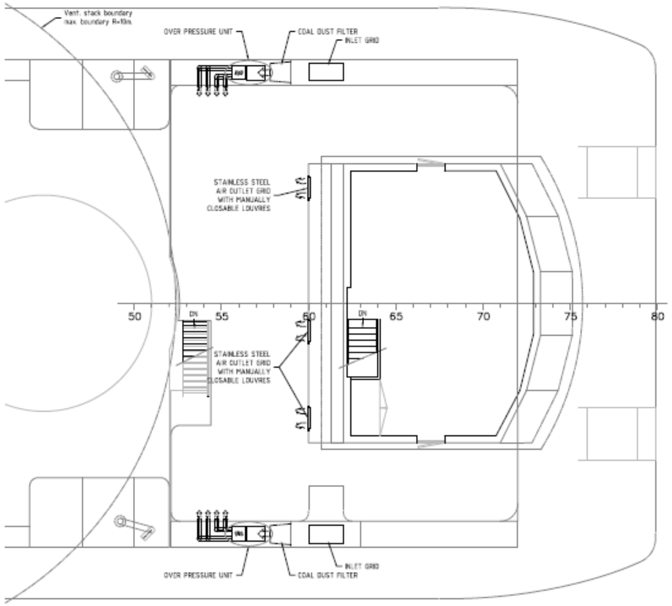
DRW-No. 204-409-001 | SHEET: 5/5 | SCALE: 1:50 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT FORE SHIP



CROSS SECTION FR.60





Accommodation

Over pressure unit (with fan, heater, gas detector and gravity valve.) in extended boxes
SB + PS.
Air supply through ducts above ceiling to all accommodation spaces.

Air intakes equiped with gravity valve that closes when fan has stopped.

Vent. inlet: In bottom side extended boxes of flexible superstructure.
2x Inlet grid with filter (1x 0.36m2 filter per grid).

Vent. outlet: Grid behind wheelhouse.

C

Rev.	Rev.date.	Remarks	Drawn by
C	[illegible]	UPDATED WITH GENERAL ARRANGEMENT REV C AND INFO FOR HAZID	PV
B	[illegible]	UPDATED WITH GENERAL ARRANGEMENT REV B	PV
-	[illegible]	FIRST ISSUE ACCORDING GA 204-031-001 REV A	A.S.

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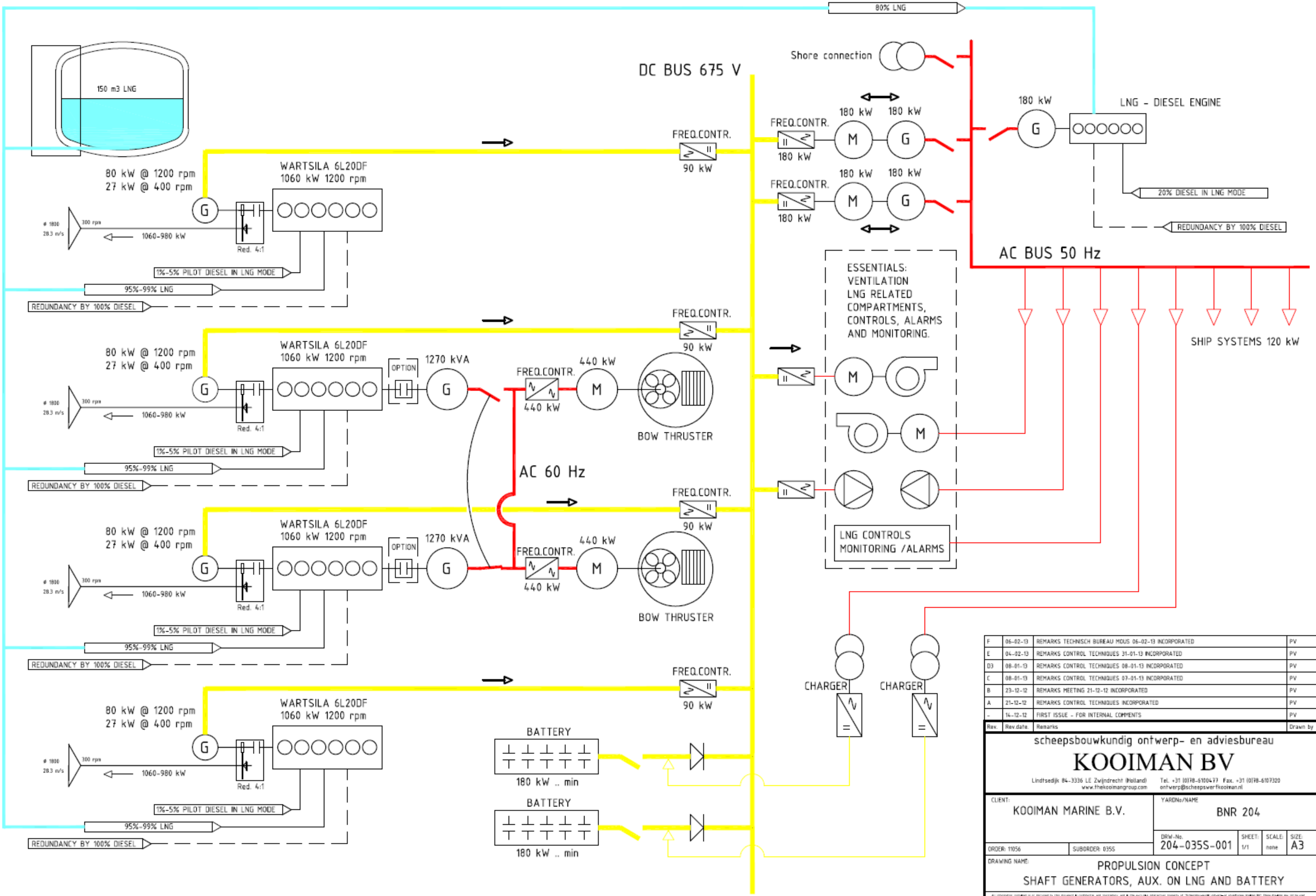
KOOIMAN BV

CLIENT: KOOIMAN MARINE B.V.

YARDNo./NAME: BNR 204

DRW-No.: 204-409-001 | SHEET: 6/6 | SCALE: 1:50 | SIZE: A0

DRAWING NAME: VENTILATION CONCEPTS LNG PUSH BOAT ACCOMMODATION



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C	08-01-13	REMARKS CONTROL TECHNIQUES 07-01-13 INCORPORATED	PV
B	23-12-12	REMARKS MEETING 21-12-12 INCORPORATED	PV
A	21-12-12	REMARKS CONTROL TECHNIQUES INCORPORATED	PV
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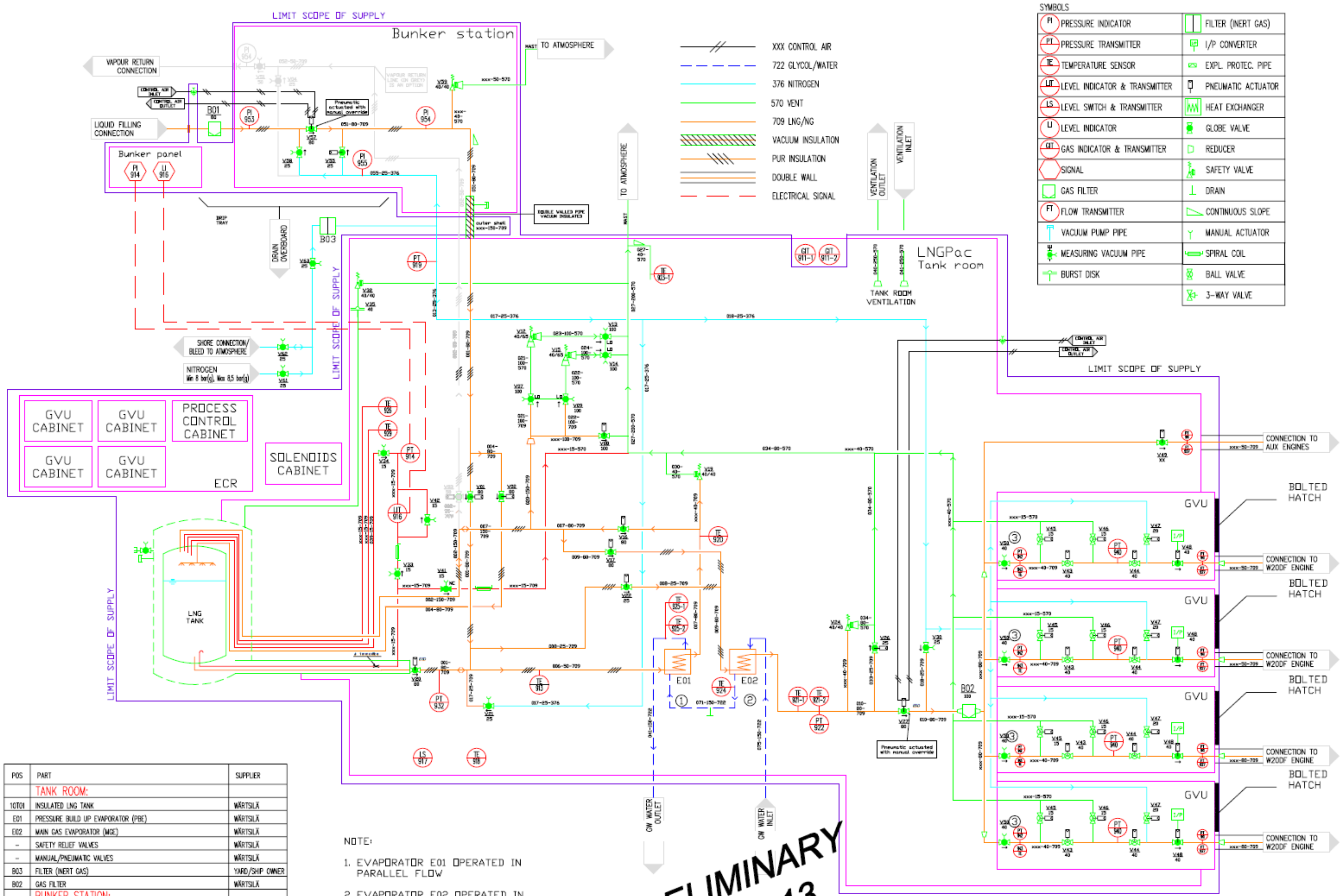
SHAFT GENERATORS, AUX. ON LNG AND BATTERY



POS	PART	SUPPLIER
	TANK ROOM:	
10T01	INSULATED LNG TANK	WÄRTSILÄ
E01	PRESSURE BUILD UP EVAPORATOR (PBE)	WÄRTSILÄ
E02	MAIN GAS EVAPORATOR (MGE)	WÄRTSILÄ
-	SAFETY RELIEF VALVES	WÄRTSILÄ
-	MANUAL/PNEUMATIC VALVES	WÄRTSILÄ
B03	FILTER (INERT GAS)	YARD/SHIP OWNER
B02	GAS FILTER	WÄRTSILÄ
-	BUNKER STATION:	
-	MANUAL/PNEUMATIC VALVES	WÄRTSILÄ
-	SAFETY RELIEF VALVES	WÄRTSILÄ
B01	GAS FILTER	YARD/SHIP OWNER

NOTE:

1. EVAPORATOR E01 OPERATED IN PARALLEL FLOW
2. EVAPORATOR E02 OPERATED IN COUNTERFLOW
3. VALVE V50 IS MANUALLY OPERATED FROM OUTSIDE OF THE GVU ENCLOSURE

WÄRTSILÄ

Product: Wärtsilä Oil & Gas Fuel Gas Handling

LNGPac System
P&I Drawing
Future Push Boat

Drawing ID: DAARxxxxxx

Made 18.01.2013 EDU003 D'Urso

Size A1, Page 1/1

Annex no. 2

BNR 204 Noncompliance of IGF code for the design of a LNG fuelled push boat (IMO-Resolution MSC.285(86) (1th June 2009))

IGF-code	Situation LNG fuelled push boat	See BNR 204 Specification and Design Concept
1.1.2. Link to Solas	For an IWW vessel Solas is not applicable	
2.8.1.2 Pipe connections to the tank normally mounted above highest liquid level.	Not all pipe connections to the tank are above highest liquid level.	See 5.3.2
2.8.1.4 Outlet from pressure relief valves located at least 6m or B/3 (whichever is the greatest) above weather deck	Outlet pressure relief valve is 4.87 m above weather deck This is > 2 m required by ADN for vents of dangerous cargo tanks. The outlet of the pressure relief valves will be combined with the (redundant) exhaust air of the tank room ventilation to ensure proper and upstream flow and mixture in case of gas ventilated.	See 5.3.6 and 5.9
2.8.3.4 Drip trays below the tank (and tank filling station)	A stainless steel drip tray will be executed at the tank filling station on superstructure deck. Large enough to contain a volume that might escape in the event of a filling pipe / hose connection failure. From this drip tray a drain to water level beside the vessel The outer tank construction (stainless steel) can contain the volume of liquid that escapes in an event like a pipe rupture of the (welded) pipe penetration to the inner (depressurized) tank. The stainless steel tank room (cold room) can contain the LNG volume that can escape in the event of a pipe rupture in the tank room. (leakage will be detected by gas, temperature and level indicators and main tank valve will shut down immediately)	See 5.3.1 ; 5.3.3 ; 5.7.1 ; 5.7.2
2.8.4.2 Distance LNG gas storage tank to bottom plating to be the lesser of B/15 and 2 m	The distance from bottom plating to outer storage tank vessel is 760 mm The distance from bottom plating to inner storage tank vessel (pressure vessel and actual LNG tank) is 1360 mm (B/15 < 1200 mm). The required distance of a gas tank in an IWW ADN G-tanker = 600 mm	See 5.3.1

This document will indicate the principles for bunkering.

In this stage of the design it is not possible to produce a detailed procedure for bunkering in which all valve numbers, settings and sequences can be addressed, but this document will indicate the principles for bunkering.

The bunkering will be done either at a fixed shore based filling station moored alongside a jetty on which a bunker arm is placed, or the push boat will be bunkered by a bunker vessel at a proper location where push boat and bunker vessel both will be moored rigidly alongside a quay.
Bunkering whilst sailing will not be considered as a possible option.
In principle the bunkering procedure alongside a fixed shore based filling station or out of a bunker vessel will not deviate from bunkering out of a truck.
The vessel will be equipped for, and it will be possible to bunker out of a truck but the amount of LNG (145 m3 = 4x LNG truck) and the allowed time for bunkering (pump capacity) require either a shore based bunker station with a jetty for birthing or stationary bunker vessel .

The bunkering needs great attention and need to be done in the most possible safety precautions.
The following procedures shall be followed closely:

It is a must that there will be an interface by terms of an electronic connection (redundant cables optic and hard wired) between ship and shore based or floating bunker installation.
From both sides the process can be monitored, controlled and stopped.

Before the bunkering activity starts the Ports Authority needs to be informed and they need to give permission for bunkering. The authority may demand for extra safety precautions. The authority's approval for the bunker transfer must be available before bunkering has started.
As long as the Port Authority has no rules or regulations for bunkering LNG the following regulations can be taken as guidance:

- General bunker procedures for bunkering oil fuels
- Precautions and procedures for loading and discharging IWW tank vessels with ADN goods

Before bunkering warning signals should be placed and the bunker check list needs to be filled in and signed by the responsible persons of the vessel and the bunker installation.
All items of the check list should be indicated as OK and the amount of LNG, the flow rate, temperature, pressure of the LNG to be bunkered should be determined and approved by the responsible persons of the vessel and the bunker installation. As the bunker station has received all necessary documentation, transfer can commence.

During filling at least the following items should be checked constantly:
Filling hoses, connections and piping on leakages
Mooring lines
Forces on bunker connection

Tank pressure, which can be controlled by use of top filling spray facility (a vapour return is not required)
Liquid level in the tank

After the filling of the tank:
And the filling line is purged according the procedure, the filling hose is disconnected, the interface cables are disconnected and all safety signs removed, the Port Authority needs to be informed that the bunkering is finished.

Special equipment for safe bunkering that will be available on board and will be part of the bunkering procedure.

- Warning signs to be placed where indicated by procedure
- Personal safety equipment like , helmet, gloves, glasses, shoes, jackets, overall.
- Explosion prove communication.
- Special spark free tools for bunker connection.
- Ultra short filling pipe and bunker valve connection out of the cold room so 99% of the filling line is located inside the cold room.
- Purge connection just behind the bunker valve connection to be able to purge the filling line with nitrogen after the LNG supply has been stopped
- Stainless steel drip tray under bunker connection on top deck with stainless steel pipe connection to waterline.
- Interface push boat to bunker station, this is a safety link for small scale LNG transfer and LNG fuelling. This interface enables operators (ship and shore based) to monitor both sides of the transfer process to ensure measurements remain within safe criteria. The instruments can be used safely in the gas- hazardous zone. The connections are executed redundant primary by a fibre optic umbilical cable and secondary by a electric umbilical cable.
- Fixed gas detection and portable gas detection
- Spray safe location at top deck level beside the bunker station to accommodate the bunker operator and instrument and control panel
- CCTV connection to monitor the bunkering from wheelhouse and Engine Room Control station
- Water spray lines and connections

Appendix A (template)

Liquefied natural gas bunker checklist	
Precautions and appointments made for transfer of liquefied natural gas	
- Vessel's particulars .... (Vessel's name)	.... (European vessel identification number)
- Truck's, Bunker vessel's or Plant's particulars .... (Company name)	.... (Plate number)
- Bunker location .... (Address) .... (Date)	.... (Place) .... (Time)
Liquefied natural gas related particulars	
Quantity in m^3:	
Emergency procedure	
Filling must be stopped immediately in case of any leakage. All valves have to be set in their safe position. A red flashlight on the vessel will indicate the abnormal situation described. The truck driver will stop the liquefied natural gas transfer immediately. All personnel will evacuate the bunker area immediately in accordance with the safety rota.	

The start of the liquefied natural gas transfer is only allowed if all questions raised on the following checklist are answered 'yes' and both responsible persons have signed the list.

If one of the questions cannot be answered 'yes', liquefied natural gas transfer is **NOT** allowed.

