HYUNDAI HEAVY INDUSTRIES | ENGINE & MACHINERY

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TECHNICAL CIRCULAR

DOC No.: HHI-TEC-0449
Date : July 25, 2022

SUBJECT: THE HAZARD EVALUATION OF FUEL GAS ACCUMULATION FOR ME-GA ENGINE.

TYPE: ALL HYUNDAI-MAN B&W ME-GA ENGINE

DISTRIBUTION

☑ Ship yard	☑ Ship owner

Date	TEC No.	Design	Check	Approve	Change	R
20220725	HHI-TEC-0449	GCH	LDH	SSH	First issue.	0
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TECHNICAL CIRCULAR

We, HHI-EMD, inform customers of ME-GA engine's hazard evaluation for IGC Code (2014) 16.7.3.3. According to the attachment *), the overall hazard evaluation of the ME-GA engine without gas detection located in the scavenge air space, the crankcase and sump has been concluded to be equivalent to that required by the IGC Code(2014).

16.7.3 ***Safety***
16.7.3.3 Crankcases, sumps, scavenge spaces and cooling system vents shall be provided with gas detection.

We inform that engine licensor/licensee is not position to lead the process that any third party application for exemption or alternative approval. In case a Flag state or Classification society requires further clarification and more detail information, engine licensor/licensee will support the clarification/discussion.

If a Flag state/Classification society requests direct gas detection application, please refer to drawings **) for your system design.

We hope the information will do you a valuable service.

[The end]

Attachment: *) HAZARD EVALUATION OF FUEL GAS ACCUMULATION IN THE SCAVENGE AIR, SUMP AND CRANKCASE SAPCES IN MAN B&W ME-GA ENGINS.
**) Drawing for crankcase ventilation(5660069-2) & Scav air drain system(0796103-0)

Yours sincerely,

S. H. SHIN / Senior Engineer
Head of Engine System Technical Sales Dep't

MAN Energy Solutions, 2450 Copenhagen, Denmark

To whom it may concern

Copenhagen, 28th of February 2022

Ref. 11091-2022

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HAZARD EVALUATION OF FUEL GAS ACCUMULATION IN THE SCAVENGE AIR, SUMP AND CRANKCASE SPACES IN MAN B&W ME-GA ENGINES

The purpose of this hazard evaluation is to justify that the level of safety is equivalent to that required by the IGC Code (2014) 16.7.3.3 after removing the gas detectors in the scavenge air space, the crankcase and sump on a ME-GA engine.

This is based upon, the IGC Code (2014) 1.3 *Equivalents,* which allows a particular item of equipment or arrangement to be substituted if the new item of equipment or arrangement can be proved at least as effective as that required by the Code.

Conclusion

Based on the combination of cyclic monitoring of the fuel gas pressure in the fuel gas supply bore and the combustion expansion pressure, which indicates that the gas is burned, any abnormal operation will be detected and led to fail-safe condition. This ensures that the engine control system will detect a potential abnormal situation early and respond to the situation fast by changing over to operate the engine in primary essential mode (fuel oil). In addition, the sealing oil pressure is constantly monitored by redundant pressure transmitters, ensuring that the sealing oil pressure is always higher than the gas pressure. In case the pressure falls to below gas pressure, the engine is changed over to operate in primary essential mode (fuel oil). Thereby any contamination of sealing oil or hydraulic oil is avoided.

During any engine stop, the gas fuel system is separated from the combustion chamber by valves in series, and the gas supply system is depressurised, and freed from gas. Accordingly, gas contamination of the scavenge air space, crankcase and sump is only possible during engine running. However, in running conditions a constant airflow through the engine ensures that potential accumulation of gas is not possible.

The overall hazard evaluation of the ME-GA engine without gas detection located in the scavenge air space, the crankcase and sump has been concluded to be equivalent to that required by the IGC Code (2014).

For further clarification and understanding of the engine concept, please proceed to Appendix A.

Risk assessment

To ensure that the level of safety is the same for all our products, MAN Energy Solutions uses the same risk acceptance criteria for all our risk assessments.

By using the same risk acceptance criteria for all our products, we ensure that all our products are designed within the same level of safety, regardless of the combination of concepts and applications.

The risk acceptance criteria have been utilised for many years in our risk assessments and is globally accepted by flags state Authorities, Recognised Organisations, and the industry in general.

