The Technology of Methanol Fuel Supply Unit for Two-stroke Engine

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Manuscript received December 10, 2024; revised March 16, 2025; accepted April 25, 2025.

***Abstract*—The goal of the methanol Fuel Supply System (LFSS) is to provide the methanol fuel to the engine as required. It must be achieved during engine operation and bunkering. The methanol fuel must be delivered to the engine within a specific range of temperature, pressure and purity. It is achieved by means of supply pumps, heat exchanger and filters.**

***Keywords*—methanol fuel, supply system, engine**

I. Overview

Methanol as a transport fuel, its ease of synthesis and broad range of source feedstocks makes it a strong candidate for a sustainable fuel with the potential to significantly reduce the fossil carbon footprint of transportation. The increased efficiency with which it can be synthesized in relation to ethanol or synthetic hydrocarbons, coupled with the improved brake thermal efficiency it produces in combustion systems, means that there is a double, compounded effect on improving primary energy utilization. Additionally, while it does produce hydrocarbon emissions at a similar level to gasoline (albeit of different species), its combustion characteristics and single-carbon-molecule nature mean that its emissions of oxides of nitrogen and particulate matter are significantly lower than for complex hydrocarbon fuels. Hence, it has potential advantages from energy security, sustainability, and air quality viewpoints, all with no real upper limit on scale. This latter point is the case when production techniques using renewable energy and direct air capture of CO_2 are considered as a means of providing inputs to a closed carbon cycle.

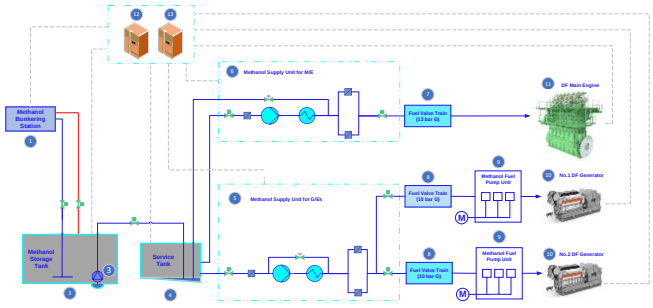

Fig. 1. The flow diagram of methanol supply system

II. General

Low-flashpoint Fuel Supply System (LFSS) is equipped to supply methanol fuel for dual-fuel main engine. Redundancy of propulsion and power supply is ensured by fuel oil in case of fuel supply shutdown. The Methanol system shall consist of bellows.

A. Bunkering Station

The methanol is transferred on board the vessel through a bunkering station. The recommended location for this station is on the open deck because there is sufficient natural ventilation.

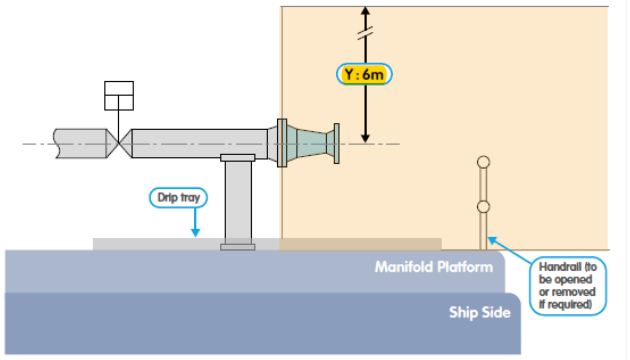

Fig. 2. Open-deck bunker station (Side View).

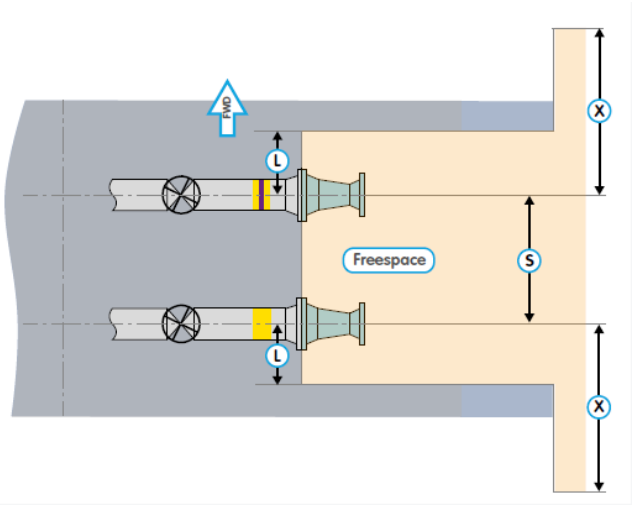

Fig. 3. Open-deck bunker station (Plan View).

The area directly outboard of the bunker station should, by design, be kept clear of obstructions, including temporary obstructions such as bunker barge mooring lines, and vessel structures.