Liquefied natural gas bunker checklist			
		Vessel	Truck / Bunker vessel / Bunker Plant
1.	Is the competent authority's permit for the liquefied natural gas transfer in the designated area available?	○	--
2.	Are the requirements of local regulations and of the competent authority met?	○	--
3.	Is the competent authority informed that liquefied natural gas transfer will be commenced?	○	--
4.	Is the vessel well moored?	○	--
5.	Is the lighting, both on the truck / bunker vessel / bunker plant and on the vessel (bunker manifold and escape routes), sufficient and in good working order?	○	○
6.	Are the signs, that designate the safe area around the tank truck / bunker vessel / bunker plant on the shore, placed?	--	○
7.	Are all for any possible leakage necessary drip-trays placed and is the water spray installation for immediate use available?	○	--
8.	Is the liquefied natural gas transfer hose properly supported and are there no extreme forces or stress on the hose?	○	○
9.	Are the liquefied natural gas transfer hose and break away coupling in good condition?	○	○
10.	Is the ground cable connected in the right way?	--	○
11.	Are all means of communication between truck / bunker vessel / bunker plant, bunker manifold and wheelhouse checked and in working condition?	○	○
12.	Are all safety and control devices on the liquefied natural gas installation checked and in good working order?	○	--
13	Is the amount of liquefied natural gas that will be transferred agreed?	○	○
14.	Do the ordered liquefied natural gas specifications apply on the delivered liquefied natural gas specifications?	○	○
15.	Is the emergency stop procedure discussed with, and understood by, the truck driver / bunker vessels captain or plant operator?	○	○
16.	Is there a liquefied natural gas quality certificate available?	○	○
17.	Has the crew been informed that the liquefied natural gas transfer has commenced?	○	--
18.	Is for the whole time of the filling or emptying of the liquid natural gas storage tank a continuous supervision by the responsible persons of the vessel and the truck / bunker vessel / bunker plant ensured?	○	○
19.	Are there suitable means of escape in case of emergency available?	○	

Checked and signed:

Vessel's responsible person:	Tank truck's / bunker vessel's / bunker plant responsible person:
.... (Name in capitals)	.... (Name in capitals)
.... (Signature)	.... (Signature)

Annex no. 4 BNR 204 Training programme crew and technical staff

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A. General:

The purpose for training crew and technical staff of IWW vessels is that they will become familiar with the properties and hazards of LNG and hat they gain knowledge over how to deal with LNG as fuel on board of a ship e.g. under operational circumstances, during bunkering and at maintenance.

The overall training consist of a theoretical part and an on board practical training in which part the crew will be trained in the real life circumstances with dedicated procedures for that specific LNG fuelled ship.

The content and training programme will be made in close contact with the Authorities involved and will be repeated every 2,5 years.

After passing an final test successfully the trainee will get a certificate by the training institute.

(Chief) Engineers and technical staff of the operating company will get extensive training for more detailed knowledge by the deliverer of main engines and DF generator and the LNG Pack.

B. LNG Training

The minimum standard **theoretical** LNG training for crew and technical staff will contain the following items:

1 Legislation:

1.1 General legislation, best practise for ADN, ROSR, Guide lines 2006/87/EG and new developments.
1.2 Available international legislation for LNG (seagoing vessels, best practice) IMO IMDG and new developments.
1.3 Class rules
1.4 Legislation health and safety
1.5 Local rules and permissions
1.6 Recommendations according ADN and ROSR

2 **Principles of LNG:**

2.1 Definition of LNG critical temperatures, LNG hazards, atmospheric circumstances.
2.2 Mixtures and properties of LNG and LNG quality certificates
2.3 SID (Safety Information Documentation) Physical properties and product specifications
2.4 Environmental properties

3 Safety:

3.1 Hazards and Risks
3.2 Risk management
3.3 Use of personal safety equipment

4 LNG and Technics:

4.1 General layout
4.2 Explanation effects of LNG
4.3 Temperature and pressure
4.4 Valves, automatic actuators, ATEX
4.5 Alarm systems
4.6 Materials (hoses, pressure relief valves)
4.7 Ventilation

5 Operation and testing the LNG system:

5.1 Daly maintenance
5.2 Weekly maintenance
5.3 Periodic maintenance
5.4 Breakdown and failures
5.5 Documentation of maintenance

6 Bunkering of LNG:

6.1 Bunkering procedures
6.2 Purging the LNG system
6.3 De-pressurizing the LNG system
6.4 Draining the tank
6.5 Check lists and certificates for bunkering

7 Measures to be taken for maintenance of the vessel:

7.1 Gas free certificate
7.2 De-pressurizing, purging the LNG system before docking.
7.3 Inerting the LNG system
7.4 Procedure for draining the LNG storage tank
7.5 First filling and cooling down the LNG system
7.6 Start up after docking

8 Emergency procedures:

8.1 Emergency plan
8.2 LNG spill on deck
8.3 LNG human skin contact
8.4 LNG spills in open air
8.5 LNG spills in enclosed spaces (electrical installations)
8.6 Fire on deck close to LNG storage tank
8.7 Fire in engine rooms / generator room
8.8 Specific hazard concerning ADN goods
8.9 Grounding of the vessel

The minimum standard **practical** LNG training for crew and technical staff on board will contain the following items:

9 Practical training on board:

9.1 Become familiar with the on board manuals especially for LNG related items.
9.2 Check of safety awareness and the use of safety equipment for LNG
9.3 Knowledge about controls, operation and alarm systems LNG related items on board
9.4 Knowledge concerning maintenance and control procedures for the LNG installation
9.5 Knowledge and getting familiar with bunkering procedure
9.6 Knowledge about maintenance procedures for docking
9.7 Knowledge about emergency procedures.

Annex no. 5

SPECIFICATION
AND
DESIGN CONCEPT
of a
DUAL FUEL PROPELLED 4240kW IWW PUSH BOAT

BNR 204   KOOIMAN MARINE B.V.
October 2013

SCHEEPSBOUKUNDIG ONTWERP EN ADVIESBUREAU KOOIMAN B.V.
LINDTSEDIJK 84, 3336LE ZWIJNDRECHT
THE NETHERLANDS

Contents

1. GENERAL

1.1 General Description

The push boat will be designed for pushing 2, 4 and 6 barges of the Europe II type (2800 Ton 76,50x11,40 m).
Based upon the existing push boats operating in the 6 barge service at the Rhine river the minimum required propulsion power is 4080 kW and the minimum required bow thruster power is 800 kW.

The push boat will be designed, build and equipped to meet the expected environmental requirements of the CCR (Centrale Commisie voor de Rijnvaart) for Fase IV engines to become effectuated in 2016.
NOx emissions: max. 1,8 g/kW/h
Particles emissions: max. 0.045g/kWh

1.2 General Description Design Approval Procedure

The push boat has to meet the rules and regulations for Inland Water Way Vessels as been given by R.O.S.R and A.D.N.
But either R.O.S.R as well as A.D.N do not allow fuels with a flame point below 55^{o} C.
Installations that do not comply with the rules should be proposed to CCR and ECE/VN and can be approved if the alternative installations are proven to be at least as safe as the conventional installations that do meet the R.O.S.R. regulations.
So it must be demonstrated that the alternative installations are as safe as those on a ship with diesel propulsion.

Lloyd's Register and Dutch Ministery of Infrastructure and the Environment agreed upon a procedure to check the LNG installation with existing rules and legislation as far as practical. (like IGF code IMO- resolution MSC. 285(86) and Lloyd's draft rules and regulations for the classification of LNG fuelled ships)

As part of the approval the safety of the LNG systems and ships design Concept are judged in a Hazid Study in which the if- than technique is followed as mentioned in the IMO-Resolution MSC.392 appendix 3 part 5.

This has brought us to the following stages of the design and approval program.

1. Kooiman's Design and Concept proposal submitted to Class and checked by Lloyds.
2. Design and concept proposal worked out into a more detailed design to meet the requirements of Owner, Class, Regulatory bodies.
3. The hazardous situations possibly able to occur in relation with the design and installations are investigated by a hazard identification (HAZID study executed by Lloyds resister and witnessed by TNO.
4. The risks and recommendations to cover these risks are written down in a Hazid report and Lloyds have made a log file in which the recommendations and the solutions (technical and operational) will be recorded.
5. The recommendations out of the Hazid study will be incorporated in the final design which will be submitted in detail to Lloyds Plan Approval department for final approval. (Procedures for use and maintenance of ship systems will be part of the approval procedures)
6. The vessel will be build and equipped under supervision of Lloyds Register and Class will be maintained during ships life time.
7. The crew and technical staff will be trained to operate the vessel and its installations in a safe an efficient way using the approved procedures.
8. After commissioning vessels operations and performance will be monitored and reported.

(Writing this specification in April 2013 we are working on the details of stage 5.)

Working according the above mentioned system we came up to the following specifications of ship and systems:

1.2 Main Particulars

Length over all: 40 m

Because of the total convoy length is not to be more than 269,5 x 22,90 m upstream in operational area Rhine Maasvlakte – Duisburg and 193 x 34,35 m downstream, (see Rijnvaart Politie Regelement) the push boat's length is maximized to 40 m.

Beam:

The beam will be in between 17 and 18 m wide. The final beam will be determined after all weights are final and the hull shape is determined.

Height: 2,80 m

Draught: 1,60 m at minimum amount of consumables.

Air draught: 9,00 m above waterline

1.3 Classification, Government and Other Regulations

- Regelement betreffende Onderzoek Schepen op de Rijn. (ROSR) (1 man radar operation)
- Lloyds Registers Rules and Regulations for the Classification of Inland Waterways Ships.
- Lloyds Registers Rules and Regulations for the Classification of Natural Gas Fuelled Ships.
- Interim Guidelines on Safety for natural gas-fuelled engine installations in ships (Resolution MSC.258(86) as adopted on 1 June 2009)
- Rijnvaartpolitieregelement. (RPR)
- Binnenvaartpolitieregelement. (BPR)
- Regulations Binnenschifffahrts Berufsgenossenschaft (BSBG)
- European Agreement Concerning the International Carriage of Dangerous Goods by Inland Water Ways (ADN) – Volume I & II, issued 01-01-2011.

The vessel will meet the Stability regulations (damaged and intact conditions) as given in Part 9: 9.1.0.93-94 and 95 IWW ADN rules for the construction of dry cargo vessels containing ADN goods.

1.4 Operational area and ship speed.

Operational area is: Inland Water Ways; Rhine, side rivers and canals as far as allowed within the several convoy and single boat dimensions.

Sailing speed through water:

Maximum	16.5 km/hr.	(Realistic speed 13-14 km/hr.) for the single push boat.
Minimum	13 km/hr.	for any convoy sailing the Rhine
Maximum	19 km/hr.	for a 6 barge loaded convoy. (3 x 2 barges)
Maximum	20 km/hr.	for a 6 barge empty convoy. (2 x 3 barges)
Maximum	20 km/hr.	for a 2 and 4 barge loaded convoy.
Maximum	22 km/hr.	for a 2 and 4 barge empty convoy.

1.5 Crew

The push boat will be build and equipped to sail 24 hours continuously and the crew will exist of:

- 2 Captains
- 2 Steersmen (navigating officers)
- 1 Chief engineer
- 2 Deck hands.

Crew changes normally every 2 weeks.
The crew will be properly trained for sailing a LNG fuelled vessel.

1.6 Voyages and Bunkering

The main voyages of the vessel will be sailing from Rotterdam (Maasvlakte) to Duisburg (Schwelgern).
Upstream approx. 240 km sailing time 28 hr. Downstream approx. 12 hr.
Including coupling and decoupling the barges the vessel will make approx. 4 complete voyages each week.

The bunker capacity of the vessel will be so that it can sail min. 3 full round trips one fully filled LNG tank and min. 3 full round trips on the fully filled gasoil fuel tanks.
So the minimum bunker capacity will be:

LNG:	165 m3 (Gross capacity) (is approx. 145 m3 Net. capacity)
Gasoil:	80 m3
Fresh water:	20 m3
Sewage:	20 m3
Lub. Oil	10 m3
Prop. shaft lub. water:	15 m3 (on board integrated circulation tank)

The push boat will be designed for a sailing draught of 1,60 m on even keel,
for which the displacement will be determined to carry the following loads:
Light ship weight in with the systems will be filled for sailing,

Spare parts and stores	2 Ton
LNG	38 Ton
Gas oil	20 Ton
Fresh water	10 Ton
Lub. Oil	5 Ton
Prop. shaft water:	15 Ton

2. HULL AND DECK HOUSE

2.1 General

Looking from forward to aft the push boat is compartmentalized as follows:

Below deck level:
Fore peak
E-driven Bow thruster room in between PS and SB side ballast tanks and
PS and SB side fuel tanks
SB Diesel fuelled generator room
Sewage and potable water tank at CL
Compartment for storage of LNG tank and Tank (Cold) Room at CL
Beside this compartment at PS a Fuel treatment room and void double shell compartment
An on SB side of the compartment for the LNG tank a Water treatment room (bilge, ballast, deck-wash, fi-fi, and fresh water installations) and void double shell compartment.
Behind the Compartment for storage of LNG tank the engine room is situated with on PS and SB side fuel tanks and box cooler compartments.
Aft of the engine room the aft peak compartment is planned.

Above deck level:
The accommodation (two layers and a wheelhouse) is planned placed on flexible air cushion elements.
Behind the accommodation at CL the LNG tank compartment with at PS the separate well ventilated auxiliary engine room for the gas fuelled generator and on SB side of the LNG tank a wet (change) room and the engine control room.
At the aft end of the fixed structure superstructure the engine room with ventilation room is situated.
At SB side outside the fixed superstructure beside the engine control room the LNG bunker station is situated.
Funnels for exhaust gas lines are situated at the SB and PS forward and aft corners of the fixed superstructure to meet the required distances to the vent stack of the LNG tank.

3. PROPULSION SYSTEM

3.1 Main Engines

Main Engines and reduction:
4x Wärtsilä 6L20 DF engines each 1060 kW at 1200 rpm.
Reverse reduction gears:
4x Reintjes WAF 743 reduction ratio 3,952:1 (or equal)

3.2 Auxiliaries

1x Dual Fuelled generator (20% diesel 80% gas) (approx. 180 kW)
2x Electric driven bow thrusters (approx. 2x 400 kW)
4x Shaft generator driven by the propeller shafts or the reverse reduction gears (approx. 4x 80 kW)
2x Battery box (approx. 2x 80 kWhr.)

3.3 Propulsion / Power Concept

The propulsion and power concept for the push boat is as follows.
Sailing upstream the required propulsion power will be established by the 4 - 6 cyl. Dual Fuel powered Wärtsilä engines the power for the ship systems can be obtained from the 4 approx. 80 kW shaft generators.
If all power of the Wärtsilä engines is needed for propulsion the approx. 180 kW Dual Fuel generator can deliver electrical power to the ship systems.
In normal operation the DF generator will be used as a simple diesel generator and the gas lines will be closed and in purged condition. (So in normal operation mode the generator room can be seen as a non hazardous machinery space).
If the vessel is birthed e.g. for main engine repair or maintenance and the LNG tank is (partly) filled the DF generator can be operated in Gas diesel mode to prevent the LNG tank for boil off / venting. (The generator room for that purpose is fully equipped and ventilated for the use of natural gas).
In the ship electrical system two batteries are incorporated that can store the extra unused energy of shaft generators and (DF) generator.
The two centre propulsion engines can also act as generator (1270 kVA) and so each single generator can supply power to two E-driven bow thruster units.
(the bow thruster units will only be operational during harbour manoeuvres and emergency stop situations.).
In case of a short circuit in each of the ship AC or DC systems the batteries can provide redundant power for ventilation and emergency systems.
In case of lack of LNG supply the main engines will run on 100% diesel and the shaft generators will provide power supply, in the full diesel mode as in LNG mode the dual fuel driven generator (approx. 180 kW) can deliver power for ship systems.

4. FIRE FIGHTING SYSTEM

4.1 General fire fighting systems.

The vessel will be equipped with all by the rules required fire fighting systems and equipment.
The crew shall be trained to operate the ship systems and regular roles and practical training shall be planned to maintain the skills of the crew

4.2 Fixed fire fighting system engine room

The engine room will be equipped with a fixed fire fighting system either the system will be filled with HFC-227 or with FK-5-1-12 gas and the tanks will be placed inside the engine room.
Therefore the main engines will be executed with a direct pipe connections to open deck (outside hazardous zones) for the supply of combustion air.
The installation will meet the requirements of the rules (ADN part 9)

4.3 Fixed water spray system

The exposed parts of the gas storage tank located above deck level will be surrounded by a water spray system able to spray the horizontal projected surfaces with 10 l/min/m2 and the vertical surfaces with 4 l/min/m2 with water.

4.4 Other firefighting installations

The vessel will be equipped with firefighting equipment according Class regulations (R.O.S.R and ADN constructive rules part 9 construction rules dry cargo vessels)

4.5 A60 insulation

The following bulkheads of the tank compartment and the adjacent spaces will be insulated to A60 class standard (incl. 500mm heat leak area's): Engine room bulkhead, the longitudinal bulkhead between ECR and tank compartment and the longitudinal bulkhead between gas fueled generator room and tank compartment , the longitudinal bulkhead of the separator room.
Steel bulkheads between compartments will be steel. Penetrations will be water / gastight conform Class regulations.
Ventilation ducts of the compartments will be equipped with Class approved closures.

5. VESSELS SAFETY CONCEPT AND GENERAL INFO LNG RELATED ITEMS.

5.1 Rules and regulations.

The following rules and regulations are used to define the layout of the vessel and its systems:

- Lloyds Rules and regulations for the Classification of Inland Waterways Ships August 2011
- Lloyds Rules and regulations for the Classification of Natural Gas Fuelled Ships July 2012
- Interim Guidelines on Safety for Natural Gas-Fueled Engine Installations in Ships Resolution MSC.285(86) adopted on 1 June 2009. (IGF code)
- Lloyds Requirements for Machinery and Engineering Systems of Unconventional Design (Part 7 Chapter 15)
- ROSR (Regelement Onderzoek Schepen op de Rijn) Central Commission Navigation on the Rhine CCNR
- Cryogenic vessels – Static vacuum insulated vessels Part 2 design, fabrication inspection and testing (European Standard EN 134582:2002)
- European Agreement Concerning the International Carriage of Dangerous Goods by Inland Water Ways (ADN) – Volume I & II, issued 01-01-2011.