Within all risk assessments, we have implemented the ALARP principle as the best practice to ensure that we design our products with the lowest reasonable risk as possible.

Safety concept

The overall safety for the ME-GA engine is based on the safety philosophy of ***early detection, fast response*** and ***fail to safe condition***.

All failures detected during normal operation with dual fuel results in a stop of the secondary essential fuel supply and initiate an automatic changeover to primary essential fuel. Following the changeover, the secondary essential fuel pipes and the complete secondary essential fuel supply system are blown out and freed from gas by purging.

This condition also applies to failures of the control system itself. The control and safety system is designed so that any changeover between fuel modes is done without power loss of the engine to ensure the safety of the vessel and its operation.

For further information or additional question please forward you request to:
Classification2S@man-es.com

Best regards,

Christian Rasmussen
Head of Classification Departement

Denis Cederholm-Larsen
Senior Classification Engineer

Appendix A

General description of the ME-GA engine

The MAN B&W ME-GA engine is a crosshead two-stroke low-speed dual fuel engine. The engine illustrated in Figure 1 shows the exhaust receiver, exhaust valve, combustion chamber, piston and piston rings, scavenge air space, stuffing box and crank case.

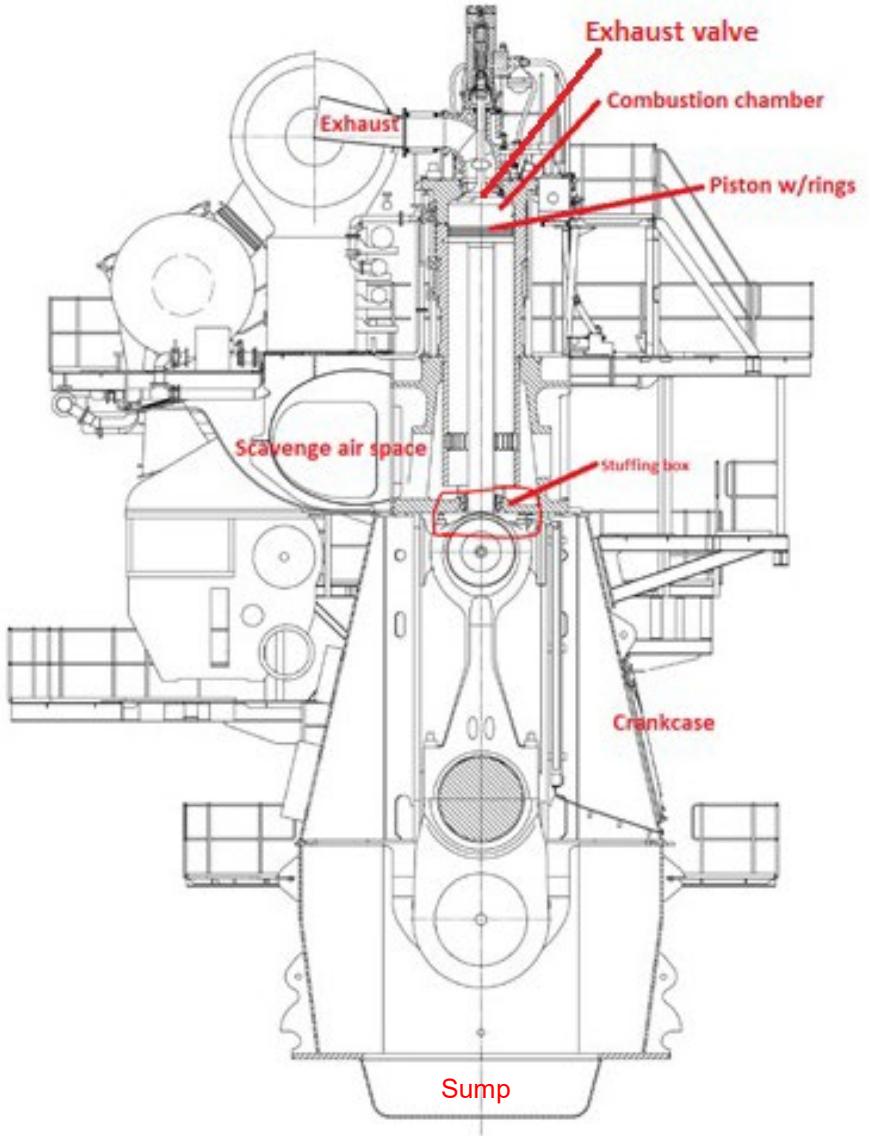

Figure 1. Engine cross section, turbocharger(s) mounted on the exhaust side

The stuffing box between the crankcase and the scavenge space ensures that scavenge air does not enter the crankcase. The stuffing box is designed to withstand the scavenge air pressure.