Additionally, it must be at a certain distance from air intakes, accommodation openings and machinery spaces. The bunkering lines must not be led through accommodations. In case of passage in enclosed spaces, a second barrier for the bunkering line must be considered (e.g. double-wall type or located in gas-tight ducts) [1]. The connections at the bunkering station must be of the dry-disconnect type [2]. The bunkering lines must be arranged for inerting and gas freeing. For safety purposes, drip trays must be provided below the bunkering connections to collect and direct any spillage to a dedicated drain tank.

DOI: 10.7763/IJET.2025.V17.1311

B. Methanol Storage and Service Tanks

From the bunkering station, methanol is transferred to the methanol storage tank(s) and to the service tank(s) by means of transfer pumps. Different type of tanks can be used for methanol, such as independent, integral and portable tanks.

The independent tank is self-supporting, do not form part of the ship structure and not essential to the hull strength [3].

The integral tank means a fuel-containment envelop tank which forms part of the ship structure and which can be stressed in the same manner and which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship hull.

The portable tank is an independent tank which can be easily connected and disconnected from ship systems, and easily removed from the ship and installed on the board ship [4]. Independently from the selected type, the fuel tanks must be fitted with a tank-controlled venting system to ensure the tanks are gas freed and filled with fuel from a gas-safe condition. Each tank must be fitted with pressure and vacuum relief valves. All fuel tanks must be fitted with inerting connection, to be inerted all time during normal operation . A cofferdam around the fuel tanks must also be provided as an additional layer of gas and liquid tightness protection against external fire, toxicity and flammability.

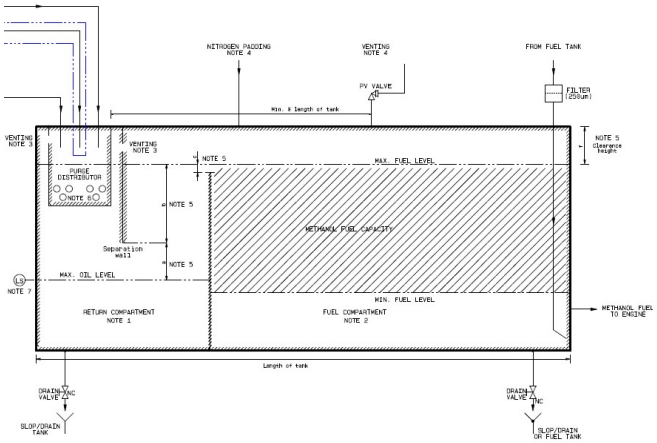

Fig.4. Methanol service tank.

The service tank should be nitrogen padded and equipped with a P/V valved and vacuum conditions. The maximum allowable opening pressure is 200 mbarg (Pressure Vacuum valve) able to protect the service tank from over pressure overpressure. for overpressure and -50 mbarg for vacuum. Nitrogen padding pressure should be set just below opening pressure for overpressure [5]. The vent and P/V valve should be dimensioned to avoid excessive pressure on vacuum in any of the following situations:

- Purging of engine to service tank
- Purging of fuel supply system to service tank
- Pumping fuel from service tank to M/E at full LFSS pump capacity
- Filling service tank fuel compartment at full transfer pump capacity

C. Methanol Fuel Supply System

The Methanol Supply Unit (MSU) is equipped to supply methanol for dual-fuel marine engines under the premise of specific meeting temperature, flow and pressure requirements. Methanol fuel is extracted from the methanol service tank, passed through the methanol supply pump and pumped into the Fuel Valve Train (FVT) eventually to meet the temperature and pressure requirements of M/E. According to the special operation environment of methanol powered vessels, the unit has been designed with the advantages of compact structure, automatic control, high safety, and stable fuel supply etc. The unit also gives full consideration on the convenience of installation, operation, and maintenance to greatly reduce the workload of crews.

MSU skid shall be installed in the FPR room. The skid consists of necessary components mounted on a common frame, complete with piping, valves, electrical cabling and other accessories.

All remote operated shut-off valves shall be of fail-safe type [6]. The main components of MSU skid as following:

- Supply pumps
- Methanol/ Glycol water Heater exchanger
- Methanol Circulation pumps
- Methanol Duplex filter
- Mass flow meter
- Glycol water pumps
- Glycol water/Low Temp. Fresh Water Heater exchanger
- Control valve
- Purging and drainage

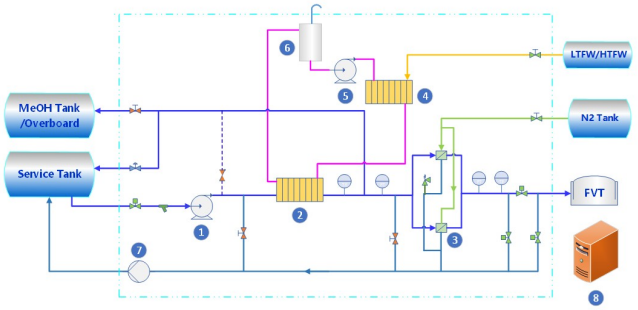

Fig. 5. Methanol supply unit flow-chart.

