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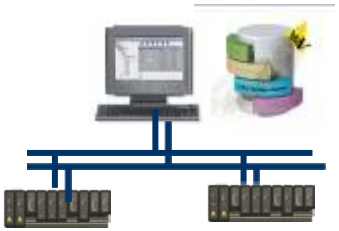
Uniform and Integrated Solution

Engines

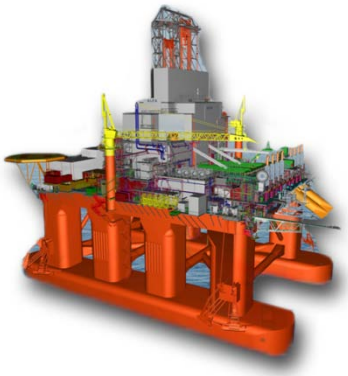
Propulsion



Automation

Power Distribution

Power Drives



Widest product portfolio

Leading edge solutions

- Concepts
- Applications
- Project Execution Models
- System Integration Capabilities
- Engineering Services
- Third party supplies

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LNG Engine Technology

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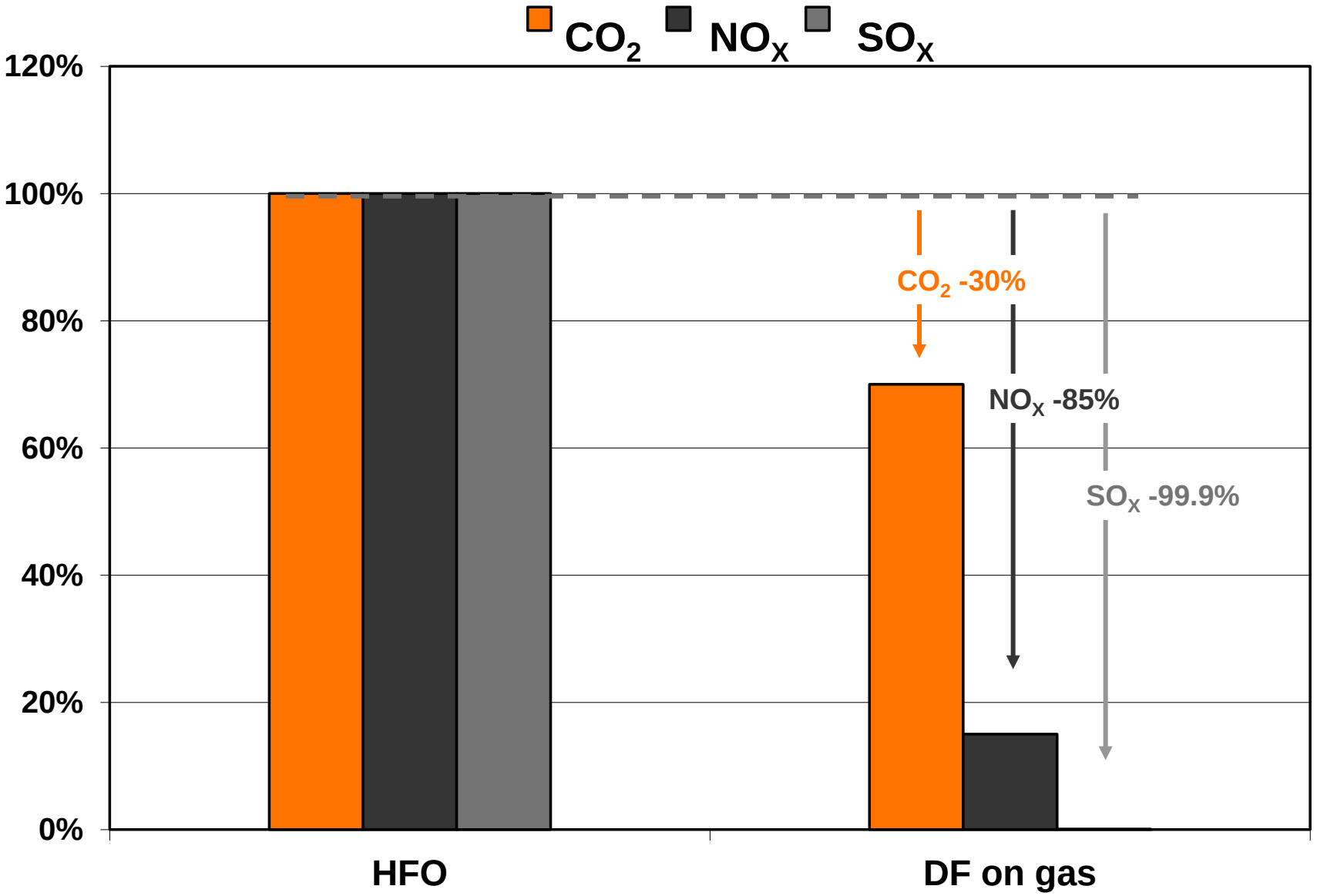
LNG ship - Emissions



Gas engine technologies

Gas-diesel (GD) engines:

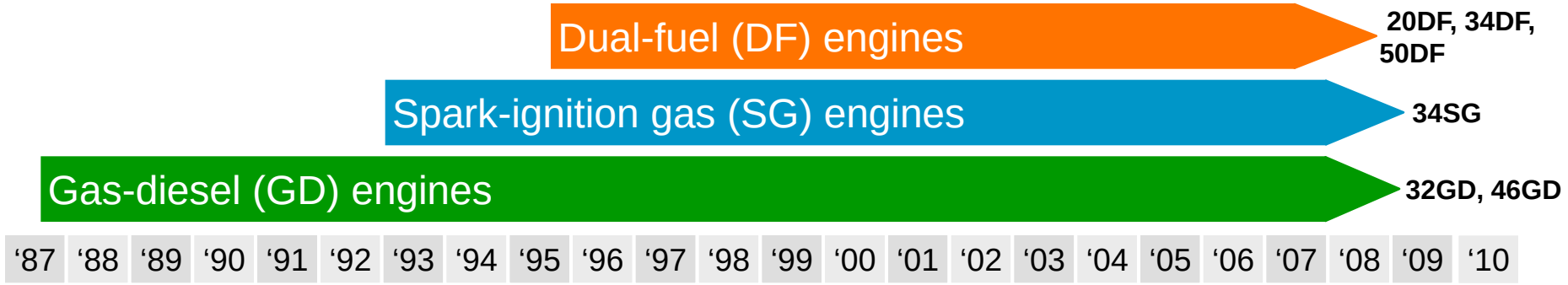
- Runs on various gas / diesel mixtures or alternatively on diesel.
- Combustion of gas, diesel and air mixture in Diesel cycle.
- High-pressure gas injection.