5.2 Approval and survey

The concept design and its compliance to the rules will be evaluated by Lloyd Register in a Hazid study.
This Hazid will be assessed by TNO for the Ministerie van Infrastructuur en Milieu Directoraat-generaal Luchtvaart en Maritieme zaken.
Plan approval for final design and engineering will be done by Lloyds Register.
Onsite surveys at the building location of hull and components will also be executed by Lloyds Register.
At weekly basis the LNG system and components will be inspected visually by ships chief engineer according instructions formalized in the safety manual.
During all LNG operations functioning of the systems and procedures will be evaluated and reported.
Annual reporting and evaluation will be shared with the CCNR as stated in the recommendation. Procedures and systems on board will be actualized by the result of these evaluations.

5.3 General LNG systems

5.3.1 LNG Tank

The LNG tank is a tank placed in the center of the ship according the GA, partly below deck level in a separate inner space so called tank compartment, partly exposed to open air. The distance from gas storage tank to outer shell is approx. 6 m and the distance from gas storage tank (inner tank) to ships bottom plating is min 1360 mm (IGF rule : the lesser of B/15 or 2 m (B= 18 m max) = 1200 mm). Distance outer tank barrier to ships bottom plating is min. 760 mm.
In between tank room and A60 insulated engine room bulkhead there is a cofferdam of min. 900 mm.
All around the LNG tank there is a +600 mm space for inspection of the outer tank shell.
The LNG tank can contain 152 m3 LNG at 95% filling level
The cryogenic LNG tank is an independent tank IMO type C designed in accordance with the classification rules & regulations. The inner vessel, which contains the liquid LNG, is made of austenitic stainless steel (or in 9% Nickel steel). The outer vessel is made of austenitic stainless steel (or in 9% Nickel steel). The annular is filled with perlite and drawn to vacuum to minimize heat transfer from the ambient. Outer vessel is designed to withstand the vacuum pressure.
Perlite is neither combustible nor toxic and has a superior insulation even if the vacuum in the annular space would be lost.
The cryogenic tank does not need any regular maintenance or because of the usage of non-corrosive materials for both inner and outer tank, as well as the internal piping in annular space. As the annular space is drawn to vacuum, there is no need for maintenance inspection of the annular space. All welds on inner tank, as well as all welded internal piping connections are 100% X-rayed according to classification requirements.
Inner tank design pressure ....from 7.5 to 9.0 barg
Minimum tank design temperature .... -162 °C
Minimum tank test temperature (liquid Nitrogen)..................... -196 °C
Design load – longitudinal acceleration ax............................ TBD g
Design load – transversal acceleration ay .... TBD g
Design load – vertical acceleration az .... TBD g
Design collision load .... 0.5 g
Final main technical data shall be available after approval of classification society.

5.3.2 Gas piping

All piping containing gaseous natural gas is fitted with a secondary barrier. The zoning of hazardous and safe spaces is thus not affected by such double wall piping.
Piping intended for liquid natural gas is arranged within the tank room (secondary barrier), with the exception of the bunkering manifold which is arranged on top deck. The bunkering pipe outside the tank room is only filled with liquid LNG during the bunkering process and will be purged to behind the main shut off valves in the tank room by N2 after the bunkering is carried out.
All pipe connections to the inner tank are within the outer tank boundary, the outer tank serves as an a secondary barrier All pipes that are penetrating the outer tank barrier do that within the tank room (cold box) that is welded to the outer tank. The shut off valves are welded to the double walled pipes where penetrating the outer shell.

5.3.3 LNG bunker manifold

The bunker manifold is situated at the aft side of the tank room approx. 1m above superstructure deck level.
The manifold consists of a cryogenic valve a connection flange for the bunker connection and a purge connection.
Under the connection flange a drip tray will be constructed made of austenitic stainless steel. The volume of the drip tray can is that large that it contain the content of the bunker hose and a stainless steel drain will be made to waterline level

5.3.4 Gas detection

Gas detection is arranged as per class requirements.

5.3.5 Gas odorization

Gas odorant is added to the natural gas before leaving the tank room towards the GVU compartments. Gas leakage can thus be detected by smell in all enclosed spaces except the tank room. Gas emitted directly from the tank through the pressure release valves (vent stack) cannot be odorized and thus also cannot be smelled.

5.3.6 Ventilation, safety distances

All ventilation intakes and outlets, openings and entrances to enclosed spaces are located outside the hazardous area's as defined in above mentioned rules and regulations as well as all hot spots like engine exhaust pipes are.

5.3.7 Purging of gas equipment

A limited N2 supply is permanently connected for the purpose of purging GVU and/or engine gas feed systems for the purpose of maintenance or in case of emergency.
The LNG fill pipe from filling manifold outside the tank room to behind the filling shut off valves inside the tank room will be purged by N2 delivered from the bunker station.

5.3.8 Boil off

The boil off of the LNG inside the tank will be consumed by the main engines whilst sailing and by the dual fuel generator only whilst in harbor and lay down conditions.
(In normal operation the DF generator will be used as a simple diesel generator and the gas lines will be closed and in purged condition. (So in normal operation mode the generator room can be seen as a non hazardous machinery space).
If the vessel is birthed e.g. for main engine repair or maintenance and the LNG tank is (partly) filled the DF generator can be operated in Gas diesel mode to prevent the LNG tank for boil off / venting. (The generator room for that purpose is fully equipped and ventilated for the use of natural gas).)
The electric power consumption for ship systems whilst in harbor conditions is about 60-80 ekW.
The Boil Off Rate of the LNG tank in combination with the fuel consumption of the DF generator in harbor conditions is roughly calculated to be so that when there has been no gas consumption within two weeks the DF generator has to run for 5 days to bring the tank pressure at its original pressure of just before the docking.

5.3.9 UPS

A combined DC AC system, in which the DC system is equipped with batteries, is arranged to provide power to essential ventilation and safety systems. During a black out situation the capacity is sufficient to allow time (30 minutes min) for multiple start attempts on the back-up generator. (Specify link to essential systems and specify time)

5.3.10 Back-up generating set

A back-up DF generating set is arranged outside the engine room with an independent fuel supply.

5.4 Accommodation & wheelhouse

5.4.1 Ventilation

An over pressure is maintained on the accommodation and wheelhouse to prevent hazardous substances from entering these spaces.

5.4.2 Gas detection

Gas detection is arranged at the accommodation ventilation air intakes. In case of gas detection the ventilation system is stopped and quick closing arrangements prevent further gas entry into the accommodation and wheelhouse.

5.5 Engine room

5.5.1 Dual fuel engines

The engine room is a non-hazardous (gas safe) area because the LNG fuel lines to the main engines are double walled from engine to the Gas Valve Units integrated in the tank room.
The double walled piping is ventilated from outside the engine room through the engines and the gas valve unit compartments and this ventilated system has an outlet beside the vent stack of the LNG tank.
Each of the four engines has a separate ventilated piping system an GVU box
See dual fuel engine safety concept, (Wärtsilä), see Project Guide Wärtsilä 20DF engine

5.5.2 Dual fuel engines used for generator

The two main engines on both sides of the centerline can either be used as propulsion engine or as generator. The generators (approx. 1270 kVA each) are both able to deliver power for two 440 kW bow thrusters the 60Hz circuit is exclusively used for bow thruster drive.

5.6 Auxiliary engine rooms

5.6.1 Dual fuel generator

At PS amid ships the auxiliary engine room is situated in which a 80% LNG 20% diesel fueled (DF) generator is placed. This generator room is well ventilated by min 30 air changes per hour. The ventilation is fully redundant. The layout and ventilation system in this room is as simple and flat as possible and subject to CFD calculation to prove there are no pockets and corners in which an explosive gas mixture can occur. Escape to open main deck SB side.

5.6.2 Battery room

The batteries are stored in safe strong frames below main deck in a separate well ventilated room. Escapes to separator room en bow thruster room

5.6.3 Bow thruster room

The bow thruster room is a separate room situated amidships forward of the LNG tank space. The bow thruster room is situated below the accommodation and only E-driven bow thruster units are placed inside that area. Escapes to water treatment room, battery room, and open foredeck.

5.6.4 Separator room

The separator room is situated on SB side below deck underneath the gas fueled generator and in between engine room and battery room. The separator room is separated from the adjacent spaces by steel bulkheads, decks and doors. Escapes to engine room and battery room.

5.6.5 Water treatment room

Is situated on PS below deck opposite from the separator room below the ECR and wet area (entrance accommodation) and in between the bow thruster room and the engine room The water treatment room is separated from the adjacent spaces by steel bulkheads and doors. Escapes to engine room and bow thruster room.

5.6.6 Steering room

The steering room is situated below deck behind the engine room and separated from the engine room by a steel watertight bulkhead. Entrance and escape from and to open deck

5.7 Tank compartment

5.7.1 LNG tank compartment

This is a well-ventilated (min 30 air changes/hr.) compartment that contains the LNG storage tank and cold room. This compartment is executed with a single bottom construction constructed to support the LNG tank with above mentioned loads and acceleration forces.
The construction of the tank support and tank room well insulated from ship construction so no cooling down of ships construction can occur in case of leakage of inner tank or tank valves.
The tank compartment is gastight separated from other compartments of the vessel, also the penetration of the tank and cold room through the superstructure deck will be executed as gas tight.
In the tank compartment the LNG tank outer shell and tank room shell can be inspected visually inspected.
Entrance to this space from main deck level and though two escape hatches on superstructure deck level.
The tank compartment is considered non-hazardous. In this space there is a minimum safety distance from tank room aft bulkhead to engine room of 900 mm.

5.7.2 Tank room

The tank room can only be accessed from outside (bolted or gastight circular hatches on top deck of tank room) to prevent non-odorized gas from entering enclosed spaces other than the tank room.
In normal operation mode it is not necessary to enter the tank room (cold box) emergency valves can be operated from outside the tank room.
Entering the tank room is allowed only for authorized persons.
At least the lower part of the tank room (cold box) is executed as a austenitic stainless steel drip tray.
The tank room will be drained by a single bilge line completely separated from ships bilge system this single bilge line is connected to an ejector type drain pump.

5.8 GVU compartments

Independent gas tight GVU compartments are arranged below deck. Each GVU compartment can be isolated from the rest of the gas system and independently purged for the purpose of inspection and/or maintenance whilst the gas tank system and the other GVU's remain in operation. The appropriate procedure is to be followed.

5.9 Vent stack

The outlets of the pressure release valves, tank room ventilation and purging of the engine gas feed systems are independently piped to the vent stack. These pipes are arranged at the tip of the vent stack to promote mixing of the outflows with the purpose of dissipating temperature differences, nitrogen concentrations, LNG concentrations and/or local pockets of gas with a density greater than ambient.

5.10 Weather deck

5.10.1 Outer deck within the 10m vent stack safety radius

In case access is required to this area the appropriate procedure is to be followed. Ventilation inlets and sources of ignition (exhausts) are located outside the 10m vent stack safety radius as per IGF. Access of personnel to this area is not required for the safe navigation of the vessel nor for the normal operation of the gas systems. To prevent unintended access the hazardous zone is marked on deck.

5.10.2 Top deck in way of the bunker station

During bunkering, access to the on top deck situated bunker station is regulated by the bunkering procedure. Any other movement of personnel between fore and aft can safely take place at main deck level. To prevent unintended access the bunkering zone the hazardous zone for bunkering is marked on deck.

Enclosures:

1. SPD032590-01-LNGPacV155   Wärtsilä safety philosophy document for vertical LNG pack 10-04-2013 Rev 16-04-2013
2. 204-035S-001 Propulsion Concept Shaft generators Aux. on LNG and Battery Rev. M

SAFETY PHILOSOPHY DOCUMENT FOR VERTICAL LNGPAC

Annex no.5 Enclosure 1

(to Specification and Design Concept BNR 204)

Customer:
Scheepswerf Kooiman Marine BV

Customer Reference:
40 meters Inland Push Boat for ThyssenKrupp Veerhaven BV

Description:
LNGPac V155 for 40 meters Inland Push Boat for ThyssenKrupp Veerhaven BV, equipped for 4xW6L20DF Main Engines & 1x Auxiliary Single Gas Engine

Project number
032590

Date
10 April 2013

TABLE OF CONTENTS

Rev.	Date	Content of Changes

-	16-04-2013	Initial creation of document

Created by: J. Byggmaster / F. Harteveld

Checked by: L. Boaro / F. Sundlin

Approved by: S. Karlsson

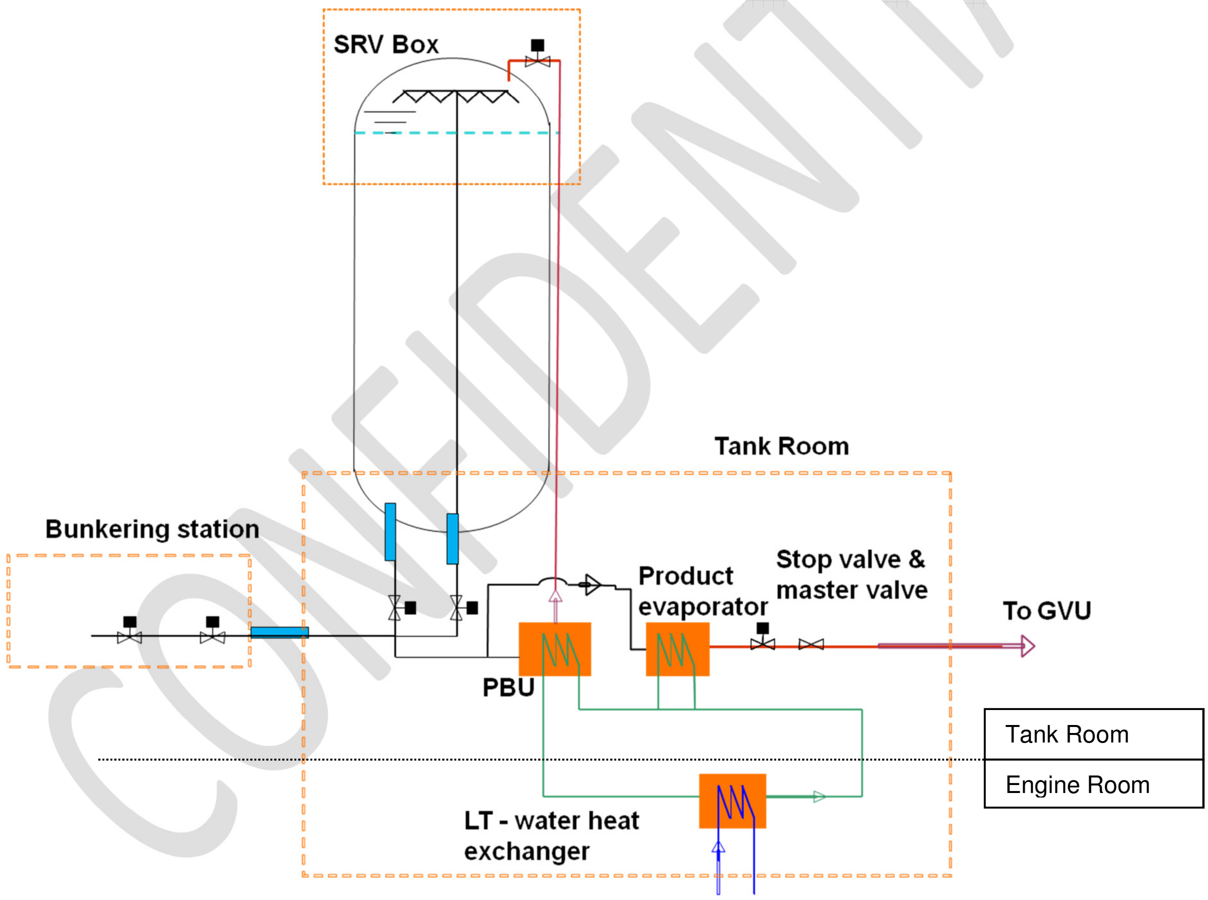
1. INTRODUCTION

1.1. Fuel Gas System Operational Description

This system description is describing the Wärtsilä design philosophy of the Vertical LNGPac system. The LNGPac design philosophy is based on safety and simplicity. A complete system approach has been targeted from the very beginning with seamless interface with other Wärtsilä products and systems.

The Vertical Fuel Gas system is based on a double-shelled vacuum insulated LNG tank, where the LNG tank insulation is sufficient to keep the gas in liquid state for extended periods, even without any gas consumption, meeting classification requirements.

The Safety Relief Valves are always situated above highest liquid level of the Tank. Further details, special arrangements, equipment and connections are specified in the Scope of Supply for the project.



Typical functional diagram for a Vertical LNG Fuel Gas System arrangement
(Above design can slightly differ from the Scope of Supply for the project as described in chapter 2)

The LNG is processed inside the Tank Room, which is a gastight enclosure with dedicated ventilation system, made of stainless steel and therefore functioning as a secondary barrier to avoid LNG spill to the vessel hull structure in case of a LNG leakage.

The process control of the LNGPac includes a PLC cabinet, a separate solenoid valves control cabinet and junction box for all electrical equipment & sensors inside the Tank Room and several peripheral interfacing connections.

Human Machine Interfacing of the Fuel Gas Process control is realized by two redundant panel computers, designed for full remote control of all primary process & safety control functions. The system includes all classification required alarms and indications, to be connected, either hard-wired or via serial interfacing, to the vessel alarm & monitoring system. A serial interfacing can be provided for visualization & limited process control at secondary level to the Vessel Automation System. Where required by classification or local authorities, the necessary alarms, controls & signals shall be provided for the Vessel / Engine Room Safety System.

Main electrical system interfacing:

- Power Distribution System
- Alarm & Monitoring System (mandatory) and/or Vessel Automation System (optional)
- Engine(s) – Gas Valve Unit(s)
- Glycol/Water System
- Ventilation System
- Vessel / Engine Room Safety System
- Gas/Fire Detection System

The LNGPac is installed partly “on deck” and “below deck” in fuel storage hold space. The Tank Room ventilation is directly connected to a dedicated ventilation system (yard supply), all designed according to classification requirements.

LNG shall be bunkered through the Bunkering Station on open deck, directly attached to the Tank Room. Interface to shore bunkering facilities is carried out with a flexible hose connection or fixed loading arm (not included in scope of supply).

The engine Gas Valve Unit(s) (included into scope of the engine) shall be integrated inside the Tank Room. This integration possibility exclusively applies for Wärtsilä engines Gas Valve Units, allowing freeing space in machinery rooms, especially indicated for small size vessels.

1.2. LNG Fuel Gas Containment System

The safety philosophy for “Containment Systems for the carriage of Liquefied Gases in Bulk” was defined during the development of the International Gas Code (IGC) in the seventies. Containment Systems were classified into the different A,B,C and the requirements to secondary containment in case of leakage, a so-called “Secondary Barrier”, was defined.