MAN B&W engines are designed with a crankshaft housing release valve, dimensioned to provide safety if any explosion occurs in the crankshaft housing. Further, the crankshaft housing is designed with ventilation to deck.

Thanks to the stuffing box between the crankcase and the scavenge air spaces, there is no direct connection between the crankcase and the combustion chamber. Leakage and accumulation of gas to the crankcase is not possible.

MAN B&W engines are equipped with a scavenge space safety valve designed with an opening pressure of 5 bar. The safety valve is dimensioned to provide safety in case of ignition in the scavenge space. The scavenge space is ventilated through the engine scavenge air drain.

When the engine is running, the scavenge air pressure is higher than in the exhaust gas receiver. The scavenge space will therefore be continuously ventilated through the combustion chamber to the exhaust system when the piston is in bottom position.

Engine control system

The ME-GA engine has two basic modes of operation: the primary essential mode (fuel oil) where the engine is operating according to the Diesel combustion principle, and the second essential mode (dual fuel) where the engine is operating according to the Otto combustion principle. In both modes, the engine is controlled by the engine control system (ECS).

The gas supply system is arranged in such a way that no gas is present in the engine when the engine is not running. Before changing to gas mode, the engine will be running in fuel oil mode, and a safety test will be conducted. The safety test is a start-up sequence that tests all the safety functionalities including all valves in the gas supply system by means of cyclical pressure checks with nitrogen.

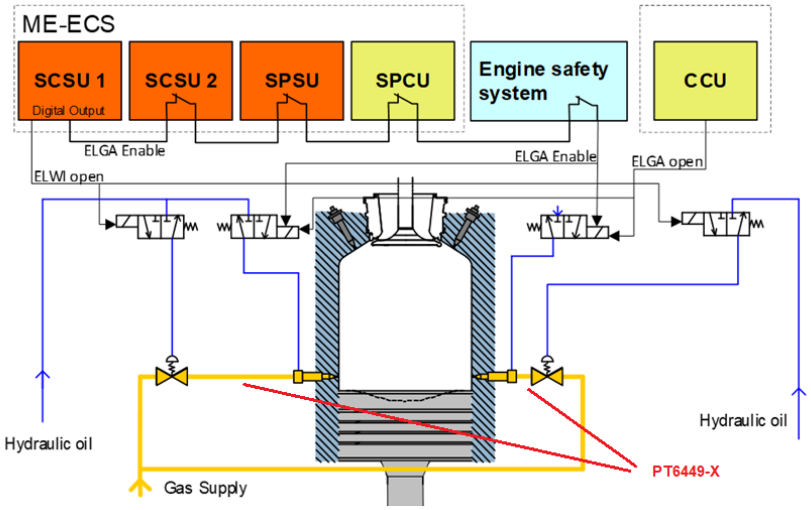

Figure 2. Schematic diagram

The engine is equipped with a set of valves in series, a window valve (WV) and a gas admission valve (GAV).

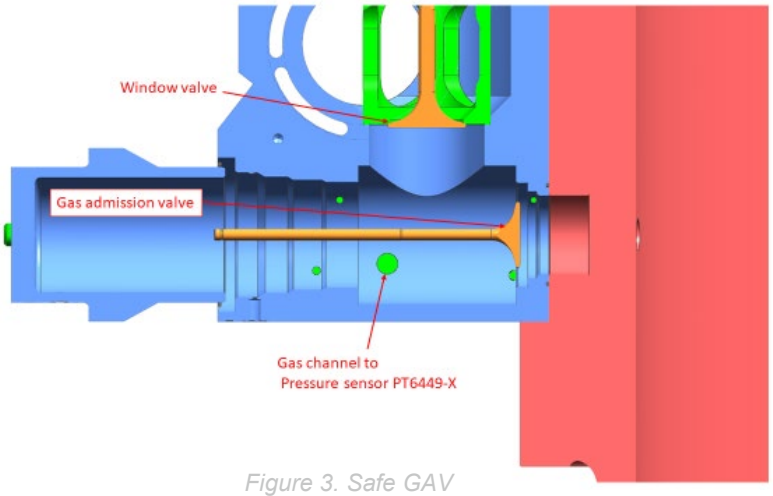

Figure 3. Safe GAV

The two valves in series make two independent systems for preventing mistimed admission. The fuel gas supply pressure PT6449-X is monitored between the WV and the GAV, and if the pressure is not as expected during the cycle, a gas shutdown will be initiated, and the engine will continue running in the primary essential mode (fuel oil).