Spark-ignition gas (SG) engines:

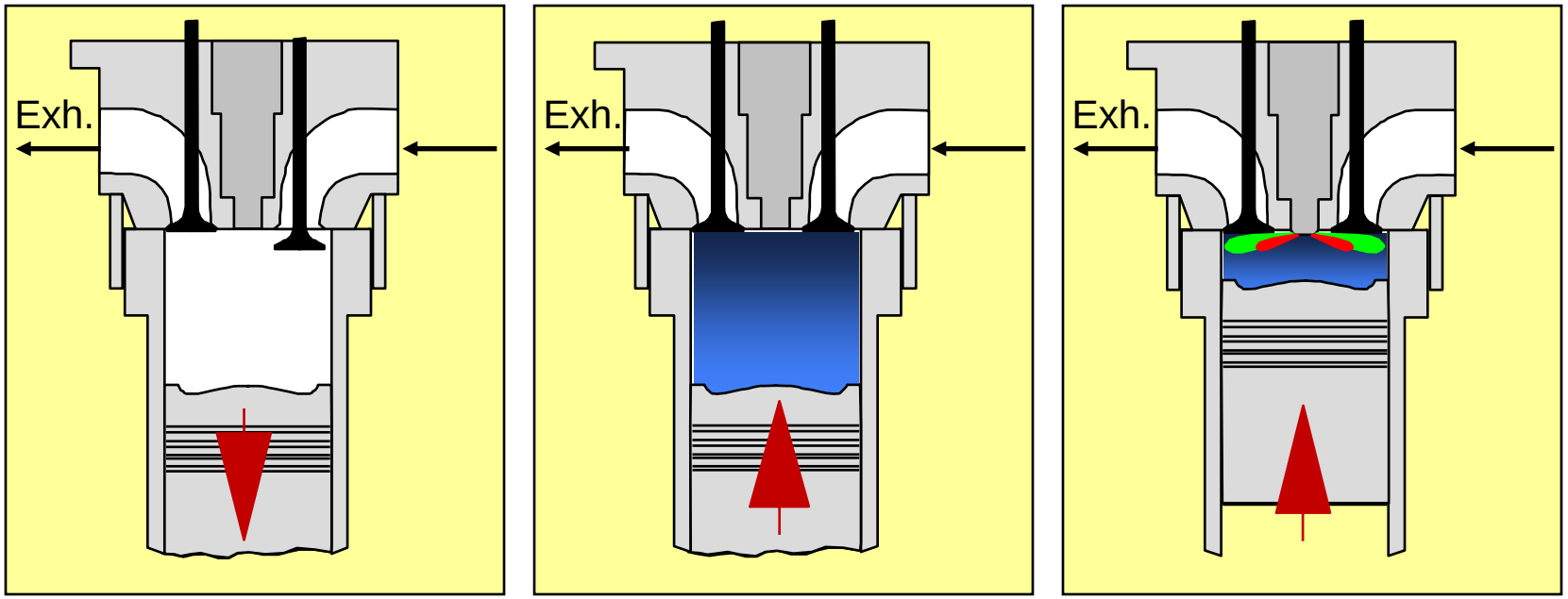
- Runs only on gas.
- Combustion of gas and air mixture in Otto cycle, triggered by spark plug ignition.
- Low-pressure gas admission.

Dual-fuel (DF) engines:

- Runs on gas with 1% diesel (gas mode) or alternatively on diesel (diesel mode).
- Combustion of gas and air mixture in Otto cycle, triggered by pilot diesel injection (gas mode), or alternatively combustion of diesel and air mixture in Diesel cycle (diesel mode).
- Low-pressure gas admission.



Wärtsilä 32GD & 46GD Gas Diesel = High Pressure Gas with direct Injection



Air
Intake

Compression
of Air

Injection of Gas
and Pilot Fuel Ignition

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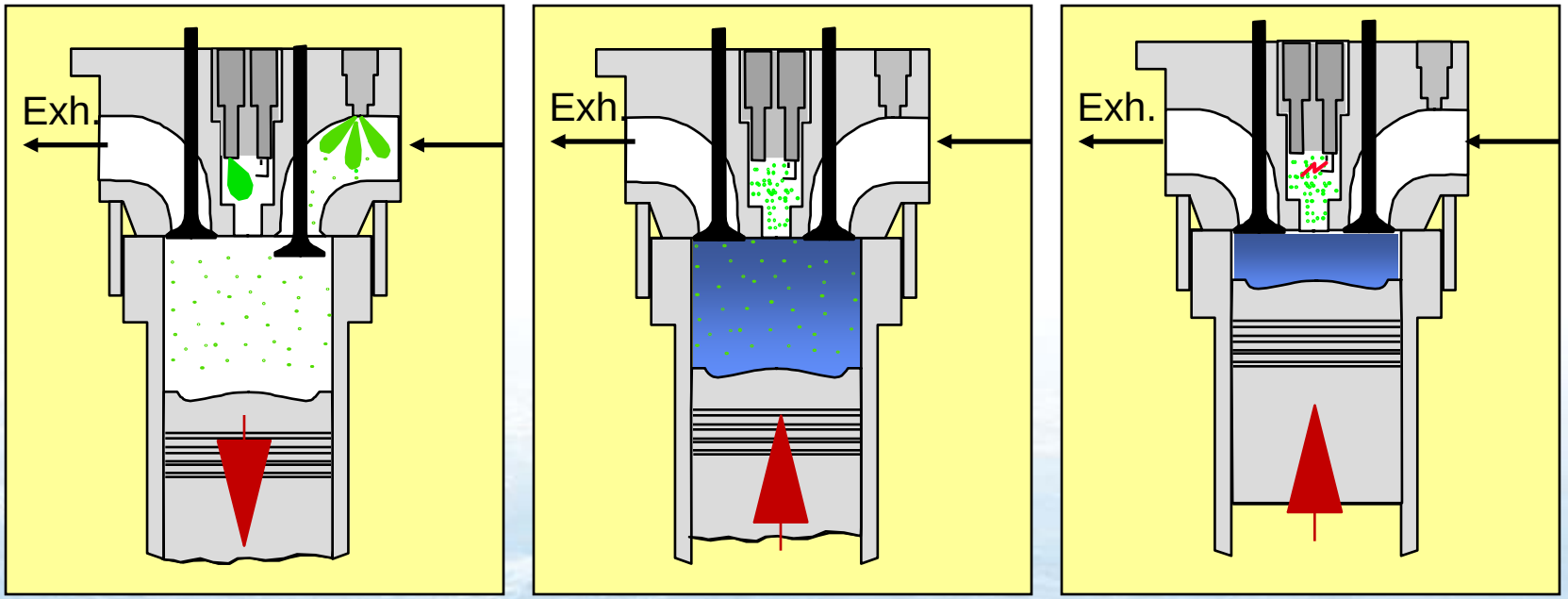
LEAN BURN ENGINE WORKING PRINCIPLE