Since a LNG tank for marine purposes is expected to be more exposed to stress and fatigue loads than a land-based LNG tank, it is to be considered into the design that cracks in the used materials for the containment and process equipment might occur. If a crack occurs, this crack will due to the dominating membrane stresses progress through the tank shell rather than on the surface. The crack can therefore be discovered before it reaches the “critical size”, and remedial actions can be taken. The predominating membrane stresses and the material ductility are the major prerequisite for this “leak-before-failure” concept.

A pressure vessel is classified as an “Independent Tanks Type C”, and is almost completely subject to membrane stresses. The membrane stresses are mainly caused by the well defined internal pressure of the tank. Fatigue loads are very small relative to the internal pressure load.

Due to the well defined membrane stresses and the ductile materials, the "Independent Tanks Type C" is accepted without a Secondary Barrier, however in the case of penetrations situated below liquid level, a "Secondary Barrier" is required to reduce the risks in case of a leakage. The properties of the used materials are justifying that a tank or internal pipe rupture is very unlikely to happen and therefore not described in this document.

Wärtsilä LNGPac Tank design is based upon above described system configuration and is meeting the additional classification requirements for these solutions.

1.3. Inner Shell & Outer Shell of LNG Fuel Gas Containment System

Material of inner tank/shell and outer tank/shell of the LNG Fuel Containment System is typically made of low temperature SS304 steel. As the outer tank is functioning as a "Secondary Barrier" and the inner tank is having the function of a pressure vessel, the design parameters of both tanks are differing.

The design principles and safety philosophy of the LNG Fuel Containment System is based upon the same principles as for the safety of Independent Types C Tanks in the IGC code.

Inner tank/shell

The inner tank design is primary qualified as an Independent Type C Tank, where the basic design criteria are mainly related to the operating pressure of the tank, which is typically in the range of 5.0-7.0 bar g. Design pressure & MARVS settings of the tank are usually set for higher values to reduce critical system operation under normal circumstances and meet the holding time requirements for the LNG according to classification requirements.

As in this vertical tank design, there are pipe penetrations in the bottom part of the inner tank. These penetrations shall be designed in such way that a rupture or leakage in this area is almost negligible. The pipe penetrations will be designed with shell opening reinforcement as per Class Rules Requirements.

Outer tank/shell

In the very unlikely case of a rupture or leakage in the area of these pipe penetrations, the outer tank is acting as the "Secondary Barrier" and the annular space is designed to withstand a full liquid fill-up with limited overpressure under de-pressurized tank conditions.

The vacuum space between the inner and outer tank shell is about 25-30cm wide and filled with Perlite to assure optimum insulation.

In order to withstand both vacuum pressure and pressure due to external loads, the outer shell is equipped with special reinforcement/stiffener rings, where class calculations are proving the rigidness of the outer tank under all considered internal/external design load conditions.

1.4. LNG Tank Holding Time

For the calculation of the LNG Tank holding time most classification societies are referring to the actual IGF Code BLG17, section 7.9.5.1.

"The tank should have a holding time of at least 15 days, with average filling of 50%. Within this period of time the tank should not reach the pressure relief valve set pressure and/or not become liquid full."

All Wärtsilä LNG Tanks are designed according to additional, more specific, requirements:

1. The tank should be able to withstand the pressure increase of at least 15 consecutive days without opening the Safety Relief Valve, from the initial condition of a saturation pressure of 5 barg (liquid homogenously saturated) with a tank filling ratio of 95%.
2. Net Evaporating Ratio (at 101325 Pa, 15 ˚C): Daily boil off rate lower than 0.2% / 24 h

In the event of a docking or repair period longer than 15 days (under the conditions that it is acceptable to keep the LNG in the Tank), where it is not possible to run the main engines/consumers, the pressure in the Tank shall increase.

To avoid an increase to Safety Relief Valve set value and venting of the boil off gas (BOG) during an extended period, the auxiliary generator can be considered to be started and run for a short time. In that case the auxiliary generator will extract the BOG from the gas cushion to reduce the pressure in the Tank.

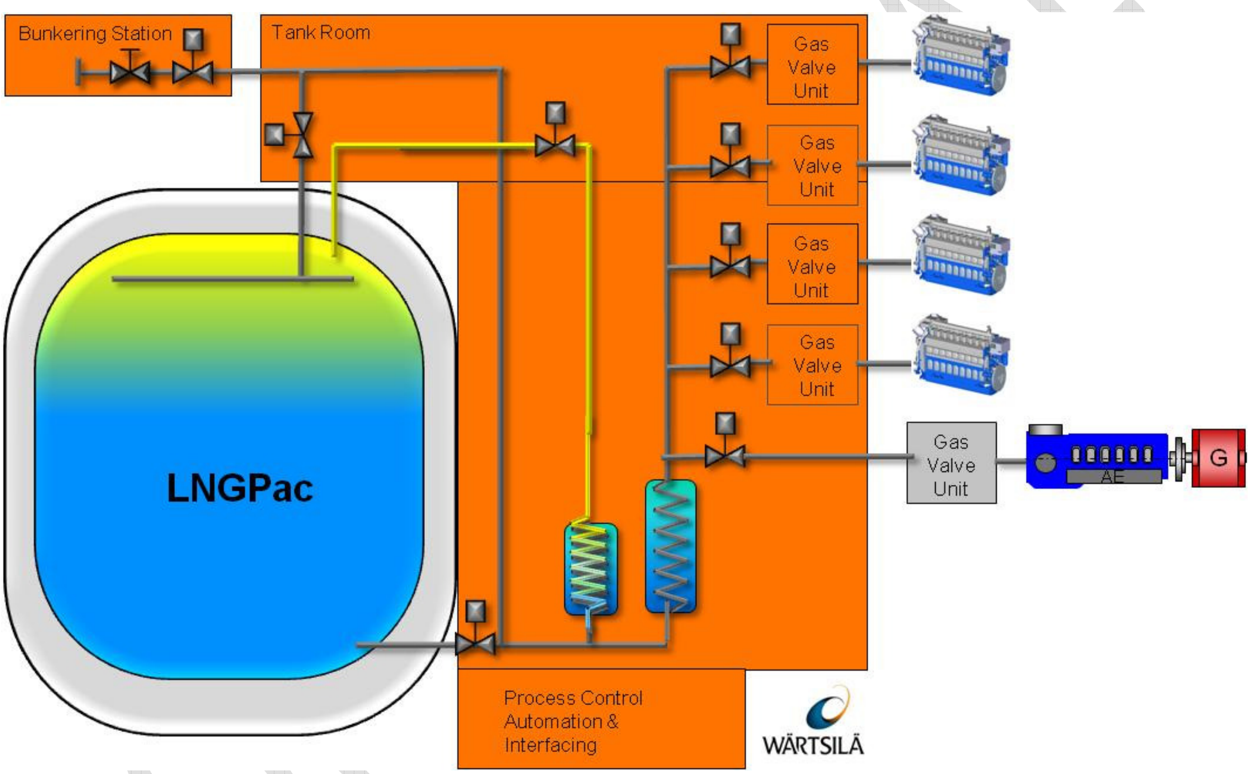
Duration of the running period is depending on the actual pressure in the Tank, the pressure reduction and fuel/power consumption of the auxiliary generator. Under normal ambient conditions of the Tank, the boil off gas rate is very low (<0.2%/24hr) and there is only need for a small consumer, running for a short period in order to bring back the pressure in the Tank.
If the auxiliary generator (usually only applies for high speed, low power engines) fuel feed pressure is very low, the pressure in the Tank can be brought back to about 2 bar. Tank can then be shut down for another extended period.

Important safety aspect: During a docking or repair period the LNGPac Process Control & Automation System should be active in order to have continuous monitoring (and alarm) of the pressure in the Tank.

2. PROJECT DATA

(See BNR 204 Specification and Design Concept)

Image shows an overview of the LNGPac configuration.



3. NATURAL GAS LEAKAGE ANALYSES

The whole fuel gas system and its components are designed and manufactured according class rules and requirements. This ensures that fuel leakages are unlikely to happen. Nonetheless, the process is designed to detect the location of gas leakages in relative short time. In this chapter the different potential locations for leakages and the strategies to deal with them are discussed.

Potential sources of leakages are the inner tank, all lines containing fuel (either in gaseous or liquid state), valves and heat exchangers.

3.1. Leakage in the Annular Space

Leakage in the annular space can either be from the inner tank or the piping within the annular space. Leakages from these items and the measures included in the design for protection and detection of possible leakages are described below.

3.1.1. Leakage from the inner tank

The low temperature materials required by the Rule Requirements are ductile, and this ductility prevents brittle fracture and fast propagating cracks.

The high ductility means that the pressure vessel can be subject to mechanical stress relieving, whereby welding stresses are relieved, and secondary bending stresses due to misalignment are removed. Crack initiation points are thereby reduced.

Since the primary load is the internal pressure, and the fatigue loads are relatively small, the likelihood of fatigue cracks is fairly low.

A crack initiation flaw will have to have a certain size to be able to develop into a crack. In case of the unlikely event that a crack initiation flaw above a certain size exists, the crack growth will be extremely slow due to the relatively small fatigue loads.

If such a crack starts to grow, the crack will, due to the predominating membrane stresses, grow through the inner vessel shell. When the crack has grown through the shell, the tiny crack will let some gas into the “annulus” between the inner and the outer shell. Due to the pressure drop and temperature increase, it is unlikely that any liquid will reach the perlite filled annulus in the initial phase of the leakage.

The above rationale applies to the inner tank shell, in general designed in accordance with the requirements to Independent Tanks Type C. The LNG Fuel Tank will have one pipe penetration in the bottom of the tank. The opening in the inner shell will be designed with shell opening reinforcement and should as such be as safe as the rest of the tank.

The likelihood of crack in way of the bottom penetration can be reduced to less than for the inner shell by applying substantial opening reinforcement, bottom pipe without any transversal weld, and with a well designed thermal deflection loop.

In case that a crack develops, natural gas will fill the volume and pressure will rise until the pressure relief system releases the gas. The design of the pressure relief system should therefore be based on this scenario rather than on fire.

3.1.2. Bottom Pipe Arrangement

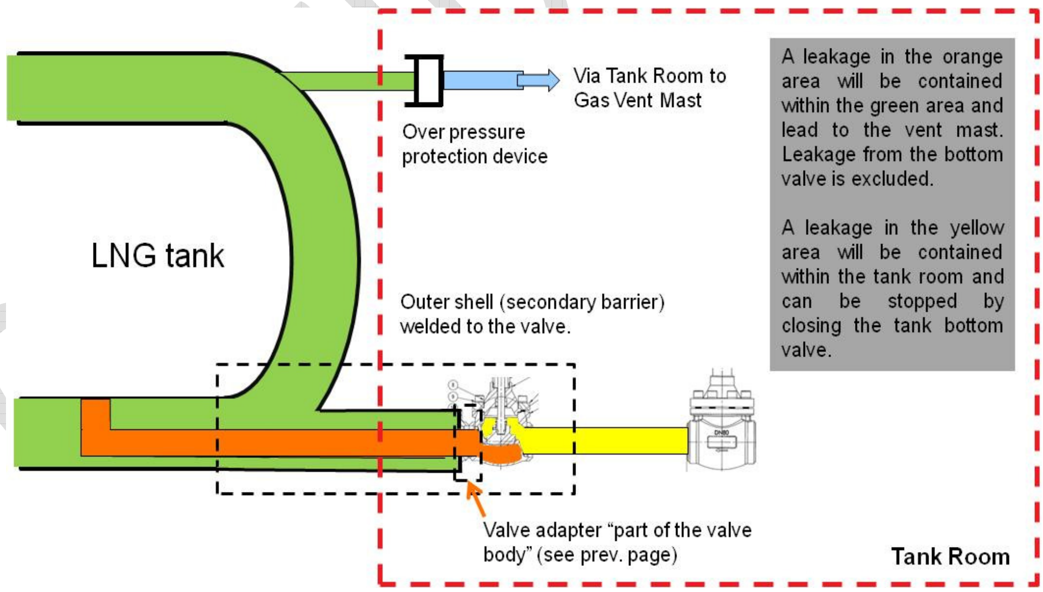
The bottom pipe is completely installed within a secondary barrier, see the sketch in the picture below. After the routing in the annular space the pipe is enclosed in a second pipe all the way until the first stop valve inside the tank room (main tank valve). The secondary pipe is connected to the same vacuum space as the outer tank. The bottom valve is welded to the outer and the inner pipe with a specially made adapter. This arrangement ensure that all leakages can be stopped or limited and will not harm the integrity of the vessel.

Any leakages in the LNG containing pipe will be contained within the outer tank. The outer tank is protected by a drop off disc (described in a later chapter) which will open in case of leakages and subsequent pressure rise in the annular space.

- Leakage in the liquid piping before the valve will be contained within the secondary barrier
- Leakage internally in the valve can be stopped by closing valves downstream. This is detected in the regular valve leak test procedures
- Leakage in piping after the valve is limited to the extent in the piping system and the amount flowing out of the tank before the bottom valve is fully closed. This is detected with the gas detectors inside the tank room.

To prove the integrity of the bottom valve and adapter several analyses have been made:

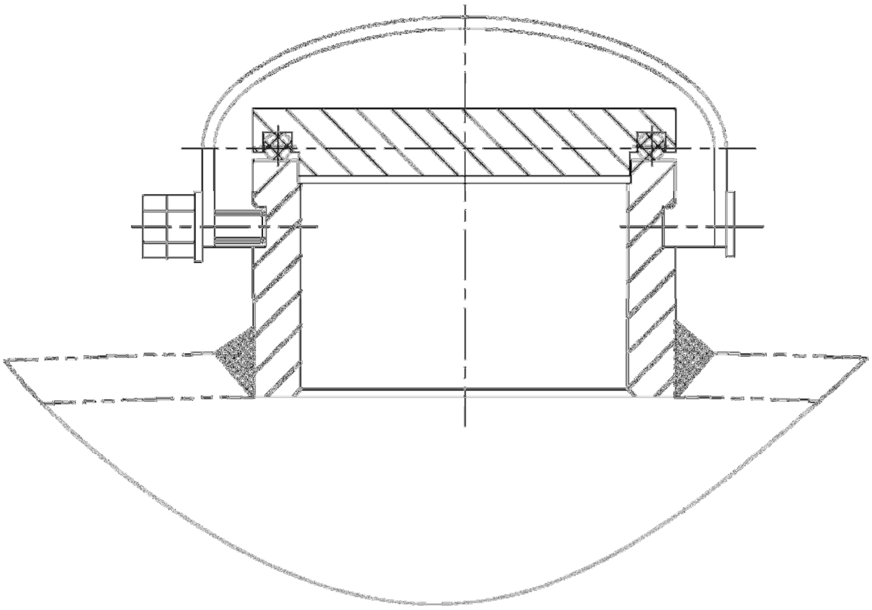
- Risk analysis, FMECA (Doc: DBAC585276)
- FEM analysis (appendix in doc DBAC585276) of the critical parts in the valve showing that no failure due to fatigue will happen in 1 million open and close cycles – estimated operation cycles of the bottom valves is maximum 1-3 cycles/day (in normal operation and bunkering the bottom valve is constantly open)
- Burst test report (Doc: DBAC591715) showing that the valve body withstands at least 620 bars.



3.1.3. Protection of the outer tank/shell

The stainless steel outer tank is designed to hold the vacuum and act as a secondary barrier. Due to the design pressure of – 1 bar on the outer tank it has been calculated that the outer tank will withstand an overpressure of several bars, meaning that the risk of rupture of the outer tank in case of leakages in the annular space is very unlikely.

The outer tank is protected against overpressure with a drop off disc, similar to the device in the picture below.



The device is meant to hold the vacuum in the tank and open if the pressure inside the outer tank reaches above the atmospheric pressure. The drop off disc will be equipped with redundant position indicators that will detect when the disc drops off. The outlet from the drop off disc is in the tank room. By having the disc opening into the tank room the detection of a gas leakage will be by the gas detectors in the tank room. A combination of indication from the position indicator and gas detection will lead to shutdown and de-pressurization of the tank. Detection of leakage with the gas detectors is seen as the most reliable method.

If the drop off disc drops off without subsequent gas detection an alarm will be triggered. The drop off disc will be installed in a way to provide easy access for inspection and maintenance.

3.1.4. Protection of the Vessel Hull from Cold

In case of the unlikely event of leakage from the inner tank as mentioned above, the annulus space between the tanks, the outer tank shell, the tank skirt structure and the vessels Tank Top structure will be cooled down.

The skirt of the LNG Fuel Tank (as well as the outer tank) are made of the same material as the inner tank, and can thus sustain LNG temperatures. The need for insulating material between the tank saddles and the ship structure will be investigated in the design phase to ensure that the ship structure will not be cooled down below the material requirements in case of leakage in the outer tank.

3.2. Leakage inside the Tank Room

The tank room has to be ventilated with 30 air changes per hour. Since ventilation of the tank room will be performed through dedicated channels, any gas leakage in the tank room will be sensed by gas sensors in the ventilation channels or gas sensors in the tank room itself. In addition the tank room floor is equipped with a temperature & level sensor which indicates if cold LNG is present on the tank room floor.

All LNG leakages inside the tank room can be stopped after detection by closing automatic valves. The amount of LNG leakage inside the tank room is limited to the volume of the piping and that amount of LNG that might flow out from the tank before the valves are fully closed. The continuous ventilation will also prevent pressure build up in the tank room in case of leakage. See also chapter 3.1.2.

All liquid lines outside the tank room will be installed in ventilated ducts or as double walled pipes. Gas supply lines to the GVUs/engines are installed in ventilated ducts. In case of gas leakages, gas sensors installed in the ducts will immediately activate an alarm.

3.3. Internal Leakage in the Heat Exchangers

The fuel tank system includes two heat exchangers (evaporators) in the tank room, each of the shell and tube type, with water/glycol on the tube side and NG/LNG on the shell side.

Since NG pressure will be larger than water/glycol mix pressure, an internal leakage in the heat exchanger will push gas into the water/glycol loop. To be able to spot an internal leakage in the heat exchanger, gas sensors are installed in the expansion tanks of the water/glycol loop. Those tanks will have to be located in the highest place of the loop so that gas will naturally reach them.

3.4. Identification of the Leakage Source

Fuel leakage may occur from the inner tank, inside the heat exchangers or from pipes and valves. A leakage from the inner tank will trigger an alarm and lead to a shutdown of the LNGPac. Internal leakages in the heat exchangers will be identified via the gas sensors in the water/glycol expansion tank.