During an gas shutdown, engine stop or a timed period without gas running, the gas supply pipes are vented and purged by nitrogen.

In gas mode, the gas will be injected approximately at mid-cylinder position when the piston is on its upward movement. Gas admission can only occur when the piston is below the point of the gas inlet. The gas is ignited by pilot fuel oil when the piston is close to its top position.

When the engine is operating in gas mode the cylinder pressure is constantly monitored by the pressure transmitter PT1422-X. This monitoring evaluates whether a correct combustion has occurred for each cycle. A gas shutdown will be initiated in the event of a failure and the engine will continue running in the essential mode (fuel oil).

The ME-GA engine uses pressurized hydraulic oil for control and activation of the Window valves (WV) and fuel gas admission valves as well as for sealing purpose, to ensure that fuel gas does not enter the control oil in the WVs and fuel gas admission valves.

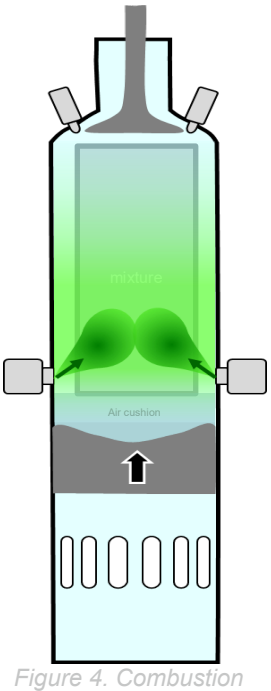

Figure 4. Combustion principle

When the engine is operating in gas mode the sealing oil pressure is controlled to be 3 bar higher than the gas pressure. The sealing oil pressure is supervised by two sensors, PT6110 & PT6104, and if pressure is below margin to gas pressure, PT6006, PT6024, PT6017, on one of them, a gas trip will be initiated and gas pipes ventilated.

Risk assessment considerations

In order to evaluate all hazards related to the ME-GA engine, a dedicated risk assessment team has conducted a full risk assessment.

The full content of the risk assessment can only be witnessed by flag states Authorities and Classification Societies since the content is classified as confidential and business critical.

However, a quantified selection of items have been identified, and these are listed in Table 1, to support the overall understanding of this hazard evaluation. These items are limited in the information where deemed necessary to avoid any violation of our confidentiality and company policies.

In case further clarification is needed, or if you wish to apply for full access to the risk assessment, please forward your request to: Classification2S@man-es.com

Risk terminology and definitions:
Unintended area – *all other areas than specified as intended*
Combustion gas – *mixture of combustion products and air*
DF – *dual fuel*
GAV – *gas admission valve*
Explosive atmosphere – *a mixture of fuel and air with the potential of ignition*
Standby – *only diesel operation*
ELGA - *electronic gas valve (pilot valve activating gas admission valve)*

Node	ID	Mode	Hazard event	Possible Causes	Consequence	Barriers
2	13	Start-up DF operation	Gas channel pressure does not increase when WV is closed	C1. Leaking GAV	C1. Gas injected under piston	B1. Gas channel supervision PT6449-X detects leaking GAV. Limited volume between WV and GAV.
2	53	DF Operation	Missing gas injection	C1. GAV does not open. C2. ELGA-Valve does not open	No gas injection	Cylinder pressure supervision PT1422-X
2	54	DF Operation	Too little injection amount	C1. Window Valve does not open. (Gas admission low) C2. FO Atomizer clogged. C3. Fast de-acceleration	Low injection	Cylinder pressure supervision PT1422-X
2	23	Standby	Gas leakage through GAV into cylinder. Both above and below piston.	C1. Minor leakages in GAV	C1. Gas in unintended areas	B1. Gas channel supervision PT6449-X detects leaking GAV. Limited volume between WV and GAV.
Node	**ID**	**Mode**	**Hazard event**	**Possible Causes**	**Consequence**	**Barriers**