Wärtsilä 34SG and 50SG – Spark Gas with pre-combustion chamber



Air and Gas Intake

Compression of Gas/Air Mixture

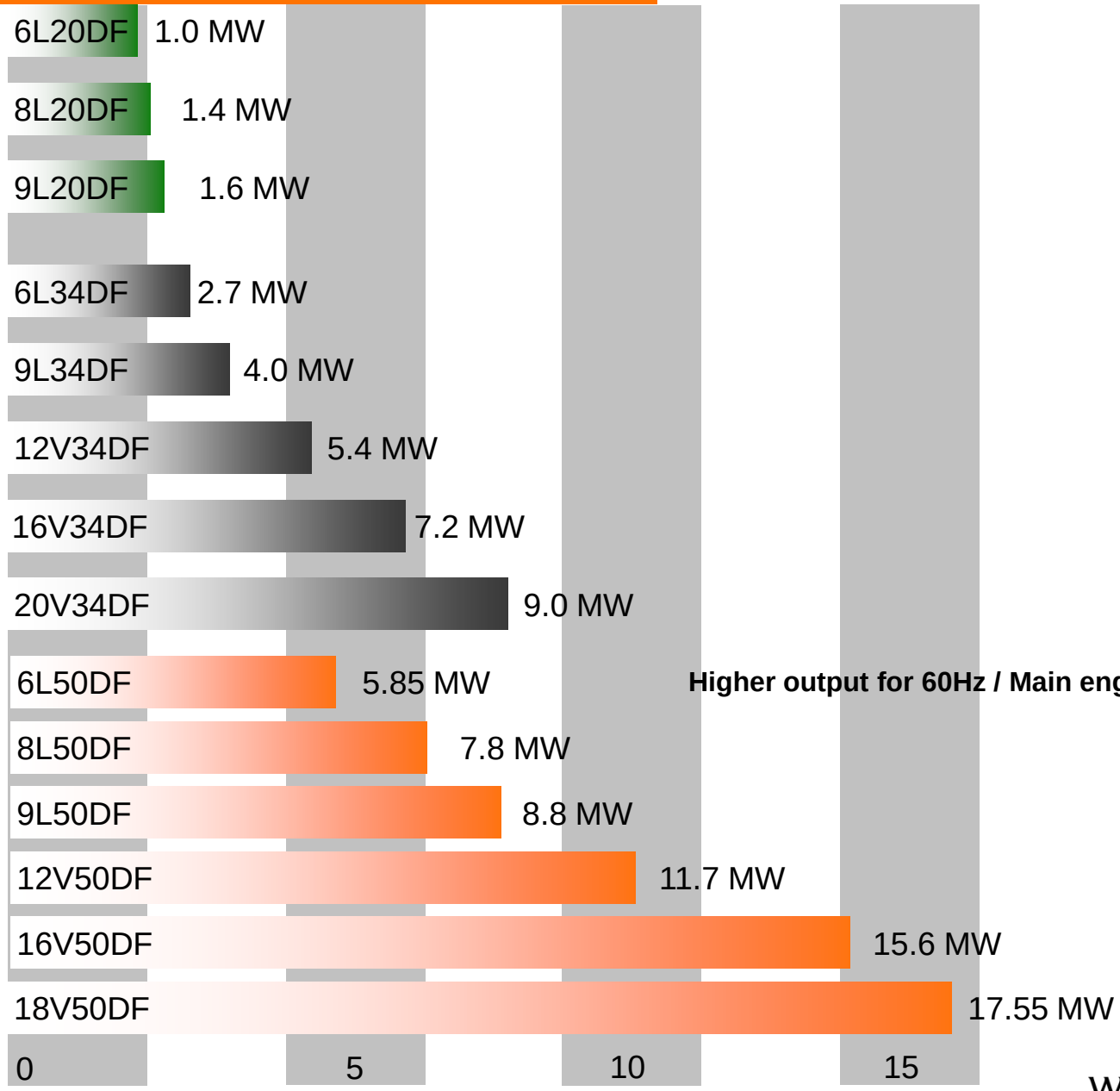
Ignition

Wärtsilä dual-fuel engine portfolio

WÄRTSILÄ 20DF

WÄRTSILÄ 34DF

WÄRTSILÄ 50DF

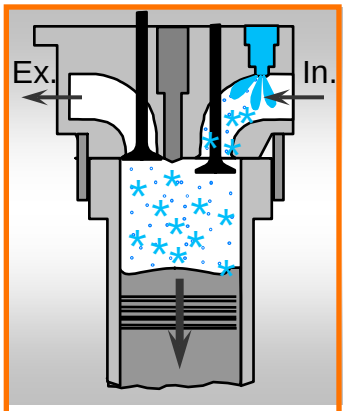


Higher output for 60Hz / Main engines

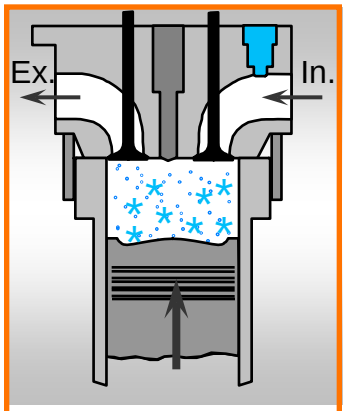
Engine characteristics - Operating modes

Gas mode:

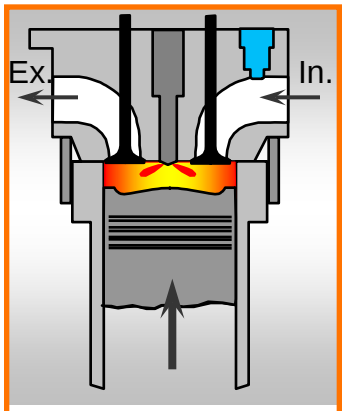
- Otto principle
- Low-pressure gas admission
- Pilot diesel injection



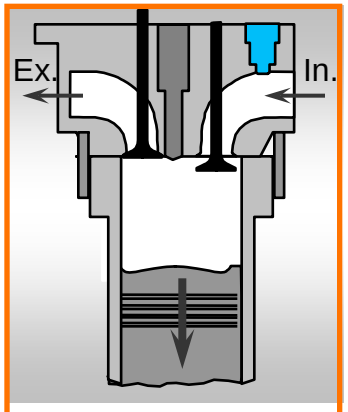
Intake of
air and gas



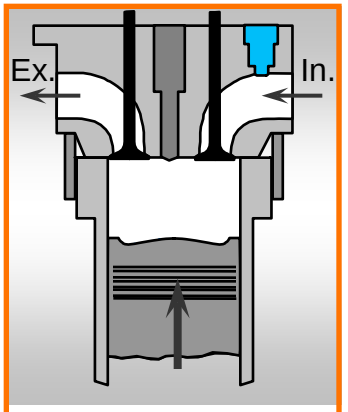
Compression of
air and gas



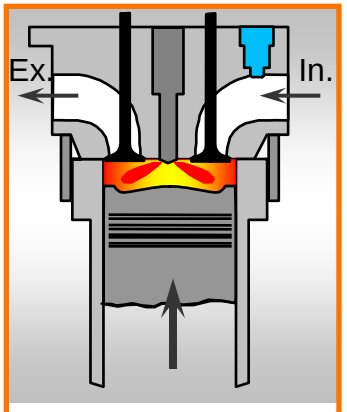
Ignition by
pilot diesel fuel



Intake of
air



Compression of
air



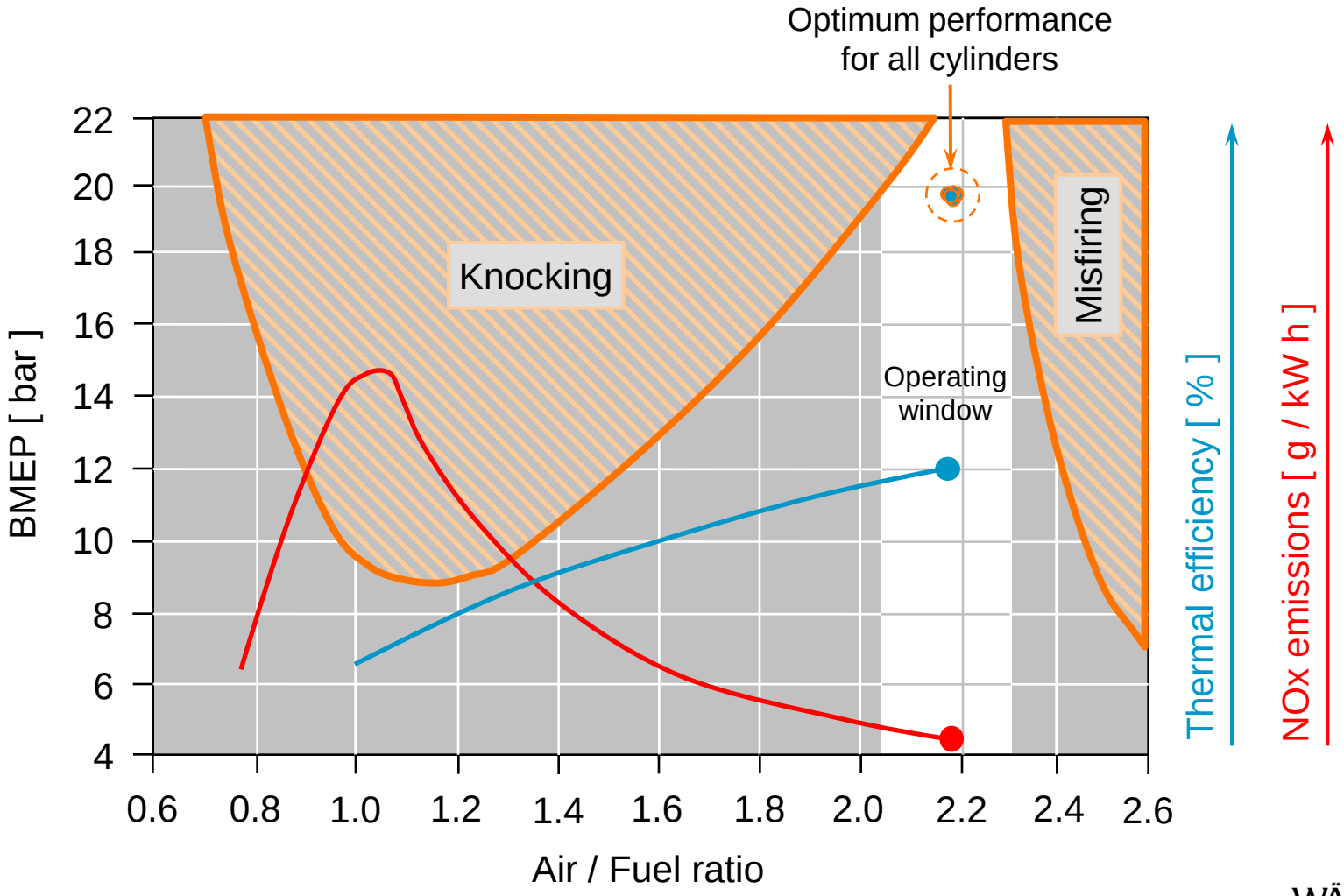
Injection of
diesel fuel

Diesel mode:

- Diesel principle
- Diesel injection

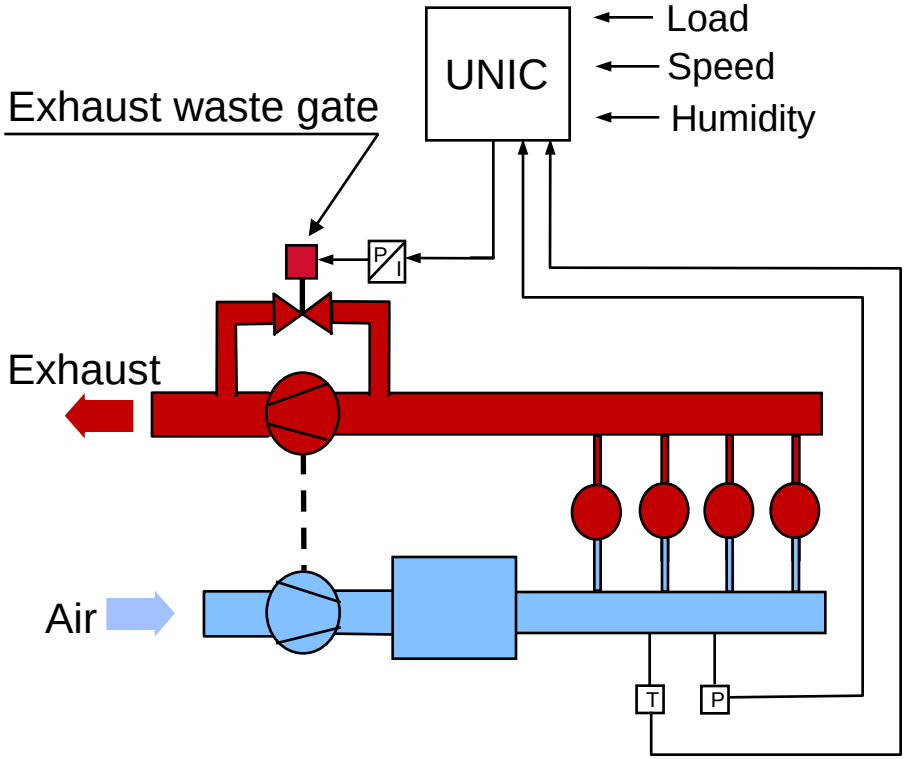
Engine systems - Engine control system

- Energy released to ignite the gas-air mixture is about 1000 times higher with a pilot fuel injection compared to other ignition alternatives
- High compression and optimum fuel control ensure high engine efficiency



Air-fuel ratio control

- Correct air amount into the cylinders needed to get the optimal combustion and engine performance
  - Too rich => knocking
  - Too lean => misfire
- Several input parameters used for waste gate control giving same engine performance regardless of changing ambient conditions