Identification of leakages on valves and pipes will be enforced locating gas sensor in the different zones (typical: bunkering line channel, tank room, fuel line to the engine).

Maintenance of the heat exchanger must never be done during normal operation. If a leakage occurs, the gas detectors will trigger an alarm and the LNG tank will be isolated. Identification of the leakage source can only be done after pipe inerting / venting of the tank room.

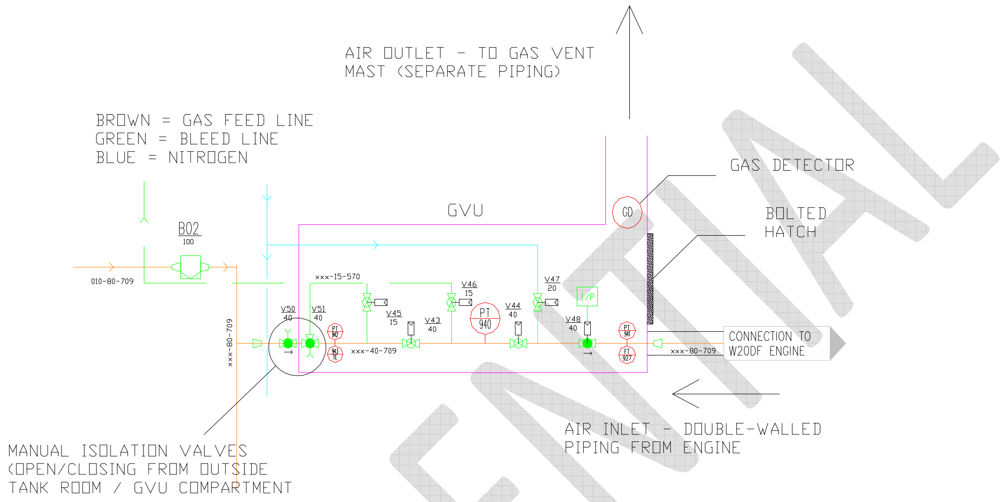
The LNG tank is equipped with a separate glycol system (optional supply by Wärtsilä). Any leakage to the glycol side will be detected by the gas detector installed in the expansion tank of the water/glycol loop (Not included in Wärtsilä supply). Gas detection in the expansion tank will lead to a shutdown of the LNGPac.

3.5. Internal leakages in valves

The cryogenic valves are tested regularly to identify internal leakages in the valves. The comprehensive procedure is done manually when the LNGPac is not in operation and is described in the operation & maintenance manual.

3.6. Fuel Leakage in Double-Walled Piping from DF Engine or GVU

A fuel leakage in the double-walled piping will be detected by the gas detector, which is monitoring the quality of the ventilation air in the annulus (space between inner- & outer pipe) of the double-walled pipe.
This ventilation air (minimum 30 changes/hour) of each engine is separately guided via its GVU compartment to the Gas Vent Mast on top of the Tank Room.



In case of a leakage detection the respective engine will be shut down by closing the fuel gas feed valve(s) in the GVU, while the other engines will remain in operation – running on gas. The GVU control system will start a block- & bleed sequence to ensure that all gas is removed in double-walled piping, piping on engine and GVU components.
If gas remains detected after the block- & bleed sequence, it is expected to be a defect at the input of the GVU block inside the compartment. In that situation a emergency shutdown (ESD) of the complete system is generated.

Each GVU compartment is accessible from the Tank Hold by means of a gastight bolted hatch. If a need for inspection of the GVU block, it needs to be ensured that no gas is in the compartment before opening. A proposal solution (as per diagram) is V50/V51 are acting as a double blocking valve configuration with manual lever at the outside of the Tank Room. The hatch can only be opened when both levers are in safe(valve closed) position. During opening the ventilation needs to run continuously.

4. NATURAL GAS ENCLOSED VOLUME ANALYSES

Safety Pressure Relief Valves and Thermal Relief Valves are required to protect enclosed volumes from expansion of gas or liquid.

4.1. Safety Relief Valves for the LNG Tank

Design of the Safety Relief Valve configuration system has to be based on the worst case scenario. IN most cases this will be fire on board, where continuous venting is most likely. This scenario is consistent with the design of the inner tank pressure relief system. In case of fire a certain amount of heat will reach the inner tank surface, and start warming up the liquid. At first, the heat will warm up the liquid up to its boiling point, next the liquid will start to boil and a consistent pressure build up will occur in the tank. The time needed for the pressure to increase will depend on the degree of liquid sub-cooling, stratification and on the actual tank filling level. In order to design the pressure relief system for the worst case scenario, we have assumed that the liquid is at its boiling point.

4.1.1. Design of the Pressure Relief System for the Inner Tank

The safety relief valves for the inner tank are dimensioned according to class rules and the IGC code on a project specific basis. Two independent safety valves, each with 50% of the total needed capacity, are required. The safety valves are dimensioned to a fire scenario with the fire exposure factors as defined in the IGC code with the set point (MARVS) at 9 barg.

The piping to the safety valves is designed in such way so that pressure drop in the vent line from the tank to the pressure relief valve does not exceed 3%. The back pressure from the safety valves until the vent mast outlet is designed to not exceed 10 % of the MARVS for unbalanced safety relief valves and 30 % for balanced safety relief valves.

4.1.2. Safety Relief Valve operation under abnormal conditions

In the situation that the vessel sinks in deep waters and the LNG Fuel Gas Tank will disappear under the waterline, the functioning of the Safety Relief Valves needs to be evaluated. As the vessel is designed for damage stability according the ADN and the vessel is mainly operating in shallow waters (less than 9m = height safety relief valves above bottom plating) such an event is very unlikely.

The LNG Tank Safety Relief Valves are designed and dimensioned for fire cases, where the Tank is exposed to large heat radiation and continuous venting is to be considered. In the situation that the Tank is submerged, the functioning of the valves will basically be more related to anticipate on thermal expansion.

For the moment there is no data/information available regarding this topic of the safety relief valves.
In the LNG Pressure Relief System there is a valve foreseen for de-pressurization the Tank under normal circumstances that overrules the Safety Relief Valves. To be investigated whether it is possible to operate this (fail to close) by hand or automatically in these circumstances.

4.2. Thermal Relief Valves on Piping

All pipe sections that can be trapped with liquid LNG are equipped with thermal relief valves. The relief valve in the bunkering station is designed according to the standard API 521.

The heating media (glycol-water) flow in the evaporators will continue after a shutdown of the LNGPac. This means that the two relief valves inside the tank room on the pipe sections with the evaporators have to be designed according to the max vaporized gas flow in the evaporators.

5. BUNKERING SAFETY FUNCTIONALITY

Bunkering of LNG is performed at the bunkering station(s), where LNG is transferred from the bunkering station to the LNG tank. If the bunkering station is not an integrated part of the tank room, the piping in between shall be insulated. Piping above deck is of the single-walled type and below deck piping needs to be executed in double-walled piping with ventilated outer pipe.

The bunkering station(s) are classified as hazardous area zone1 during bunkering, while otherwise they are considered as safe area.

During the bunkering process there is a potential risk for leakage or spill (need for drip trays) and human exposure to the cold liquid. Therefore special precautions are to be foreseen to minimize these risks. One of the critical design aspects of the bunkering station is to ensure the safety under all circumstances during bunkering operations and avoid human errors, causing fatal accidents or damage to the vessel. This implies the need for development of detailed procedures for bunkering operations, where the definition of bunkering interface between bunkering supplier and onboard installed LNGPac shall be thoroughly investigated to ensure safety & reliability of the entire bunkering system.

The information about the bunkering interface and onboard pipe routing is needed in order to make safety relief valve calculations, pipe stress analysis and necessary descriptions of the bunkering, pre-cooling and safety procedures.

The system is as a standard equipped without vapour return line, however for quick de-pressurizing of the tank before bunkering, this feature can be obtained. In case of a vapour return line the bunkering supplier should be able to handle the vapour return gas.

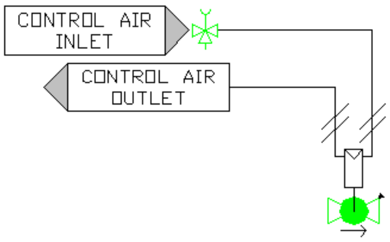
Bunkering of the LNGPac needs usually to be carried-out in a limited time to avoid vessel downtime. Therefore filling of the tanks is an optimized automated process operation, controlled by the LNGPac Process Control & Automation System. During bunkering, the filling process needs to be continuous observed by an operator, who can control the process from the bunkering local control panel. This panel is to be situated at safe distance from the bunkering flanges and contains the primary functions – start, stop & emergency stop and level/pressure indicators. During bunkering there shall be a communication link between bunkering supplier and the vessel.

The equipment and process control is designed in a way that under normal circumstances during bunkering no gas will be vented.

After bunkering is completed, bunkering station equipment and liquid bunkering lines are to be inerted with Nitrogen.

5.1. Valve arrangement at Bunkering Station

The main bunkering shut off valve is equipped with a manual shut off device to ensure that the valve is closed after bunkering. By means of a manual three-way valve on the control air piping the air from the actuator is released and the supply blocked. It is not possible to operate the valve remotely before the three-way valve is manually switched to correct position.



5.2. Liquid bunkering line from Bunkering Station to Tank Room (if installed)

Liquid bunkering lines on open deck are usually of the single-walled, insulated type. Liquid bunkering line piping below deck is to be enclosed within a secondary barrier for protection against leakage. Various designs for this piping can be considered, where the ventilated secondary barrier pipe or duct is common used. Alternative solutions are the vacuum insulated or Nitrogen filled secondary barrier. Most common is to insulate this piping in order to minimize warming-up of the liquid during the transfer of the liquid.

Preferably bunkering lines should be a short as possible, however the thermal stress & fatigue of piping and supports needs to be analyzed. Therefore thermal expansion of piping and pipe supports is a critical design aspect of the bunkering lines.

5.3. LNG Consumption during Bunkering

LNG consumption is not to be considered during bunkering.

5.4. Emergency Shut Down (ESD) Functionality

In the event of ESD activation during bunkering, the LNGPac Process Control & Automation System is sending a shut down signal to the bunkering source (on shore or bunkering vessel) to stop the pump system.
In addition to this ESD functionality, there is a requirement for an open communication link between bunkering source and the operator during the whole bunkering operation.

5.5. Overfilling & Overpressure Protection

The bunkering process is in principle an automated process to avoid human failures during filling-up of the tank(s). In the first stage of the bunkering process, the piping system is cooled-down up to the tank connection(s). As the pressure of the tank can still be at operational pressure, the pressure in the tank should first be reduced before ramping-up the bunkering flow to full capacity. This is usually performed by spraying cold liquid via the top filling connection on the gas cushion. Gas will re-condensate and the pressure in the Tank will go down. When the pressure is reduced sufficiently, the actual bunkering process can be started.

During bunkering the Process Control & Automation System is continuously monitoring the level of the tank, where the alarm limit settings are related to the maximum allowed filling rates (result of approved calculations). The tank level is continuously monitored by the differential pressure based level measurement. In addition two sensors are installed to shut down at first the bunkering operation. In case this sensor is not responding, a second sensor is shutting down the complete system.

Under normal bunkering conditions it is very unlikely that the pressure inside the tank increases, however a pressure transmitter is continuously monitoring the pressure in the tank. In the event of a pressure increase above set point level, the system will be shut down automatically.

At the bunkering station tank level and pressure can be observed by the operator by means of the installed indicators.

5.6. Important procedure notes to ensure safety during bunkering

- Safe mooring, the height difference between bunkering station of the vessel and the bunkering source.
- Type and size of the hose connections. The hose connection will be a quick/break-away coupling connection, where the last one is preferably to be used for fast / short-time bunkering procedures.
- The Bunkering Station is equipped with valves, pipes, instruments and connections needed for the bunkering procedure. A blind flange on the pipe connection protects the piping and first valve from humidity and water.
- The bunkering terminal/source should supply sufficient pressure to deliver the LNG from the terminal/source to the LNG tank. The pressure should however not exceed the inner tank design pressure, which is 9 bar(g).
- The Bunker Station is to be made of stainless steel with drip trays fitted below the liquid gas bunkering connections. From the Bunkering Station a drain pipe is to be routed from the drip tray to the water line.
- During bunkering there will be a continuously open communication link between bunkering supplier and operator.

6. TANK DE-PRESSURIZATION

De-pressurization of the Tank under normal circumstances is only needed at start of the bunkering process. In this case it can be considered either by consuming gas from the gas cushion before bunkering or start initial filling of the Tank by spraying liquid LNG on the gas cushion. The gas condensates, resulting in a pressure decrease.

In case of following circumstances, a full de-pressurization of the Tank, followed by emptying/draining of the Tank, is to be carried-out:

- Leakage of LNG in annular space.
- Maintenance (i.e. welding) on tank and/or tank room equipment.
- Docking (if required to empty the Tank by shipyard/authorities).

As a Blow Down Systems is not required for LNG fuelled ships, full de-pressurization & emptying/draining has to be made possible in the event of a defect or for maintenance purposes.

Leakage of LNG in annular space
In case of leakage detection (loss of vacuum, sensor drop-off plate activated and gas detected in Tank Room) in the annular space, the pressure inside inner tank will be de-pressurized and emergency vented through the Gas Vent Mast. As this is a first action into an emergency situation and the leakage amount is unknown, the most safe procedure is to minimize the evaporation of the LNG in the tank and vent the gas until further investigations on the cause of this leakage has been carried-out.
Depending on the cause, it can be decided to drain the Tank, which is described in the chapter below.

Maintenance or docking
When need for emptying the Tank during maintenance on the Tank and/or Tank Room equipment, the pressure in the Tank will first be reduced, preferably by consuming gas from the gas cushion.
Next step is emptying of the Tank according to description in the next chapter of this document.

7. TANK DRAINING

Tank draining is required in case of maintenance or docking. The emptying/draining procedure needs to be thoroughly prepared and discussed with tank supplier (Wärtsilä), shipyard and authorities, as this means that the tank will warm-up and after works have been carried-out, the initial cool down procedure needs to be followed.

Main steps in draining process:

1. First step into the draining process is a de-pressurization to a low pressure level, as described in Chapter 6 of this document.
2. PBE pressure is used to remove liquid via the bottom valve pipe connection through the bunkering line to shore.
3. Once the remaining liquid has reached the lowest level of the PBE inlet, it becomes impossible to remove the last liquid by means of tank pressure built-up. The last liquid in the tank is to be removed by adding Nitrogen to build up pressure through the spray line at the top of the tank. At sufficient pressure, the Nitrogen valve and the spray valve will be closed, while the bottom valve pipe connection will be kept open to release remaining liquid through the bunkering line.
4. Purging of Tank and all piping systems inside Tank & Tank Room and external piping such as bunkering lines.

In unlikely event of a defect or leakage on the inner/outer tank, the draining procedure needs to be thoroughly investigated before start of the draining process. Depending on the analyses and the severity of the defect, the draining procedure has to be determined. Preferably this to be done by a minimized controlled pressure built-up. In that case the tank liquid column pressure and height of the bunkering outlet connection needs to be considered in order to remove the liquid out of the tank.

Worst case condition is when it is not possible anymore to push-out the liquid via the bottom valve connection (rupture of inner tank) . In this situation the one and only possibility that remains is to heat-up the tank in a controlled way and vent the gas via the Gas Vent Mast.
Vaporized Gas can than be collected from the Vent Mast and / or at a vapour return connection

8. LNGPac AUTOMATION – DESIGN & SAFETY PRINCIPLES

8.1. General System Description

Number of Process control & automation systems: **1**

The LNGPac Process Control & Automation System is based on distributed control & monitoring system. Communication interfaces is provided for alarm generation, visualization and limited control functions within the Vessel Alarm & Monitoring system and/or Integrated Automation System, based on momentary standard interfacing and protocols.

The main functionality of the LNGPac Process Control is based on a PLC based Process Control System and a separated PLC based Safety Control System to create safe operation under all circumstances and minimize potential risks. Where required by classification, additional control logic shall be installed in accordance with the classification society.

System configuration

The LNGPac Process Control & Automation System is consisting of the following main equipment:

- Process Control Cabinet, to be mounted in a non-hazardous area below deck, preferably in a conditioned room, i.e. Engine Control Room. The Cabinet should be powered by a dual power supply, whereof one of these supplies to be powered by an UPS system. Main functionality of the Process Control Cabinet:
- System power supply distribution.
- System process monitoring & control, consisting of a single PLC.
- System safety monitoring & control, consisting of two independent operating Safety PLC's.
- Modbus/TCP interfacing equipment for Human Machine Interfacing.
- Intrinsic safe interfacing to all Tank Room equipment.
- Interfacing to bunkering station(s).
- Emergency shutdown handling. Interfacing to Vessel Safety System.
- Serial interfacing to Vessel Alarm & Monitoring System and/or Integrated Automation System.
- Interfacing (digital or serial) to engines, gas detection system, fire detection system, glycol-water system, LNG related ventilation systems.
- Solenoid Control Cabinet for all pneumatic air actuated valves inside the tank room, mounted on the outside enclosure of the Tank Room.
- Junction boxes inside/outside of the Tank Room for wiring-up of all sensors and control equipment, including Ex safety barriers and remote I/O for communication with the PLC's.
- Redundant Human Machine Interfacing by means of two redundant Process Operator Stations, where usually one operator station will be situated in the Engine Control Room and the second operator station to be situated in the wheelhouse.
- Local Operator Panel for bunkering station(s), including cabinet & junction box for all controls & monitoring functions.

Controlling the LNGPac

The LNGPac Process Control & Automation is designed in accordance with the Unmanned Machinery Spaces (UMS) notation. During normal operation the LNG fuel gas handling process is completely automated and all control interfacing to external systems (engine GVU's, glycol-water system, ventilation systems) is designed for remote control of these systems.

Each Process Operator Stations contains visualization of all process data, alarms & operational features, including also alarm logging & trending functionality. In case of malfunction of a Process Operator Station, the other stations remain in operation, as the communication is realized by a ring network, where each Process Operator Station is equipped with its own network switch.

The Process PLC contains all primary and secondary functionality, including also (where practicable possible and accepted by classification) automatic sequences for bunkering, purging operations, system tests etcetera.