D. Ventilation Systems for Methanol Application

Independent ventilation systems of mechanical under-pressure type must be installed in all the hazardous areas where methanol vapour can accumulate [7], e.g. fuel preparation room, enclosed and semi-enclosed bunkering station, ducts and double-walled pipes, as well as any other spaces identified in the risk assessment.

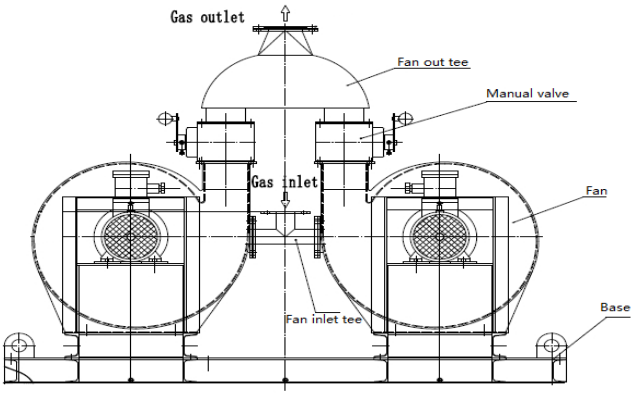

Fig. 6. Double wall pipe fans.

E. Gas Detection System

One set of gas detection system shall be used to monitor methanol leakage of LFSS.

The gas detection system shall be self–monitoring type. If a system fault is detected by the self–monitoring function, the output of the detection system is to be automatically disconnected such that the detector fault shall not cause false emergency shutdown.

The gas detection system shall be continuous without delay and always be in operation under the following conditions: methanol in the pipeline, normal operation and purging before maintenance [8].

Permanently installed gas detectors are to be supplied in FPR and any other machinery spaces containing methanol pipes and methanol consumers.

Audible and visible alarms of the gas detection equipment shall be supplied to the position required by the Class society.

The gas detection system shall be monitored on the main gas detection panel and shall be interfaced with AMS for common alarming with location of activated Gas detector & monitoring. Gas detectors of continuous measuring type to be provided for machinery trip for the following points. Where control actions are initiated by gas detectors, voting type arrangements to be used in accordance with regulation and rules requirement. Permanently installed gas detectors should be fitted in:

- All ventilated annular spaces of the double walled fuel pipes;
- Machinery spaces containing fuel equipment or consumers;
- Fuel preparation spaces;
- Other enclosed spaces containing fuel piping or other fuel equipment without ducting;
- Other enclosed or semi-enclosed spaces where fuel vapours may accumulate;
- Cofferdams and fuel storage hold spaces surrounding fuel tanks;
- Airlocks;
- Ventilation inlets to accommodation and machinery spaces, if required.

The number and placement of detectors in each space should be considered taking into account the size, layout and ventilation of the space. Gas dispersal analysis or a physical smoke test should be used to find the best arrangement.

Fuel vapour detection equipment should be designed, installed and tested in accordance with a recognized standard. (IEC 60079-29-1:2016-Explosive atmospheres-Gas detectors –Performance requirements of detectors for flammable gases.)

1) N_2 generating system

Two sets of membrane nitrogen generator unit shall be supplied to purge methanol pipeline after bunkering or stopping methanol supplying.

The following pipes and equipment shall be purged:

- Methanol bunkering pipes
- Methanol supply pipes

The nitrogen generator unit contains the following parts:

- Air compressor
- Membrane nitrogen generator

Discharge pressure about 10 bar G
Purity: No less than 95 %
-3 stage filter packaged
-PDP (pressure dew point) and purity (oxygen) sensor with alarm
-N_2 buffer tank
- Control module
Compressor status indications
Pressure, temperature indications
Compressor control
Meters (running hours, loading hours)
Safety-warning indications
Safety-shutdown indications
Output for remote monitoring
Block and bleed valves unit including related instruments

F. Emergency Shutdown System

The emergency shutdown system shall be designed according to MSC.1/Circ.1621 and Class requirements to ensure that the ship's methanol supply system is in safe condition in case of emergency.

Emergency shutdown system is designed to trip starting circuit of all gas related electric motor (s) except for ventilation fans and WG pump. The ventilation fan is required to run continuously unless that fire is detected in methanol area.