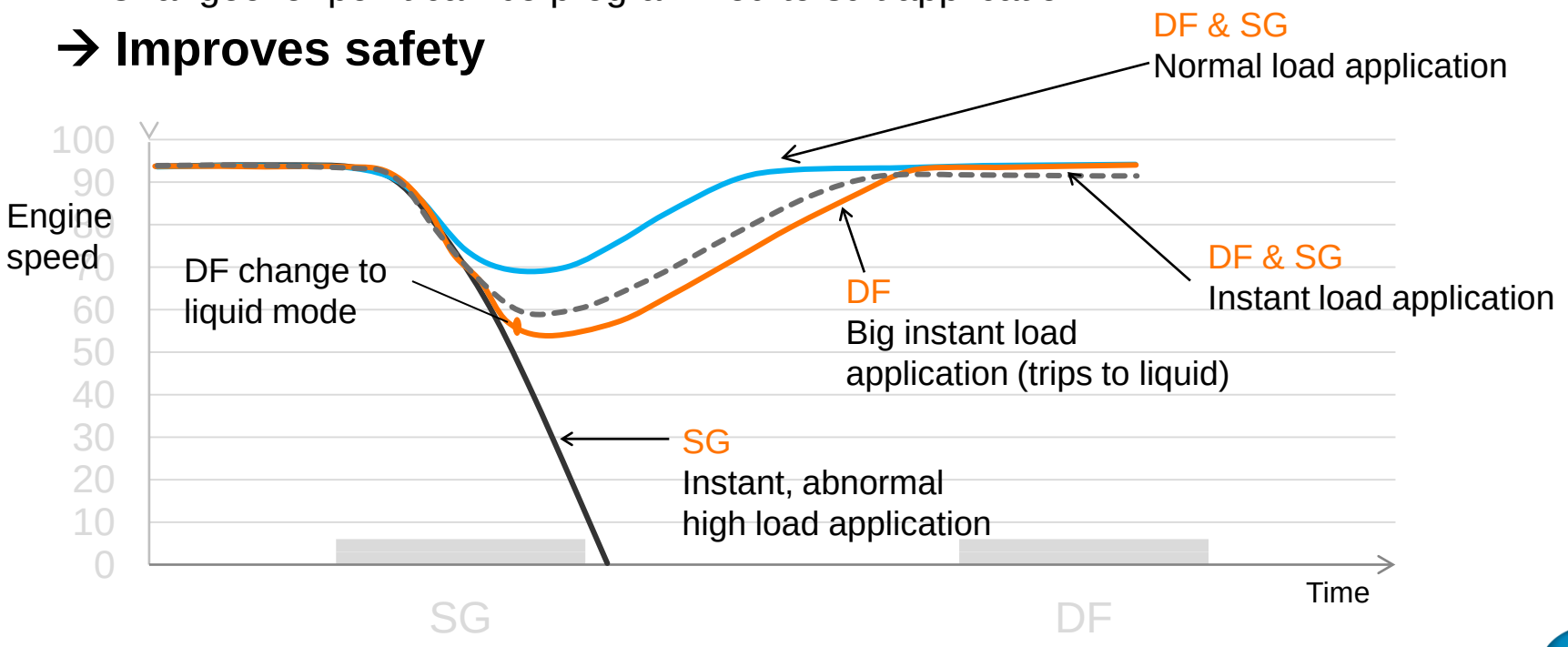


Dual-Fuel advantages

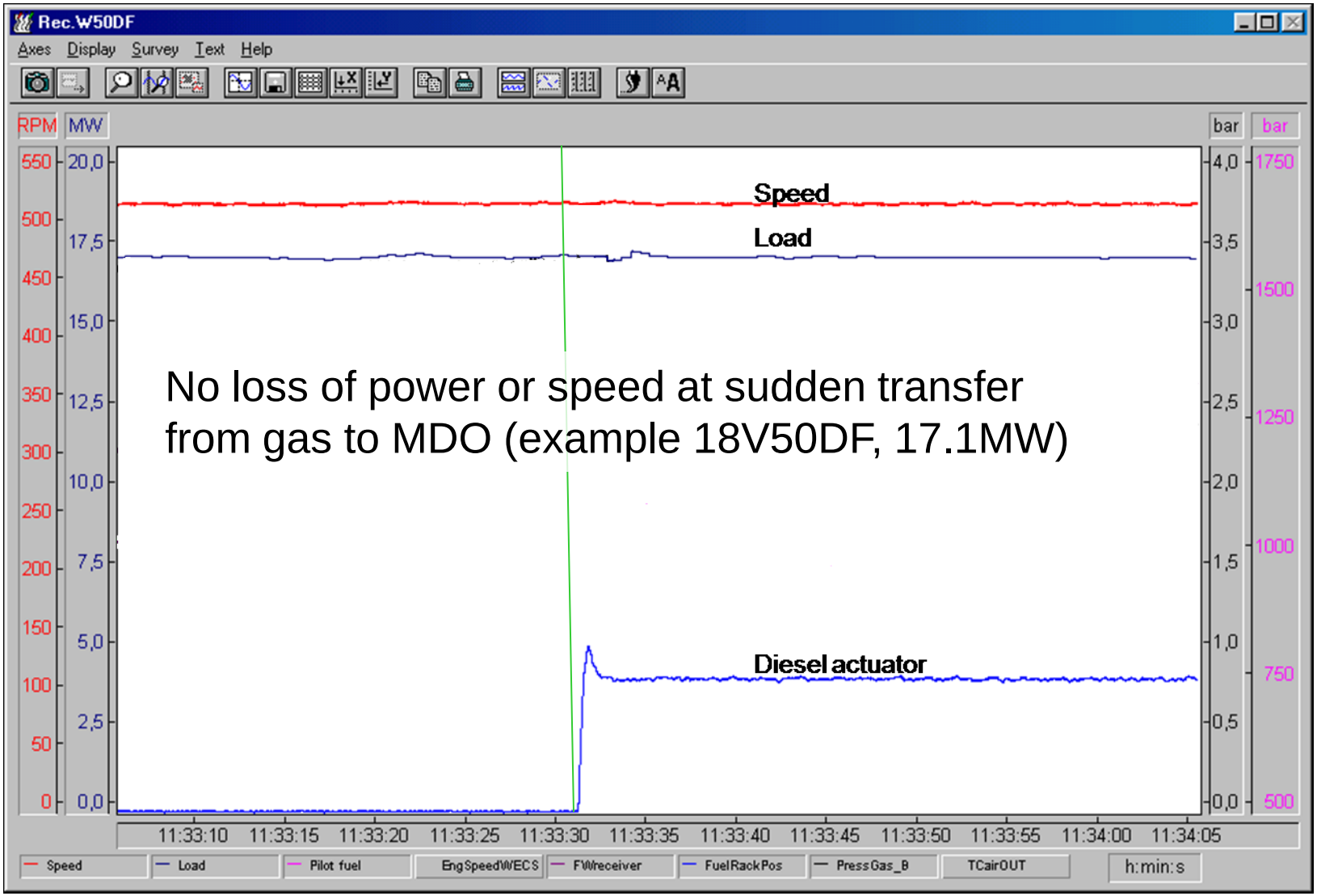
Main advantages of the Dual-Fuel 4-stroke engine compared to SG (spark ignited):

- Simple mechanical propulsion application
  - Full power available in both fuel operation modes
- Load application capability
  - Load application capability is equal between dual-fuel and SG
  - Dual-fuel can change to liquid fuel in case instant abnormal high load / unload requirement (no shut-down)
  - Changeover point can be programmed to suit application

→ Improves safety

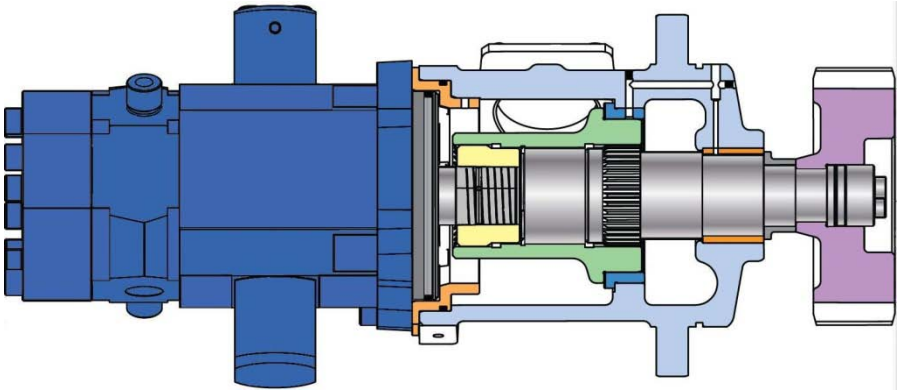


DF Gas Trip (GAS -> MDO) on 100% load - instantaneous



Pilot pump

- The engine driven pump unit consists:
  - Radial piston pump
  - Fuel Filters
  - Necessary valves
  - Control system



- The pump unit receives start/stop and pressure signals from the engine control system and transmits the pressure level to it.
- The pilot fuel pressure is set to the required level by the engine control system. A common rail pipe delivers pilot fuel to each injection valve and acts as a pressure regulator against pressure pulses