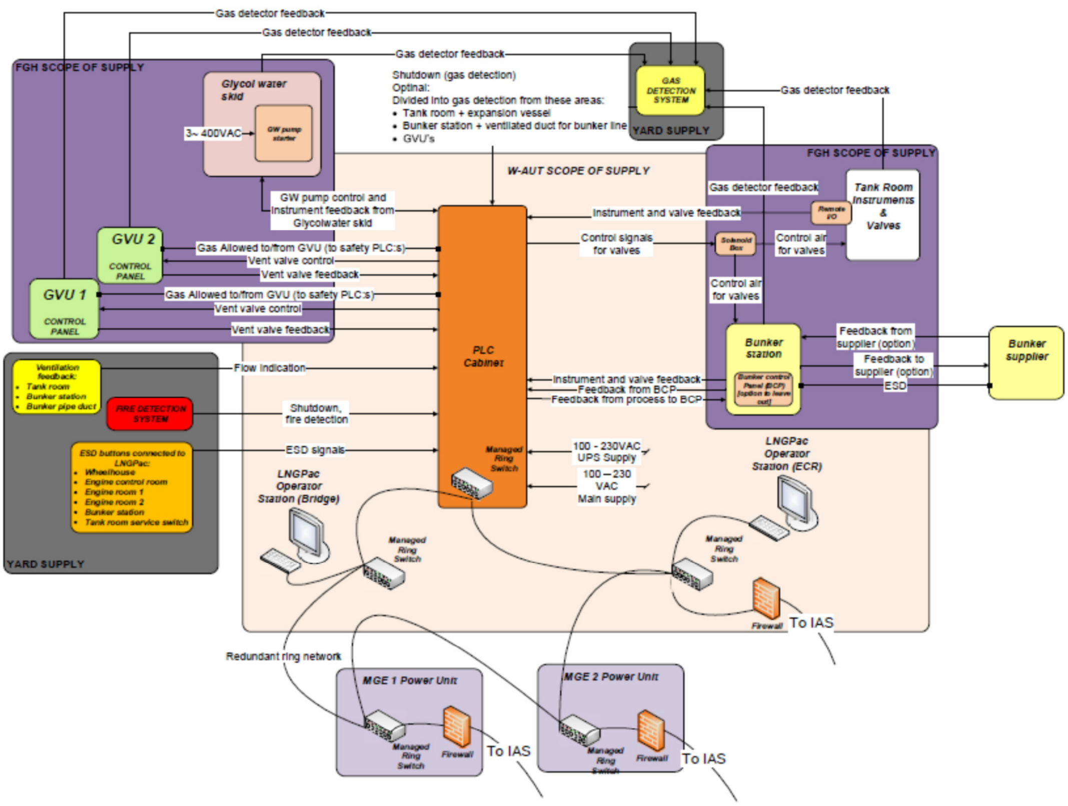
Emergency Shut Down (ESD) Functionality
ESD's of the LNGPac can be generated internally by the Process Control & Automation System or can be generated by external systems.

Internal ESD's are generated as a result of system process or automation failures, where "safety" of people, vessel & systems under all circumstances is having highest priority.

In case of an external ESD, this can be generated by manual input (activation of emergency push buttons) or an external system such as gas detection or fire detection system.

ESD activation during bunkering is stopping the complete bunkering process, where also the pump system of the bunkering source (on shore or bunkering vessel) is shut down.

Below image shows a typical overview of the LNGPac automation.



8.2. Emergency Shutdown philosophy

The philosophy for a critical situation is to close down the LNGPac and keep the LNG inside the tank to reduce any possible release and in that way reduce the risk for any possible damage to other systems and/or people.

Critical measurements in LNGPac are done with two instruments, one for each Safety PLC. This ensures us that at least one Safety PLC and the Process PLC are shutting down the process.

External ESD signals are double digital inputs for the LNGPac, one for each Safety PLC to ensure a redundant shutdown.

8.3. External Power Supply Failure

The Process Control Cabinet is having two power supply inputs, preferably to be powered from separate sources on board of the vessel.

1. Main Supply 100-230Vac, usually to be powered from the main switchboard.
2. UPS Supply 100-230Vac, usually to be powered from the emergency switchboard via an UPS system with a minimum battery capacity of 30 minutes. Alternatively this secondary power source can be fed from the 24Vdc board net battery system via a 24Vdc/100-230Vac inverter. Battery capacity minimum of the same capacity as mentioned above. Under normal circumstances the board net battery system need to be charged by a charger system of sufficient power.

In case of a failure of one of the power supplies, the internal system of the Process Control & Automation System is designed in such a way that the remaining power supply will take-over without any interruption. A power failure alarm is generated by the Process Control & Automation System. This alarm is presented on the LNGPac operator stations. Further this alarm is made available for the on board Alarm/Monitoring System.

In case both power sources are failing (this implicates a double failure, which usually does not have to be considered) the Process Control & Automation System will shut down and all pneumatic actuators of the valves will be de-energized, resulting into fail-safe closing position of these valves.

8.4. Internal Power Supply Failure

The internal power supply distribution of the LNGPac Process Control & Automation System is designed in a way where all system components are separately fused by automatic circuit breakers. In the event of a short circuit in one of the sub-systems, this will not affect the operation of the other (healthy) parts of the system. A system shut down is generated (all valves to fail-safe closing position) in the following situations:

1. Failure (short circuit) in internal power supply distribution
2. Power supply (manual switch-off or failure) of Process PLC
3. Power supply (manual switch-off or failure) of Safety PLC 1 or 2
4. Power supply (manual switch-off or failure) of HMI

In case of a power supply failure, the healthy signal of the related equipment will disappear and create an alarm.

8.5. Process PLC Failure

The Process PLC is designed for the control of all primary and secondary processes which are not directly related to the system safety functionality. In the event the Process PLC fails (i.e. freezing of program), the output modules are "fallback to zero" and following will actions will be taken by the remaining healthy part of the system:

1. Alarm generated, logged and visualized in HMI
2. Common alarm to vessel alarm/monitoring system and/or Integrated Automation System
3. System shut down generation by Safety PLC's – all valves to fail-safe closing position

8.6. Safety PLC Failure

The LNGPac Process Control & Automation System is equipped with two Safety PLC's, which are continuously monitoring the critical safety functionality of the system. Basically the two Safety PLC's are acting as independent control/monitoring units with limited cross-over checking.

In the event that one of the Safety PLC's fails, the other PLC will note and generate immediately a shut down – all valves will go to fail-safe closing position. Identical alarms are generated as described for the Process PLC.

All critical process measurements/sensors are double executed. Status or analogue value of each sensor is visualized in the HMI. One sensor is wired-up to Safety PLC 1 and the other sensor is wired-up to Safety PLC 2. Critical sensors are of the 4-20mA type with a continuous "wire break" and "out of range" monitoring. If one of these detected, the respective Safety PLC will generate a shut down and all valves will go to fail-safe closing position.

In the event that for one of the Safety PLC's, a sensor reaches its alarm or shutdown set point, action will be taken independently of the signal status in the other Safety PLC.

8.7. Ship Black-Out

The LNGPac Process Control & Automation System is powered by an UPS. In the event of a black-out, the safety system will remain operating normally. Basically for the LNG process itself there is no rotating equipment into the system, except for the Glycol-Water circulating pumps which are taking the heat from the LT cooling water of the engines. As the pumps are usually powered from the main/emergency power sources, these pumps will be stopped during the black-out situation. In that case, the control system will detect from the "pump running" signal that both pumps are stopped and will generate a system shut down, where all valves are returning to fail-safe closing position.

As also the complete ventilation system has stopped during a black-out, this is also triggering a system shut down.

8.8. Start-up from Dead Ship

In the event of a Dead Ship situation, a special procedure has to be followed to start-up the LNGPac. Procedures are to be described during the engineering phase of the project in close cooperation with the yard.

8.9. Critical alarms & ESD overview

Below matrix is giving an overview of all critical alarms and possible consequential shut downs in case of major malfunctions or not appropriate actions taken by the operators.

WÄRTSILÄ

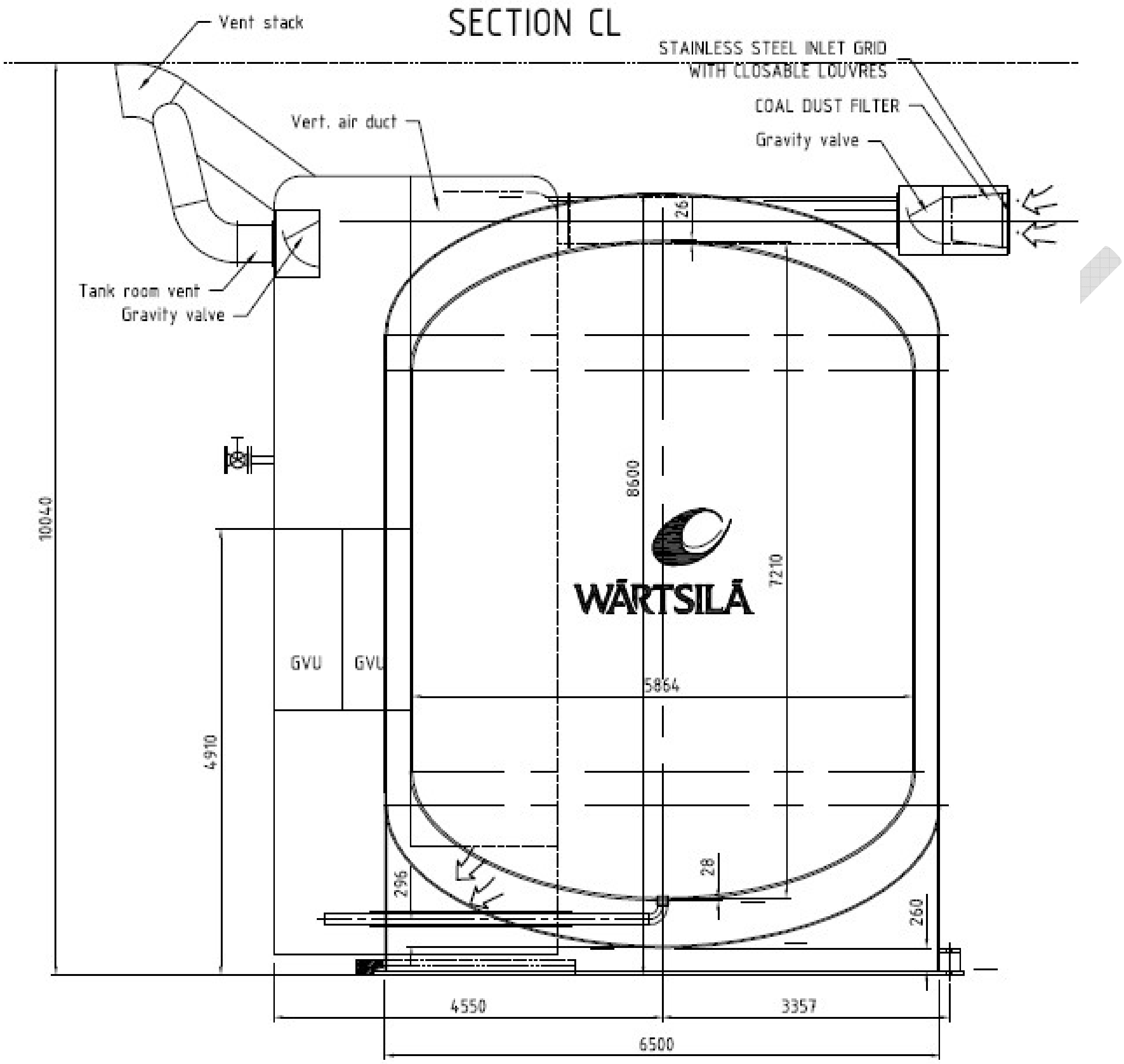
LNGPac Cause and Effect Diagram

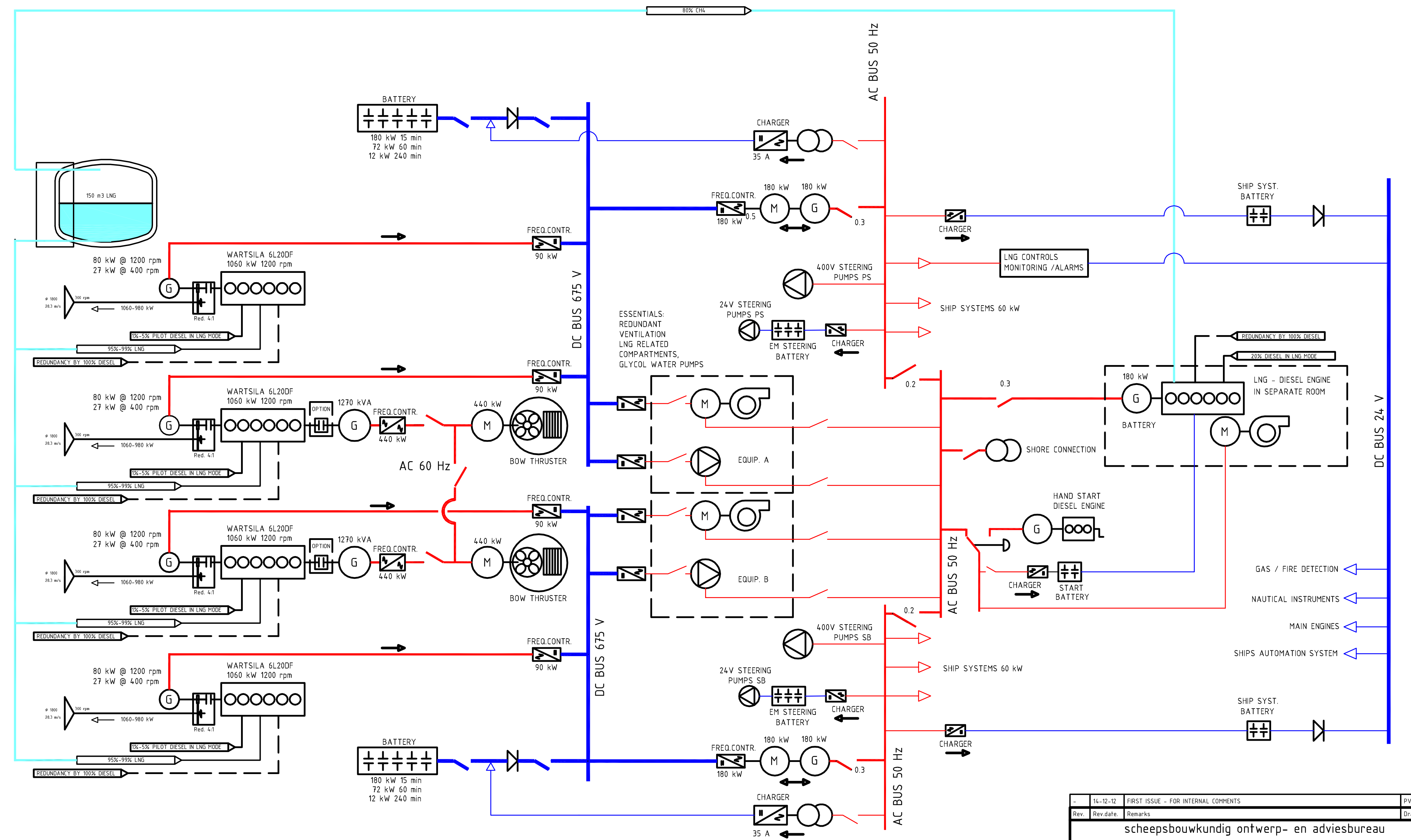
Made	Date	Product	Document	Revision
Approved	15.4.2013	LNGPac		-

Rev.	Made	Check	Appr.	Date	Description
-	FSU005			15.03.2013	
	FHA014			15.4.2013	

Tag	Description	SD type Alarm (limit)		BSD (Bunkering shutdown)	ELSD (Engine line shutdown)	TASD (Tank shutdown)	Process shutdown
Tank Room - internal signals							
LSx	Tank level High (Pre-Alarm - reduce bunkering flow)	90%					
LSx	Tank level Too High (Shutdown)			95%			
PT914	Tank pressure	7,5 Bar g		8 Bar g			
TE924	Heating media temp after MGE	0°C				-20°C	
TE925	Heating media temp after PBE	0°C				-20°C	
TE918	Tank room floor temperature	-50°C				-70°C	
TE923	Ventilation mast pocket temperature					-70°C	
TE921_1/TE921_2	Gas temperature after MGE	0°C				-40°C	
TE983	GW temperature before heat exchangers					-10°C	
LSL979	Low level indicator, expansion tank						X
PT997	GW pressure after P1 & P2	<2.5 bar >4.5 bar				<1.5 bar >5.5 bar*	
PDT71	Diff pressure over P1 & P2	<1 bar					<0.5 bar
DF Engine / GVU related signals							
HS9x	Engine/GVU 1 - Pushbutton near engine				X		
HS9x	Engine/GVU 1 - Isolation switches on outside GVU compartment				X		
HS9x	Engine/GVU 2 - Pushbutton near engine				X		
HS9x	Engine/GVU 2 - Isolation switches on outside GVU compartment				X		
HS9x	Engine/GVU 3 - Pushbutton near engine				X		
HS9x	Engine/GVU 3 - Isolation switches on outside GVU compartment				X		
HS9x	Engine/GVU 4 - Pushbutton near engine				X		
HS9x	Engine/GVU 4 - Isolation switches on outside GVU compartment				X		
External Shutdown signals							
HS8x	ESD command from Vessel Safey System (common signal to LNGPac)					X	
HS8x-1	ESD button - Entrance Tank Room					X	
HS8x-2	ESD button - Entrance Engine Room					X	
HS8x-3	ESD button - Entrance Tank Hold					X	
HS8x-4	ESD button - Bunkering Station					X	
HS8x-5	ESD button - Engine Control Room					X	
HS8x-6	ESD button - Wheelhouse					X	
Bunkering source signals							
ESDI	ESD from bunkering source			X			
Fire detection system							
FG5	Fire detection					X	
Ventilation system							
Bx-1&2	Tank room ventilation flow switch 1 & 2					X	
Bx-1	Tank room ventilation flow switch 1	X					
Bx-2	Tank room ventilation flow switch 2	X					
Bx	Bunkering line duct ventilation flow switch					X	
Bx	Engine 1 - Ventilation flow switch in double-walled piping				X		
Bx	Engine 2 - Ventilation flow switch in double-walled piping				X		
Bx	Engine 3 - Ventilation flow switch in double-walled piping				X		
Bx	Engine 4 - Ventilation flow switch in double-walled piping				X		
Gas detection system							
	Gas detection (common alarm)	X					
FGx	Gas detection (common shutdown - dependent on LEL% to LNGPac)					X	
FGx-1	Tank Room detector 1					X	
FGx-2	Tank Room detector 2					X	
FGx-3	Gas Detection in Expansion Tank Glycol-Water System	X				X	
FGx	Gas detection in ventilated duct/piping Bunkering Station (if applicable)			X			
FGx	Engine 1 - Gas detection in ventilated double-walled piping				X		
FGx	Engine 2 - Gas detection in ventilated double-walled piping				X		
FGx	Engine 3 - Gas detection in ventilated double-walled piping				X		
FGx	Engine 4 - Gas detection in ventilated double-walled piping				X		