G. Ship Shore/Ship Link System

Ship shore/ship link shall be supplied for methanol bunkering operation, it shall meet recommendations and guidelines of SIGTTO. The system shall supply 5-way electric link and fiber-optic link or 5-way electric link and pneumatic link

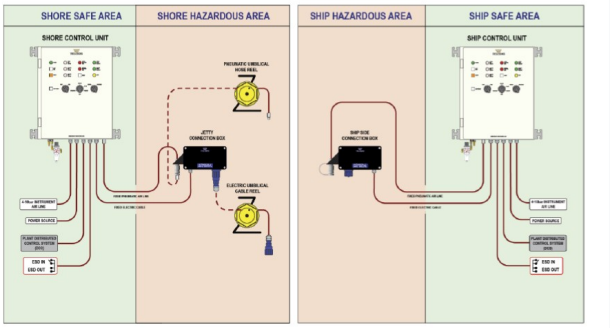

Fig. 7. Example of an electric pneumatic system.

H. Vent Mast

Vent mast shall be provided and located on upper deck of each ship side for PV valves, ventilations outlet etc.. Material of vent mast structure is carbon steel. Access ladder and maintenance platform shall be provided on vent mast head. The mast(s) are planned to be located nearby side shell, to be confirmed in detail design stage. It should be noted in this connection that the mast outlet should be at least 15 meters from inlets to accommodation or service spaces, in additional to the distances related to the hazardous zones. This is due to the toxic properties of methanol. It is noted that vent mast material is given as carbon steel, while tank venting is indicated as SS316L. Due to methanol's corrosivity, it is assumed stainless steel is also relevant as mast material.

I. Ventilation System

Ventilation system for other LFSS areas shall be supplied according to the MSC.1/Circ.1621 and Class requirements.

According to the MSC.1/Circ.1621 requirements, effective

mechanical negative pressure ventilation is supplied with capacity to change air at least 30 times per hour for enclosed space of LFSS area.

Inlet air for LFSS ventilation space is taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area [9]. Ventilation outlet of LFSS ventilation space is located on the open deck. The risk would be the same as or less than that of the ventilated space in the absence of the considered outlet.

Ventilation openings for the secondary enclosures shall be located in open air and away from ignition sources. The inlet opening shall be fitted with a suitable wire mesh guard to prevent water from entering.

All the signal output to LFSS main control panel and safety control panel.

J. Liquid Detection System

Level switches are used to monitor all locations where methanol leaks are possible.

Final type and quantity of liquid detection shall be subject to classification society approval.

K. Fire Detection and Alarm System

The fire detection system shall be installed in the related area of vessel for timely extinguishing operation by crew.

L. Fire-extinguishing System

Machinery space and fuel preparation space where methyl/ethyl alcohol-fueled engines or fuel pumps are arranged should be protected by an approved fixed fire-extinguishing system in accordance with SOLAS regulation II-2/10 and the FSS Code. In addition, the fire-extinguishing medium used should be suitable for the extinguishing of methyl/ethyl alcohol fires.

An approved alcohol-resistant foam system covering the tank top and bilge area under the floor plates should be arranged for machinery space category A and fuel preparation space containing methyl/ethyl alcohol.

The bunker station should have a fixed fire-extinguishing system of alcohol resistant foam type and a portable dry chemical powder extinguisher or an equivalent extinguisher, located near the entrance of the bunkering station as per related rules & regulation.

Welded connections are preferred wherever feasible [10]. The liquid pipelines are arranged to allow free drainage avoiding liquid traps as far as practicable. The piping system is designed to allow thermal expansion and contraction without excessive stress to the material.

Methanol piping shall be single wall in the bunkering station, TCS and methanol handling room. Double wall ventilated piping shall be supplied outside hazardous area below deck. Venting pipelines shall be single wall.

The pipe diameter shall be determined to meet the requirements of the maximum flow rate of the medium. Max. flow Velocity for methanol.

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M. Electrical System

The electrical components of LFSS are shown as follows:

- Control and monitor unit
- Methanol supply & circulation pumps starters
- Water glycol pumps starter
- N_2 generator control unit
- Safety and shutdown unit
- Monitor PC
- Multiple ESD buttons for safety system
- Repeat panel for safety system
- Two sets of UPS can supply 30 minutes of power to control unit and safety unit at least when main power fails.

N. Control and Monitor System

The control and monitor unit is based on a PLC system. As shown in the following table, it can monitor and control the signals of the methanol bunkering and storage, methanol supply, water glycol circulation.

The functions of the unit are as below:

- Manual & auto remote control of methanol bunkering
- Manual & auto remote control of methanol supply
- Level / temperature / pressure reading and alarm for methanol storage tanks
- Level / temperature / pressure reading and alarm for methanol drain tank
- Level / temperature / pressure reading and alarm for methanol processing
- Temperature reading and alarm of enclosed space
- Communication with AMS
- Communication with safety system.
- Pressure and Temperature control for methanol supply

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ding Ding conducted the research; Yudong Su analyzed the rule; Shuangqi Guo wrote the paper; all authors had approved the final version.

Acknowledgment

The authors wish to thank Chenyang Ma.

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