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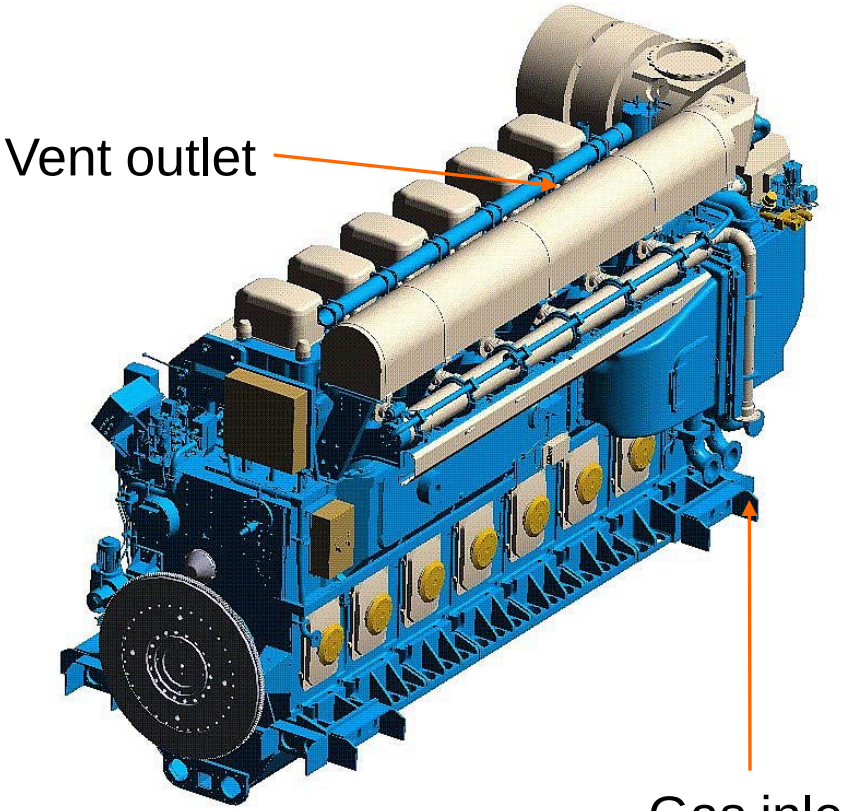
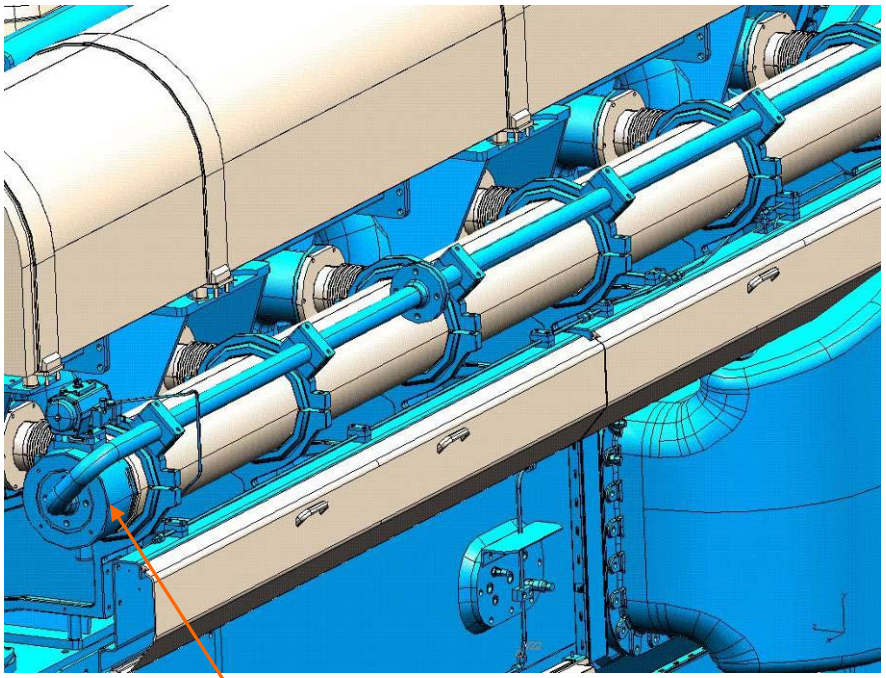
Fuel system (1/5)

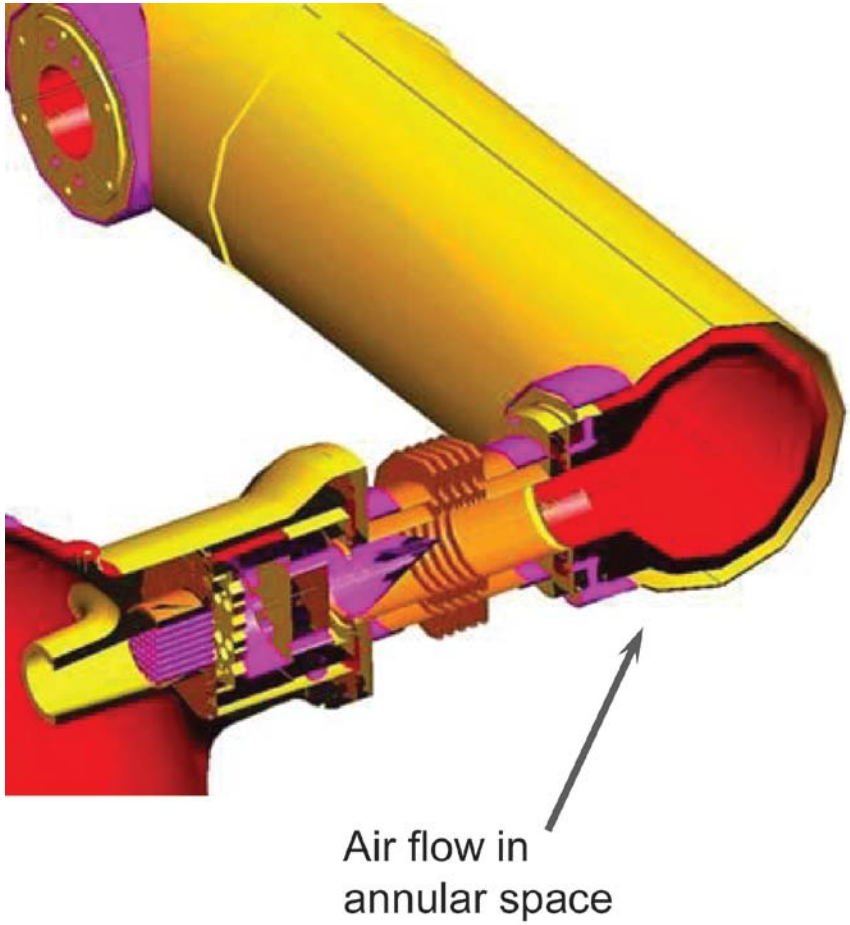
Compared to single-wall gas piping, the requirements to the ship's engine room with respect to gas detection, ventilation, etc., become less stringent with double-wall gas piping, making the engine room less complex and thus cheaper to build.