2	24	Start-up and DF Operation	Sealing oil pressure below gas pressure	C1. Severe seal oil leakage C2. WV failure C3. Seal oil supply failure	C1. Gas in unintended areas	B1. Redundant supervision of seal oil pressure PT6110 and PT6104.
2	58	DF Operation	Gas admission valve is untimed open or leaking.	C1. Damaged Valve seat C2. ELGA valve is stuck open C3. Spindle stuck	Combustion gas in gas channel	Gas channel pressure supervision PT6449-X results in gas shutdown. Cylinder pressure supervision PT1422-X
3	121	Start-up, DF Operation and Standby	Gas in Sealing Oil system.	C1. Pipe rupture. C2. Sealing Oil pressure below SF pressure.	C1. Gas in unintended areas	B1. Redundant supervision of seal oil pressure PT6110 and PT6104.
4	80	Start-up, DF Operation and Standby	Gas in hydraulic oil	C1. Sealing Oil pressure failure	C1. Malfunction of Gas admission valve, Window Valve - Gas in crankcase or sump in severe cases.	B1. Redundant supervision of seal oil pressure PT6110 and PT6104.
8	126	DF Operation	Gas in scavenge air receiver	C1. Gas passing piston rings during compression stroke. C2. Mistimed activation of GAV causing gas admission below piston head. C3. GAV failing to close or leaking	C1. Gas in unintended areas C2. Explosive atmosphere under piston / scavenge air receiver	B1. Scavenge air pressure and flow will ensure that gas does not propagate into scavenge air receiver. B2. WV limits amount of gas that can be admitted due to mistimed activation of GAV. B3. Gas channel supervision PT6449-X detects leaking GAV. Resulting in gas shutdown and WV is kept closed. **Additional barriers** - Cylinder pressure supervision PT1422-X
8	127	DF Operation	Gas in crank case	C1. Gas passing stuffing box C2. Cracked piston	C1. Explosive atmosphere in crank case	B1. Seal and drain in stuffing box prevents gas leakage to crankcase. B2. Cylinder pressure supervision PT1422-X **Additional barriers** - Gas channel supervision PT6449-X detects leaking GAV. Resulting in gas shutdown and WV is kept closed. - Explosion protection valves in crankcase.

Table 1 – Selected items from the risk assessment

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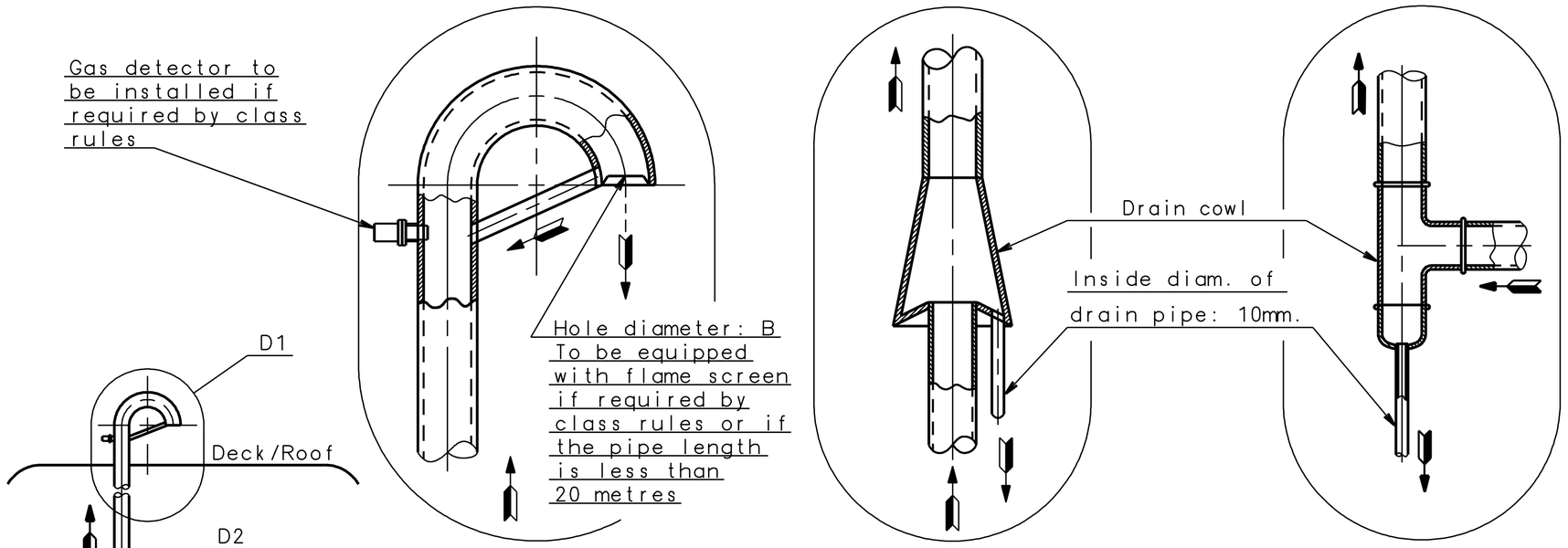
Detail 1