Annex A: LNGPac V155 preliminary dimensional drawing





ANNEX NO. 5 ENCLOSURE 2

(TO SPECIFICATION AND DESIGN CONCEPT BNR 204)

M	11-04-13	REMARKS CONTROL TECHNIQUES INCORPORATED	PV
L	09-04-13	REMARKS MOUS INCORPORATED	PV
K	09-04-13	REMARKS CONTROL TECHNIQUES INCORPORATED	PV

J	03-04-13	REMARKS CONTROL TECHNIQUES INCORPORATED	PV
I	02-04-13	REMARKS WARTSILA INCORPORATED	PV
H	29-03-13	REMARKS MOUS INCORPORATED	PV
G	28-03-13	REMARKS LLOYDS AS RESULT FROM HAZID INCORPORATED	PV
F	06-02-13	REMARKS TECHNISCH BUREAU MOUS 06-02-13 INCORPORATED	PV
E	04-02-13	REMARKS CONTROL TECHNIQUES 31-01-13 INCORPORATED	PV
D3	08-01-13	REMARKS CONTROL TECHNIQUES 08-01-13 INCORPORATED	PV
C	08-01-13	REMARKS CONTROL TECHNIQUES 07-01-13 INCORPORATED	PV
B	23-12-12	REMARKS MEETING 21-12-12 INCORPORATED	PV
A	21-12-12	REMARKS CONTROL TECHNIQUES INCORPORATED	PV

Rev.	Rev.date.	Remarks	Drawn by
-	14-12-12	FIRST ISSUE - FOR INTERNAL COMMENTS	PV

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YARDNo/NAME: BNR 204

ORDER: 11056 | SUBORDER: 035S

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DRAWING NAME: PROPULSION CONCEPT
SHAFT GENERATORS, AUX. ON LNG AND BATTERY

Memorandum

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From
A.W. Vredeveldt

Subject
HAZID, LNG pushboat new build

Date
19 November 2013

Our reference
TNO-2013-M02642, 052.03406

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Contents

Introduction

Gebroeders Kooiman are considering to build a push boat which will be employed for six-barge coal/ iron ore transports on the river Rhine with an LNG duel fuel propulsion system. This implies a design of a push boat which features both marine fuel oil (MFO) and natural gas, stored as liquefied natural gas (LNG). Current regulations do not allow the use of fuels with a flashpoint below 55° C (Chapter 8, Article 8.01, [2]). No consolidated regulations are available with respect to the use of cryogenic storage facilities. It is noted that LNG is carried at a temperature of -162 ° C (minimum).
Fortunately authorities, i.e. IWW shipping inspectorates and the Central Commission for the Navigation of the Rhine (CCNR, CCR, ZKR) are willing to grant exemptions when satisfactory technical evidence is available as regards the safe carriage and use of natural gas on board.
The current practice with regard to providing such evidence is following, at least partially, requirements from existing regulations on the carriage of liquefied gasses in sea going tankers (IGC [3]) which have been included in a code under development at IMO, known as the International code on safety for Gas-Fuelled ships (IGF) [4]. In this design a vacuumed double walled pressure tank is used for the carriage of the LNG bunker fuel. For the design of this tank usually, in Europe, a European standard on cryogenic vessels static vacuum insulated vessels is referred to (EN13458 [5]). The IGF code is under development and intended for sea going vessels. The other codes, IGC and EN 13458 are not intended for LNG bunker fuel installation on board inland waterway (IWW) vessels, although many requirement are applicable to IWW ships as well.

Clearly a new technique is introduced in IWW shipping. Therefore authorities require a safety assessment to be carried out. It is noted that in IWW shipping this assessment is often referred to as the hazard identification study (HAZID), which is formally only a part of risk assessment.
It is also noted that it is the intention to lift this requirement as soon as regulations on the use of LNG bunker fuel installations have been adopted by the competent authorities and have come in to force.
The results of a risk assessment rely heavily on the competence and skills of the people involved. Since the authorities have no staff to assess the results of a risk assessment from a technical point of view, TNO is invited to study the available material and formulate a position.
This memorandum reflects the opinion of TNO about the technical evidence currently available on the LNG fuel system design for Gebroeder Kooiman yard no. 204. The memo has been written on the request of Gebroeder Kooiman.

Technical documentation

A picture of the general lay out of the system is given in Figure 1.

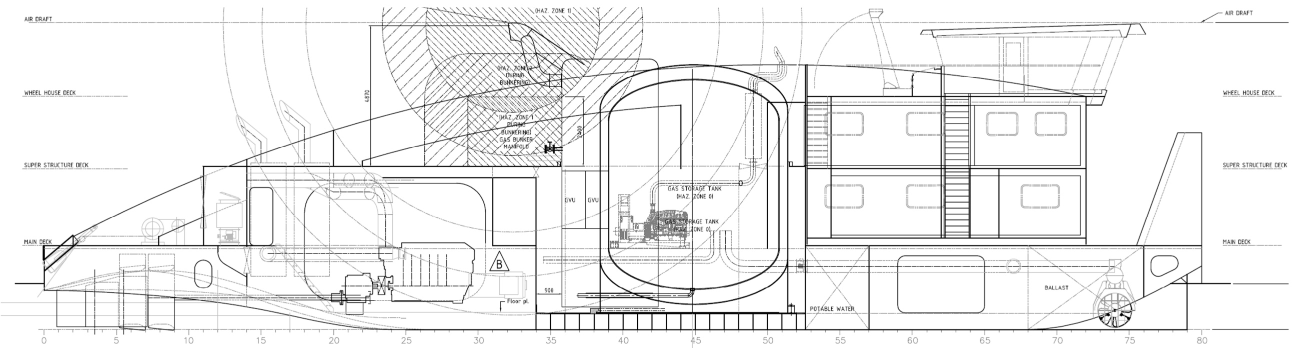

Figure 1 General lay out LNG/NG fuel system

As can be seen the LNG fuel tank is situated in front of the engine room, aft of the accommodation.

Gebroeders Kooiman have tabled technical documentation related to the design of LNG/ MFO fuelled pushboat, Yard No. 204, as listed below:

Table 1 Technical documentation from [1]

Plan no.	Description
204-051-001 rev. C	General arrangement vert. tank concept.
204-035S-001 rev.F	Propulsion concept – shaft generators, aux. on LNG and battery
E1001 rev.B	Electrical Installation single line diagram
DAAR032590-8/1 rev.0	LNGPac System Functional block diagram.
204-402-001 rev.B	Dual fuel diagram
204-403-001 rev.A	Cooling water diagram
204-409-001 6 sheets rev. C	Ventilation concepts
DAARxxxxxx (preliminary)	LNGPac System P&I drawing
	Wärtsilä 20DF Product Guide

These documents have been used in a HAZID carried out by Lloyds Register [1]. The HAZID was restricted to personnel safety. The report on the HAZID states that possible scenarios have been identified that could harm personnel which are considered to be in the 'medium risk' range and therefore require further investigation. A list of these items is given in Table 2.

Table 2 List of items for further investigation

No.	Worksheet ref.	Remarks/considerations	Responsibility
1.	Node1./ 1.1.1./1.2.1.	Max. pressure retaining capacity and relieving capacity of the lift plate to be specified.	Wärtsilä
2.	Node1./ 1.1.3.	Collision loadings on tank are to be defined. Energy absorbing ability of ship side structure to be specified. Reference is made to AND curves on collision energy	Wärtsilä, Kooiman, TNO.
3.	Node1./ 1.1.4.	Bunkering arrangements and tank filling limits are to be clarified and assessed at a later date.	Wärtsilä, Kooiman
4.	Node1./ 1.1.5.	Maximum damage condition (heel and trim) to be defined.	Kooiman
5.	Node1./ 1.1.7.	Top of cold box in way of pressure relief valves to be strengthened.	Wärtsilä
6.	Node 1./2.1.1.	Pipe arrangements for venting to be considered further.	Wärtsilä
7.	Node1./ 2.1.2.	Pressure sensor for continuous monitoring of vacuum to be fitted. Arrangements for discharging LNG ashore to be provided.	Wärtsilä
8.	Node2./ 1.	Bunker arrangements to be further considered at a later date.	Wärtsilä/Kooiman
9.	Node4./ 1.1.1.	Maximum flooding height and pressure that can be contained by cold box is to be determined. Ventilation pipes are to be sized such that they will prevent a build up of pressure resulting from ruptured pipe.	Wärtsilä
10.	Node4./ 1.2.1.	LNG leak detection should be fitted in Glycol system.	Wärtsilä/Kooiman
11.	Node4./ 1.3.1.	Arrangements to prevent freezing of heat exchangers in event of failure of Glycol system to be provided.	Wärtsilä/Kooiman
12.	Node4./ 2.2..	Maintenance regime for all gas components to be specified.	Wärtsilä
13.	Node 4./6.1.	Training to be provided for operators	Wärtsilä/Kooiman
14.	Node 4/7.1.1.	Material and survey requirements for welding of small diameter gas pipes to be investigated.	LR
15.	Node6./1.	Further advice on heat ingress from fire for tank above and below deck	LR
16.	Node6.1.5.	Means for controlling flare at vent mast to be considered.	Wärtsilä
17.	Node6./2.3	Working conditions of pressure relief valves when submerged to be investigated.	Wärtsilä
18.	Node6./3.2	Access doors or bolted manholes to the cold box. The arrangements are to be clarified.	Wärtsilä
19.	Node6./4.1	Proposal to be made for preparing LNG plant for different maintenance /repair scenarios.	Wärtsilä
20.	Node6./4.2	A procedure to state level of maintenance required for all gas components to be produced	Wärtsilä
21.	Node6./6.1.	Procedure for the gas safe restoration of power from a dead ship to be provided.	Kooiman
22.	Node6./10.1	Auxiliary engine room to be gas safe independent of ventilation in order to re-start aux. engine. In diesel mode. Arrangements are to be considered.	Kooiman
23.	Node6./10.2	Uninterrupted operation of ventilation is required after 30 minutes on U.P.S. Arrangements are to be further considered.	Wärtsilä
24.	Node6./10.3	FMEA to be submitted to deal with malfunctions in control system.	Wärtsilä

Discussion

The items identified during the HAZID are relevant and valid and should therefore be resolved.

Some additional remarks may be appropriate.

The HAZID report explicitly states that the study is restricted to personnel safety, external safety is not addressed. This issue is addressed under ad a.

Loss of gas tightness is, implicitly, referred to in action no. 1. The background of this item is that visual inspection of a vacuum tank is impossible once it has been built. This implies that, unlike any other item on board, the LNG vacuum type fuel tanks cannot be brought under the usual inspection regime of a classification society, i.e. inspections every 2.5 years and survey every 5 years. Fortunately the material used is not sensitive to corrosion (provided the outer tank is manufactured from stainless steel as well) and the substance in the tank, i.e. LNG, is non-corrosive. Hence the only remaining mechanism is fracture due to fatigue, which cannot be rule out in its entirety. It should therefore be demonstrated that, when fracture occurs and in the worst case a pipe is entirely detached from the inner tank, the consequential events, such as evaporation, pressure build up in vacuum space (hence pressure relief capacity of the lift plate), venting, icing, etc. are still manageable. It is noted that the technical evidence does currently not refer to the ADN [6], which contains regulation on the carriage of liquefied gasses in IWW ships, albeit that LNG is not on the list of allowed cargos. ADN does not allow tank penetrations below deck (section 9.3.1.11.41, ADN [6]). This is however, the case in this design.

Action no. 2 is addressed in ad a. of this section. The issue about associated acceleration on the tank has been resolved.

The bunkering arrangement (action no. 3.) and procedure as such need not be complicated. The hardware is an engineering issue, there are no reasons to believe this will be a show stopper. The main danger here is a lack of understanding on the part of the daily operators and consequential 'taking shortcuts' behavior, e.g. 'temporarily' overfilling. Therefore we advocate a training which is concluded with an examination which must be passed in order to qualify as crew on a LNG fuelled vessel. See also issue d. in this section.

Action no. 3 through action no. 6) are basically engineering and naval architectural issues. They are not expected to become a show stopper. Action no. 8 is dealt with under action no. 2. Action no. 9, the maximum LNG flooding height in the cold box is an issue and does require further investigation. Actions no. 10, and 11, are engineering items only. The issue addressed under action no. 12 is not considered to become a safety issue provided action no. 1 is properly addressed. Action no. 13 is considered crucial to safety, refer to ad. d. of this section. Actions no. 14, 15 and 16 are again engineering issues.

1

9.3.1.11.4	The bulkheads bounding the hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck. The bulkhead between the engine room and the service spaces within the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the requirements of 9.3.1.17.5.

In case of action no. 16, reference is made to a study carried out by TNO on behalf of Shell, which basically recommends to vent in a vertical direction.
Action no. 17, about proper functioning of pressure relief valves while submerged in water is an issue and needs to be resolved. Action no. 18 and 19 are again merely engineering issues. Action no. 20 is addressed under action no. 12. Action no. 21 through 24 are considered items which can be resolved.

There were a few additional issues identified, which we propose for further consideration:

a. Full burst of containment system,
b. Effect analysis LNG spill from conditioning system on deck,
c. LNG spill from a fractured bunkering hose,
d. Education and awareness.

ad. a.
Although the probability of this event may be extremely remote, the consequences are not well understood and hard to predict. Therefore it is recommended to assume the worst. From a safety point of view this still need not be a problem, provided it is demonstrated that the probability of tank burst is acceptably low. The IGF code implies that this is the case when a 1/5 B distance between ship side and the tank is observed. Currently there is an investigation on-going, which aims at verifying this implicit assumption. Preliminary results seem to indicate that a typical vacuum LNG tank is unlikely to burst in a collision or dropped object event. However it still needs to be investigated whether piping penetration in the inner tank are likely to come off and what the associated consequences may be.

ad. b.
This may typically occur when there is a malfunctioning. It is very likely that the cold-box itself is capable of dealing with this event, it is however recommended to conduct an analysis.

ad. c.
This may typically happen when a mistake is made in the bunkering procedure or a material failure occurs. It is very likely that the drip tray and discharge channels are capable of dealing with this event, it is however recommended to conduct an analysis.

ad. d.
This issue is considered a real worry. Currently there are two (in the near future three) IWW tankers which use LNG as bunker fuel. A weighty argument for supporting the request for an exemption is that these vessels as tankers, subject to the ADN requirements [6]. This implies that the crew is already aware of the dangers of hazardous cargos and is therefore expected to behave in a responsible and competent fashion toward LNG bunker fuel as well.
Moreover ADN vessels are subject to restrictions with respect to where (and when) they are allowed to sail. Moreover they have an obligation to communicate their sailing plans with traffic control and follow traffic control instructions. For the vessel discussed in this document, this is not the case.

Therefore an explicit investigation into education, enforcement and mores is recommended. This issue is probably the most likely show stopper with regard to the use of LNG as bunker fuel.

Conclusion/ recommendation

The HAZID/Risk assessment ([1]), reports 24 recommendations as shown in Table 2. TNO supports these recommendations. Only two of these recommendation are considered to become show stoppers if not resolved;

- Action no. 9, leakage of LNG in cold box (maximum flooding height …),
- Action no. 17, proper working of pressure relief valves when flooded.

We recommend to resolve these issues.

In addition we recommend to investigate the following issues:

- Full burst of containment system due to collision or dropped object and effect analysis for fracture of piping and piping connections in vacuum space in case of a collision or a dropped object,
- effect analysis for fracture of piping and piping connections in vacuum space, under long term operational conditions,
- analysis LNG spill from conditioning system (cold box) or bunkering hose,
- crew training, qualification and enforcement.

We acknowledge that some of these recommendations are generic to all IWW ship designs featuring LNG fuel. We therefore recommend that these issues are dealt with in a joint industry effort. For ad. a. from the previous section, such an effort is currently being made, results are expected early 2014.

We recommend additional answers to be provided on issues, as indicated in this memo, before granting the request for an exemption allowing the use of LNG as fuel on board the push boat gebr. Kooiman yard no. 204.

It is noted that the issues raised are generic to most LNG fuelled ships.

References

[1] Kooiman – Yard no. 204, Inland Waterways Dual Fuelled Pushboat, Hazard Identification Study (HAZID) Report RTS/ENG/130370, Lloyds Register, 17 April 2013

[2] Besluit van 23 januari 1996, houdende het van kracht zijn voor de Rijn in Nederland van het Reglement betreffende het onderzoek van schepen op de Rijn 1995, CCNR Strassburg.

[3] IGC, International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, 1993 Edition, IMO

[4] IGF, draft International code on safety for Gas-Fuelled ships, IMO

[5] Cryogenic vessels-Static vacuum-insulated vessels, European Standard EN 13458-2:2002

[6] European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN), United Nations Economic Commission for Europe, Geneva 2011.

ZENTRALKOMMISSION FÜR DIE RHEINSCHIFFFAHRT

RV (13) 91
RV/G (13) 117
JWG (13) 85
12. Dezember 2013
Or. de fr/de/nl/en

UNTERSCHUNGSAUSSCHUSS
ARBEITSGRUPPE UNTERSUCHUNGSORDNUNG
GEMEINSAME ARBEITSGRUPPE

Empfehlung für das Schubboot Kooiman Marine (Baunummer 204)

Mitteilung des Sekretariats

Das Sekretariat übermittelt zur Information anliegend die von der Arbeitsgruppe Untersuchungsordnung nach § 2.19 RheinSchUO ausgesprochene Empfehlung.

ZENTRALKOMMISSION FÜR DIE RHEINSCHIFFFAHRT

EMPFEHLUNGEN AN DIE SCHIFFSUNTERSUCHUNGSKOMMISSIONEN ZUR RHEINSCHIFFSUNTERSUCHUNGSORDNUNG

EMPFEHLUNG Nr. 24/2013
vom 27. November 2013

Schubboot, Bau-Nr. 204 KOOIMAN MARINE B.V.