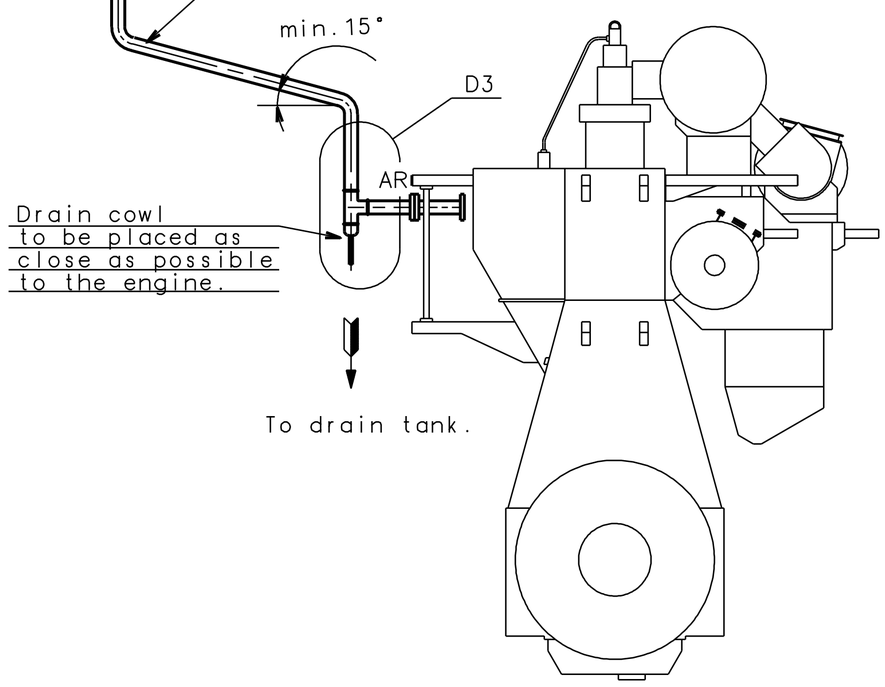
Detail 2

Detail 3

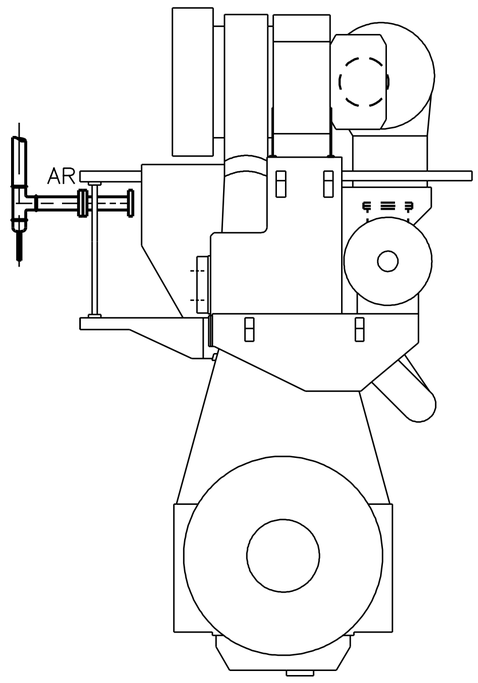


Engine type	Nom. pipe diameter in mm	
	A	B
S50ME-C8-GI	40	45
G60ME-C9-GI	50	55
S60ME-C8-GI	50	55
S65ME-C8-GI	50	55
G70ME-C9-GI	50	55
S70ME-C8-GI	50	55
L70ME-C8-GI	50	55
G80ME-C9-GI	65	75
S80ME-C8-GI	65	75
S80ME-C9-GI	65	75
S90ME-C8-GI	80	90
S90ME-C9-GI	80	90
S90ME-C10-GI	80	90
G95ME-C9-GI	80	90

The venting pipe has to be equipped with a drain cowl as shown in detail 2 and 3. Note that only one of the above solutions should be chosen.



Main engine with turbocharger located on exhaust side



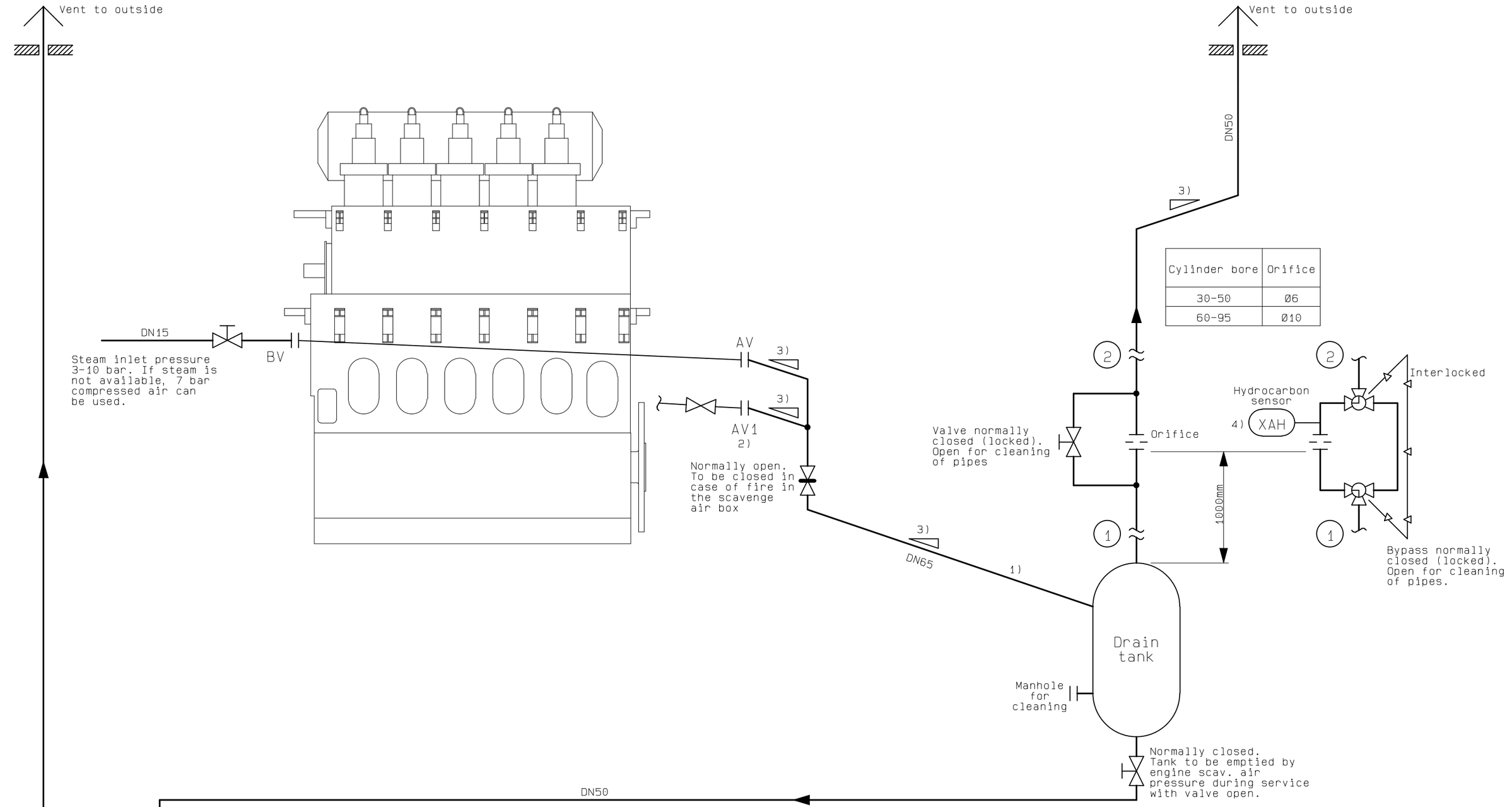
Main engine with turbocharger located on aft end