Das Schubboot (Baunummer 204 Kooiman Marine B.V., einheitliche europäische Schiffsnummer muss noch erteilt werden), wird hiermit für den Einsatz von Flüssigerdgas (LNG) als Brennstoff für die Antriebs- und Hilfsanlage zugelassen.

Gemäß § 2.19 Nr. 3 ist für das Fahrzeug eine Abweichung von den §§ 8.01 Nr. 3, 8.05 Nr. 6, 8.05 Nr. 9, 8.05 Nr. 11 und 8.05 Nr. 12 bis zum 30.6.2017 zulässig. Der Einsatz von LNG gilt als hinreichend sicher, wenn folgende Bedingungen zu jeder Zeit erfüllt sind:

1. Die Konstruktion und Klassifikation des Schiffes soll unter der Aufsicht und Einhaltung der zu befolgenden Regeln einer anerkannten Klassifikationsgesellschaft erfolgen, welche besondere Regeln für Flüssigerdgas-Antriebssysteme hat. Die Klassifikation ist beizubehalten.

2. Das Flüssigerdgas-Antriebssystem muss jährlich von der Klassifikationsgesellschaft, welche das Schiff klassifiziert hat, inspiziert werden.

3. Von der Klassifikationsgesellschaft, die die Klassifikation des Schiffs vorgenommen hat, wurde eine umfassende HAZID-Studie (siehe **Anlage 1**) vorgenommen.

4. Das Flüssigerdgas-Antriebssystem erfüllt den IGF-Code (IMO Resolution MSC.285(86), 1. Juni 2009) mit Ausnahme der in **Anlage 2** aufgelisteten Punkte.

5. Das Flüssigerdgas-Antriebssystem ist so ausgeführt, dass Methan-Emissionen auf ein Minimum reduziert werden.

6. Der Flüssigerdgas-Vorratstank erfüllt die Anforderungen an Typ-C-Tanks gemäß dem IGC-Code (IMO-Resolution MSC 5(48)). Der Tank muss auf dem Schiff so angebracht sein, dass er unter jeglichen Umständen mit dem Schiff verbunden bleibt. Der Tank ist mit Zeichen zu versehen, die ihn eindeutig als Flüssigerdgas-Tank ausweisen.

7. Das Bunkern des Flüssigerdgases muss unter Einhaltung der in **Anlage 3** aufgeführten Verfahren erfolgen.

8. Die Instandhaltung des Flüssigerdgas-Antriebssystems muss unter Einhaltung der Anweisungen des Herstellers erfolgen. Die Anweisungen sind an Bord mitzuführen. Nach jeder erheblichen Reparatur muss das Flüssigerdgas-Antriebssystem vor der erneuten Inbetriebnahme von der Klassifikationsgesellschaft untersucht werden, die die Klassifikation des Schiffs vorgenommen hat.

9. Alle Besatzungsmitglieder sind zu den Gefahren, zum Einsatz, zur Instandhaltung und Inspektion des Flüssigerdgas-Antriebssystems nach den in **Anlage 4** festgelegten Verfahren zu schulen.

10. Eine Sicherheitsrolle ist an Bord des Schiffes vorzusehen. Die Sicherheitsrolle beschreibt die Pflichten der Besatzung und enthält einen Sicherheitsplan.

11. Alle Daten zum Einsatz des Flüssigerdgas-Antriebssystems sind vom Betreiber zu erfassen und müssen mindestens fünf Jahre lang aufbewahrt werden. Die Daten sind der zuständigen Behörde auf Anfrage zuzuschicken.

12. Ein jährlicher Auswertungsbericht, der alle erfassten Daten enthält, wird zur Verteilung an die Mitgliedstaaten an das Sekretariat der ZKR gesandt. Der Auswertungsbericht soll wenigstens die folgenden Informationen enthalten:
    a) Systemausfall;
    b) Leckage;
    c) Bunkerdaten (Flüssigerdgas);
    d) Druckdaten;
    e) Abweichungen, Reparaturen und Änderungen des Flüssigerdgassystems einschließlich des Tanks;
    f) Betriebsdaten;
    g) Emissionsdaten, einschließlich Methan-Emissionen
    h) Prüfbericht der Klassifikationsgesellschaft, die die Klassifikation des Schiffs vorgenommen hat.

Anlagen :

Anlage 1: HAZID-Studie (Bericht Nr. RDS/ENG/130370 vom 18. April 2013)
Anhang 1: HAZID Worksheets and summary of actions
Anhang 2: Risk Ratings
Anhang 3: Terms of reference / scoping study
Anhang 4: General arrangement and system plans

Anlage 2: Übersicht über die Abweichungen vom IGF-Code (IMO-Resolution MSC.285(86), 1. Juni 2009)

Anlage 3: BNR 204 Principles for Bunkering Procedure

Anlage 4: Beschreibung der Schulung von Besatzungen an Bord von Binnenschiffen mit Flüssigerdgasantrieb

Anlage 5: Beschreibung des Projekts Kooiman Marine B.V. Technische Daten und Konstruktionskonzept des Schubbootes
Anhang 1: SPD032590-01-LNGPacV155 Wärtsilä safety philosophy document for vertical LNG pack 10-04-2013 Rev 16-04-2013
Anhang 2: 204-035S-001 Propulsion Concept Shaft generators Aux. on LNG and Battery Rev. M

Anlage 6: TNO Bericht (TNO-2013-M02642, 052.03406, HAZID, LNG pushboat new build)

Annexes are located on website under and	**RV 2012 EN** **RVG 2012 EN** **JWG 2012 EN**	**rv13_91en_2 and _3** **rvg13_117en_2 and _3** **jwg13_85en_2 and _3**
Les annexes sont enregistrées sur le site sous et	**RV 2012 EN** **RVG 2012 EN** **JWG 2012 EN**	**rv13_91en_2 et _3** **rvg13_117en_2 et _3** **jwg13_85en_2 et _3**
Die Anlagen stehen auf der Website unter und	**RV 2012 EN** **RVG 2012 EN** **JWG 2012 EN**	**rv13_91en_2 und _3** **rvg13_117en_2 und _3** **jwg13_85en_2 und _3**
De bijlagen staan op de website onder en	**RV 2012 EN** **RVG 2012 EN** **JWG 2012 EN**	**rv13_91en_2 en _3** **rvg13_117en_2 en _3** **jwg13_85en_2 en _3**

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COMMISSION CENTRALE POUR LA NAVIGATION DU RHIN

RV (13) 91
RV/G (13) 117
JWG (13) 85
12 décembre 2013
Or. de fr/de/nl/en

COMITE DU REGLEMENT DE VISITE
GROUPE DE TRAVAIL DU REGLEMENT DE VISITE
GROUPE DE TRAVAIL COMMUN

Recommandation pour le pousseur Kooiman Marine (n° de chantier 204)

Communication du Secrétariat

Le Secrétariat a l'honneur de distribuer en annexe pour information la recommandation formulée par le groupe de travail du règlement de visite conformément à l'article 2.19 du RVBR.

COMMISSION CENTRALE POUR LA NAVIGATION DU RHIN

RECOMMANDATIONS AUX COMMISSIONS DE VISITE
RELATIVE AU RÈGLEMENT DE VISITE DES BATEAUX DU RHIN

RECOMMANDATION N° 24/2013
du 27 novembre 2013

Pousseur, n° de chantier 204 KOOIMAN MARINE B.V.

Le pousseur (n° de chantier 204 Kooiman Marine B.V., le numéro européen unique d'identification des bateaux sera distribué ultérieurement), est autorisé par la présente à utiliser du gaz naturel liquéfié (GNL) en tant que combustible pour son installation de propulsion et son installation auxiliaire.

Conformément à l'article 2.19, chiffre 3, le bâtiment est autorisé à déroger aux dispositions des articles 8.01, chiffre 3 et 8.05, chiffres 6, 9, 11 et 12 jusqu'au 30.6.2017. L'utilisation du GNL est réputée suffisamment sûre sous réserve que les conditions ci-après soient respectées à tout moment :

1. Le bâtiment doit être construit et classé conformément aux règles et sous le contrôle d'une société de classification agréée ayant établi des règles spécifiques pour les installations fonctionnant au GNL. La classe doit être maintenue.

2. Le système de propulsion au GNL doit être inspecté annuellement par la société de classification qui a classé le bateau.

3. Une étude HAZID exhaustive doit avoir été réalisée par la société de classification qui a classé le bateau (voir **annexe 1**).

4. Le système de propulsion au GNL doit être conforme au code IGF (Résolution MSC.285(86) du 1er juin 2009) à l'exception des points mentionnés en **annexe 2**.

5. Le système de propulsion au gaz naturel liquéfié est conçu de manière à limiter autant que possible les émissions de méthane.

6. Le réservoir de stockage de GNL doit être conforme aux exigences applicables aux réservoirs de type C conformément au Code IGC (Résolution de l'OMI MSC 5(48). Le réservoir doit être fixé à bord du bateau de manière à garantir qu'il y demeure fixé en toutes circonstances. Le réservoir porte un marquage indiquant clairement qu'il s'agit d'un réservoir de gaz naturel liquéfié.

7. L'avitaillement au GNL doit être réalisé conformément aux procédures figurant à l'**annexe 3.**

8. L'entretien du système de propulsion au GNL doit être assuré conformément aux instructions du fabricant. Ces instructions doivent être conservées à bord. Préalablement à toute remise en service à la suite d'une réparation substantielle, le système de propulsion au GNL doit être examiné par la société de classification qui a classé le bateau.

9. Tous les membres d'équipage doivent avoir suivi une formation sur les dangers, l'utilisation, l'entretien et l'inspection du système de propulsion au GNL conformément aux procédures figurant en **annexe 4**.

10. Un dossier de sécurité doit être prévu à bord du bâtiment. Le dossier de sécurité doit décrire les tâches de l'équipage et doit comporter un plan de sécurité.

11. Toutes les données relatives à l'utilisation du système de propulsion au GNL doivent être conservées par le transporteur durant au moins cinq ans. Ces données doivent être communiquées à l'autorité compétente sur demande.

12. Un rapport annuel d'évaluation comportant l'ensemble des données collectées doit être adressé au Secrétariat de la CCNR pour distribution aux Etats membres. Ce rapport d'évaluation doit comporter au minimum les informations suivantes :
    a) panne du système ;
    b) fuites ;
    c) données relatives à l'avitaillement (GNL) ;
    d) données relatives à la pression ;
    e) réparations et modifications subies par le système GNL, réservoir compris ;
    f) données de fonctionnement ;
    g) données relatives aux émissions, y compris les émissions de méthane ;
    h) rapport d'inspection de la société de classification qui a classé le bateau.

Annexes :

Annexe 1 : Etude HAZID (Rapport N° RDS/ENG/130370 du 18 avril 2013)
Appendice 1: HAZID Worksheets and summary of actions
Appendice 2: Risk Ratings
Appendice 3: Terms of reference / scoping study
Appendice 4: General arrangement and system plans

Annexe 2 : Synthèse des dérogations au Code IGF (IMO-Résolution MSC.285(86), 1er juin 2009)

Annexe 3 : BNR 204 Principles for Bunkering Procedure

Annexe 4 : Description de la formation des équipages à bord de bateaux de la navigation intérieure dont la propulsion est assurée par du GNL

Annexe 5 : Description du projet Kooiman Marine B.V. (Spécifications et conception du pousseur)
Appendice 1: SPD032590-01-LNGPacV155 Wärtsilä safety philosophy document for vertical LNG pack 10-04-2013 Rev 16-04-2013
Appendice 2: 204-035S-001 Propulsion Concept Shaft generators Aux. on LNG and Battery Rev. M

Annexe 6: Rapport TNO (TNO-2013-M02642, 052.03406, HAZID, LNG pushboat new build)

Annexes are located on website under and	**RV 2012 EN** **RVG 2012 EN** **JWG 2012 EN**	**rv13_91en_2 and _3** **rvg13_117en_2 and _3** **jwg13_85en_2 and _3**
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CENTRALE COMMISSIE VOOR DE RIJNVAART

RV (13) 91
RV/G (13) 117
JWG (13) 85
12 december 2013
Or. de fr/de/nl/en

COMITÉ REGLEMENT VAN ONDERZOEK
WERKGROEP REGLEMENT VAN ONDERZOEK
GEMEENSCHAPPELIJKE WERKGROEP

Aanbeveling duwboot Kooiman Marine
(werf nr. 204)

Mededeling van het secretariaat

Het secretariaat heeft het genoegen u hierbij ter informatie de door de Werkgroep Reglement van onderzoek overeenkomstig artikel 2.19 van het ROSR geuite aanbeveling te doen toekomen.

CENTRALE COMMISSIE VOOR DE RIJNVAART

AANBEVELINGEN AAN DE COMMISSIES VAN DESKUNDIGEN MET BETREKKING TOT TOEPASSING VAN HET REGLEMENT ONDERZOEK SCHEPEN OP DE RIJN

AANBEVELING Nr. 24/2013

van 27 november 2013

Duwboot, werf nr. 204 KOOIMAN MARINE B.V.

Voor de duwboot (werf nr. 204 Kooiman Marine B.V. Europees scheepsidentificatienummer moet nog worden verkregen) wordt bij deze de vergunning afgegeven voor het gebruik van vloeibaar aardgas (LNG, Liquefied Natural Gas) als brandstof voor de voortstuwings- en hulpinstallatie.

Op grond van artikel 2.19, derde lid, mag bij genoemd schip worden afgeweken van de artikelen 8.01, derde lid, 8.05, zesde lid, 8.05, negende lid, 8.05, elfde lid en 8.05, twaalfde lid, tot en met 30.06.2017. Het gebruik van UN 1972 LNG wordt geacht voldoende veilig te zijn indien te allen tijde aan de volgende voorwaarden wordt voldaan:

1. Het schip wordt gebouwd en geklasseerd onder toezicht en overeenkomstig de van toepassing zijnde voorschriften van een erkend classificatiebureau dat specifieke voorschriften voor LNG-installaties hanteert. De klasse blijft gehandhaafd.

2. Het LNG-voortstuwingssysteem wordt jaarlijks gekeurd door het classificatiebureau dat het schip heeft geklasseerd.

3. Een volledige HAZID-keuring door het classificatiebureau dat het schip heeft geklasseerd (zie **bijlage 1**) is uitgevoerd.

4. Het LNG-voortstuwingssysteem voldoet aan de IGF-Code (IMO-Resolutie MSC 285(86) van 1 juni 2009), behoudens de in **bijlage 2** vermelde onderdelen.

5. Het LNG-voortstuwingssysteem is zodanig uitgevoerd dat uitstoot van methaan maximaal wordt beperkt.

6. De LNG-opslagtank voldoet aan de voorschriften voor Type C-tanks overeenkomstig de IGC-code (IMO-Resolutie MSC 5(48). De tank is dusdanig op het schip aangebracht dat verzekerd is dat deze onder alle omstandigheden aan het schip bevestigd blijft. Op de tank zijn tekens aangebracht die duidelijk weergeven dat het een LNG-opslagtank betreft.

7. Bunkeren van LNG wordt uitgevoerd conform de in **bijlage 3** vermelde procedures.

8. Het onderhoud van het LNG-voortstuwingssysteem wordt uitgevoerd overeenkomstig de instructies van de fabrikant. De instructies worden aan boord bewaard. Voordat het voorstuwingssysteem na een reparatie opnieuw in bedrijf wordt gesteld, moet het door het classificatiebureau dat het schip heeft geklasseerd onderzocht worden.

9. Alle bemanningsleden zijn opgeleid in de bestrijding van gevaren alsmede in het gebruik, het onderhoud en de inspectie van het LNG-voortstuwingssysteem overeenkomstig de in **bijlage 4** vermelde procedures.

10. Een veiligheidsrol is beschikbaar aan boord van het schip. De veiligheidsrol beschrijft de taken van de bemanning et bevat tevens een veiligheidsplan.

11. Alle gegevens betreffende het gebruik van het LNG-voortstuwingssysteem worden verzameld door de vervoerder en moeten minstens vijf jaar worden bewaard. Deze gegevens worden op verzoek naar de bevoegde autoriteit verzonden.

12. Er wordt jaarlijks een evaluatierapport, waarin alle verzamelde gegevens zijn opgenomen, opgesteld en naar het secretariaat van de CCR gezonden, ter uitdeling onder de lidstaten. Dit evaluatierapport bevat ten minste de volgende informatie:
    a) systeemuitval;
    b) lekkage;
    c) bunkergegevens (vloeibaar aardgas);
    d) drukgegevens;
    e) afwijkingen, reparaties en wijzigingen van het LNG-systeem, de tank hieronder begrepen;
    f) functioneringsgegevens;
    g) uitstootgegevens, methaan hieronder begrepen;
    h) verslag van het onderzoek opgesteld door het classificatiebureau dat het schip heeft geklasseerd.

Bijlagen:

Bijlage 1: HAZID Study (Verslag No. RDS/ENG/130370, d.d. 18 april 2013)
Aanhangsel 1: HAZID Worksheets and summary of actions
Aanhangsel 2: Risk Ratings
Aanhangsel 3: Terms of reference / scoping study
Aanhangsel 4: General arrangement and system plans

Bijlage 2: Overzicht van afwijkingen van de IGF Code (IMO-Resolutie MSC.285(86) van 1 juni 2009)

Bijlage 3: BNR 204 Principles for Bunkering Procedure

Bijlage 4: Beschrijving van de opleiding van bemanningen aan boord van binnenschepen die met vloeibaar aardgas worden aangedreven

Bijlage 5: Project beschrijving Kooiman Marine B.V. (Specificatie en voorontwerp van de duwboot)
Aanhangsel 1: SPD032590-01-LNGPacV155 Wärtsilä safety philosophy document for vertical LNG pack 10-04-2013 Rev 16-04-2013
Aanhangsel 2: 204-035S-001 Propulsion Concept Shaft generators Aux. on LNG and Battery Rev. M

Bijlage 6: Verslag TNO (TNO-2013-M02642, 052.03406, HAZID, LNG pushboat new build)

Annexes are located on website under and	**RV 2012 EN**	**rv13_91en_2 and _3**
	RVG 2012 EN	**rvg13_117en_2 and _3**
	JWG 2012 EN	**jwg13_85en_2 and _3**
Les annexes sont enregistrées sur le site sous et	**RV 2012 EN**	**rv13_91en_2 et _3**
	RVG 2012 EN	**rvg13_117en_2 et _3**
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