Date	Des.	Chk.	A.C.	Revision change	Chg. Not.	Rev.
			*			
			*			
			*			
20141125	DFA	KID	*			00

Basic Standards (MBD SB): EN21F-m Tolerances EN21C Surf. roughness		Suppl. Drawing No.:		
Material / Blank:		Final User Material:		Mass (kg):
Scale:	Size: A2	Product Type: ME-C-GI	Page No.: 01 (02)	Projection: MAN Diesel
Info. No.: 376660		Item Name: CRANKCASE VENTILATION		Item Id.: 5660069-2
Final User Info. No.:		Final User Description:		Final User Ident. No.:

CAD Drawing - do not correct by hand - CAD Drawing

0703A2p1



For general notes and equipment specifications, see next page.

028 The letters refer to "List of flanges".

Date	Des.	Chk.	A.C.	Revision change	Chg. Not.	Rev.
20220127	IBB	KELL	Z4	Note 4 updated.		10
20060921	IBB	SUK				00

Suppl. Drawimg No.:

Basic Standards:	Product Type: STANDARD	Size: A3	Page No.: 1 (2)
Info. No.: 376667	Item Name: SCAV.AIR DRAIN SYSTEM		Item Id.: 0796103-0
Final User Info. No.:	Final User Description:		Final User Ident. No.:

F

Scavenge air drain tank

Type:..... Pressure vessel.

Design pressure:..... The drain tank shall be designed according to the pressurised system connected to the BV connection as one of the following connected cleaning systems:

- Steam maximum working pressure
- Compressed air maximum working pressure

Tank size:..... Based on being emptied once a week.

Cylinders/Bore	26-35 (Liters)	40-50 (Liters)	60-70 (Liters)	80-90 (Liters)	95 (Liters)
5 - 6	150	300	500	800	1000
7 - 9	200	400	700	1100	1400
10 - 12	250	500	900	1500	1800

Location of tank:..... It is recommended that the drain tank is located close to the engine to avoid long piping between engine and drain tank and thereby minimize the risk of the pipe being blocked by sludge.

Cleaning hatch: ..... It is recommended that a cleaning hatch of sufficient size be installed so that it is easy to clean the drain tank.

Note 1, Drain line

General recommendation:..... The continuous drain from the engine scavenge air area must not be directly connected to the sludge or waste oil tank due to pressure level.

Design recommendation:..... The following are to be considered for the drain line between the engine and the scavenge air drain tank:

- Piping must be carried out as straight as possible, thus minimizing the use of pipe bends.
- Using bends with large/wide bending radius.

Note 2, AV1 connection

General recommendation:..... If the engine type is equipped with both AV and AV1 pipe flange connections (ref. to “List of Flanges”) these two connections shall be connected to a common pipe to the scavenge air drain tank.

Note 3, Vent pipe routing

Inclination: ..... Vent pipes has to be routed steadily ascending so no possible pipe pocket can occur according to the vessel static longitudinal and transverse inclination. In general a longitudinal inclination shall be taken as min. 5° (might be smaller based on length of vessel and applicable classification society rules) and a transverse inclination shall be taken as min. 15°.

Note 4, Hydrocarbon sensor and special vent outlet location

Engine type: ME, fuel oil only:..... Hydrocarbon sensor and special vent outlet location are not relevant.

Engine type: ME-GI/-GA/-GIE/-LGIM/-LGIP:.. Hydrocarbon sensor and special vent outlet location are not relevant, but can be overruled by applicable flag state authority who might require the following:

Tank vent: Vent outlet constitute a hazardous zone and has to be placed outside safe area. Outside hazardous zone according to flag state/classification society requirement.

Monitoring: Hydrocarbon alarm sensor to be installed in vent line.

Date	Des.	Chk.	A.C.	Revision change	Chg. Not.	Rev.
20220127	IBB	KELL	Z4	Note 4 updated.		10

Basic Standards:	Product Type: STANDARD	Size: A3	Page No.: 2 (2)
Info. No.: 376667	Item Name: SCAV.AIR DRAIN SYSTEM		Item Id.: 0796103-0
Final User Info. No.:	Final User Description:		Final User Ident. No.:

F