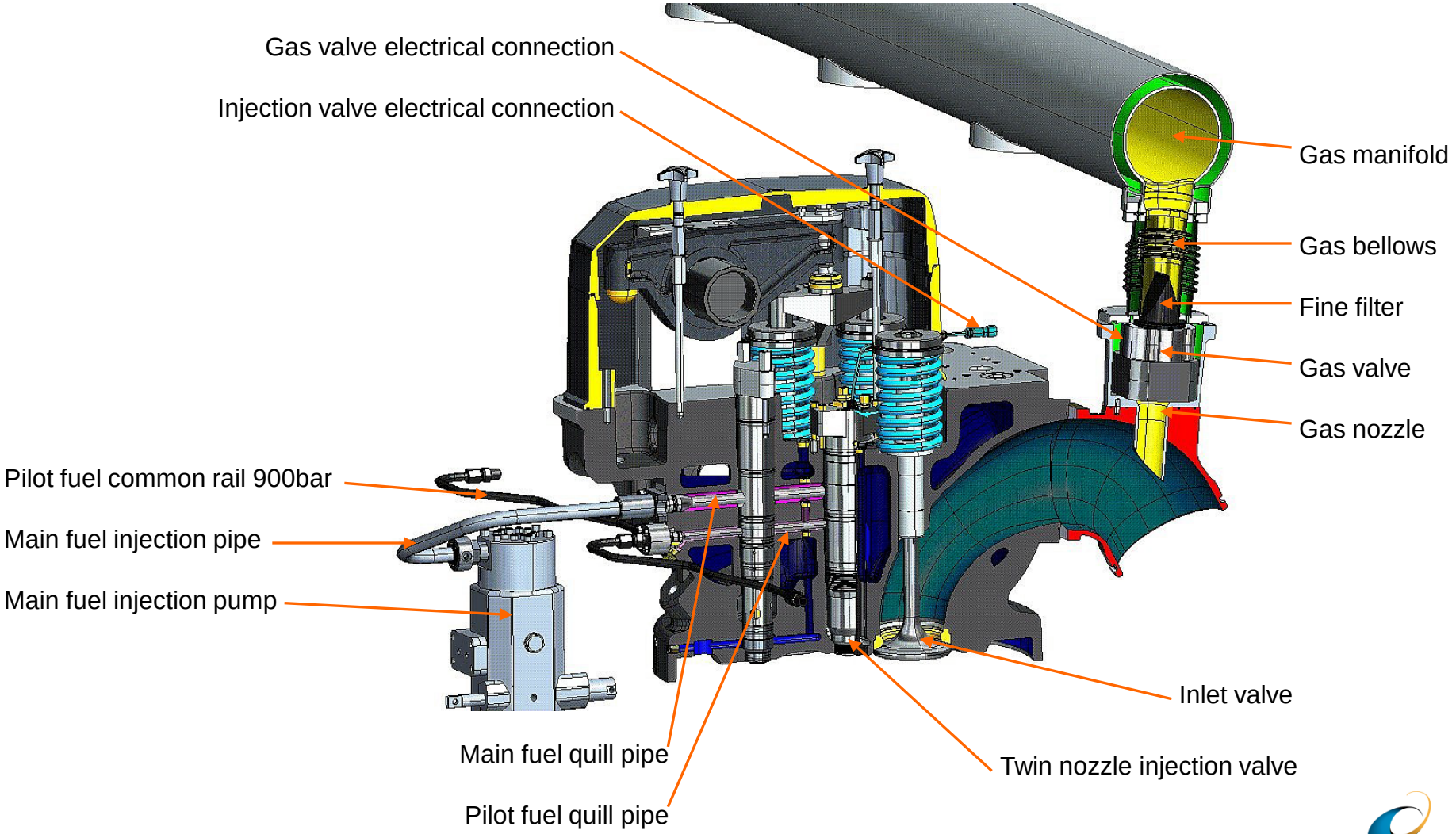
Fuel system (2/5)
Gas pipes

- Double wall and single wall gas pipings are available
- Gas supplied to cylinders via common pipe running along the engine, continuing with individual feed pipes to each cylinder.
- Annular space ventilated by air
- Gas venting valve for venting and flushing of gas system



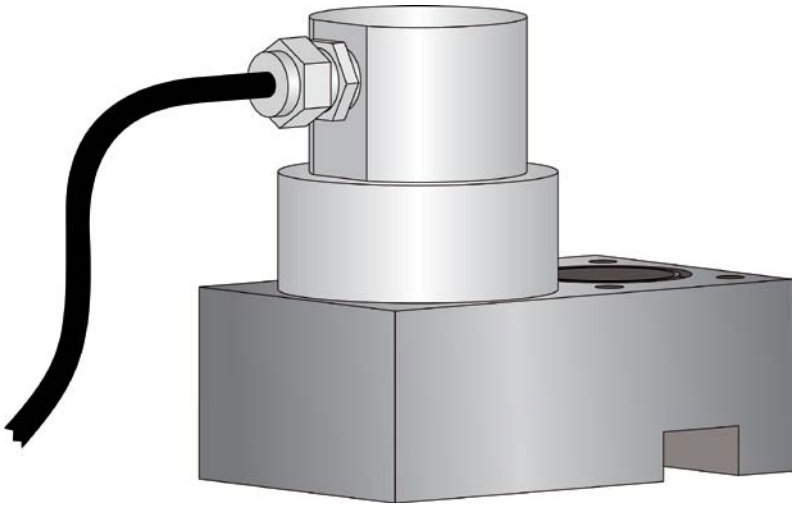
Fuel system (3/5)
in cylinder head, components

Using vented double pipe the engine room does not need to be provided with Ex-proof equipments, which reduce the overall price



Fuel system (4/5)
Fuel gas feed

- Gas admission controlled with gas admission valve on each cylinder
- The valve is a direct actuated solenoid valve and controlled by the engine control system
- Gas pressure regulation and filtration in engine external system
- Filtration on consist of “5 µm” fine filter and “90 µm safety” filter.



Fuel system (5/5)
Fuel oil feed

- Pilot fuel system include pilot fuel pump and fine filter
  - High pressure fuel pump
  - Duplex fine filter
  - Valve block with safety valve and pressure sensor
- Pilot fuel feed through common rail
  - Double walled high pressure fuel pipes
- Twin injector for both diesel and pilot fuel
- Diesel fuel system built as on conventional diesel engines
- Pilot fuel is usually LFO, but biodiesel is possible

LNG Storage

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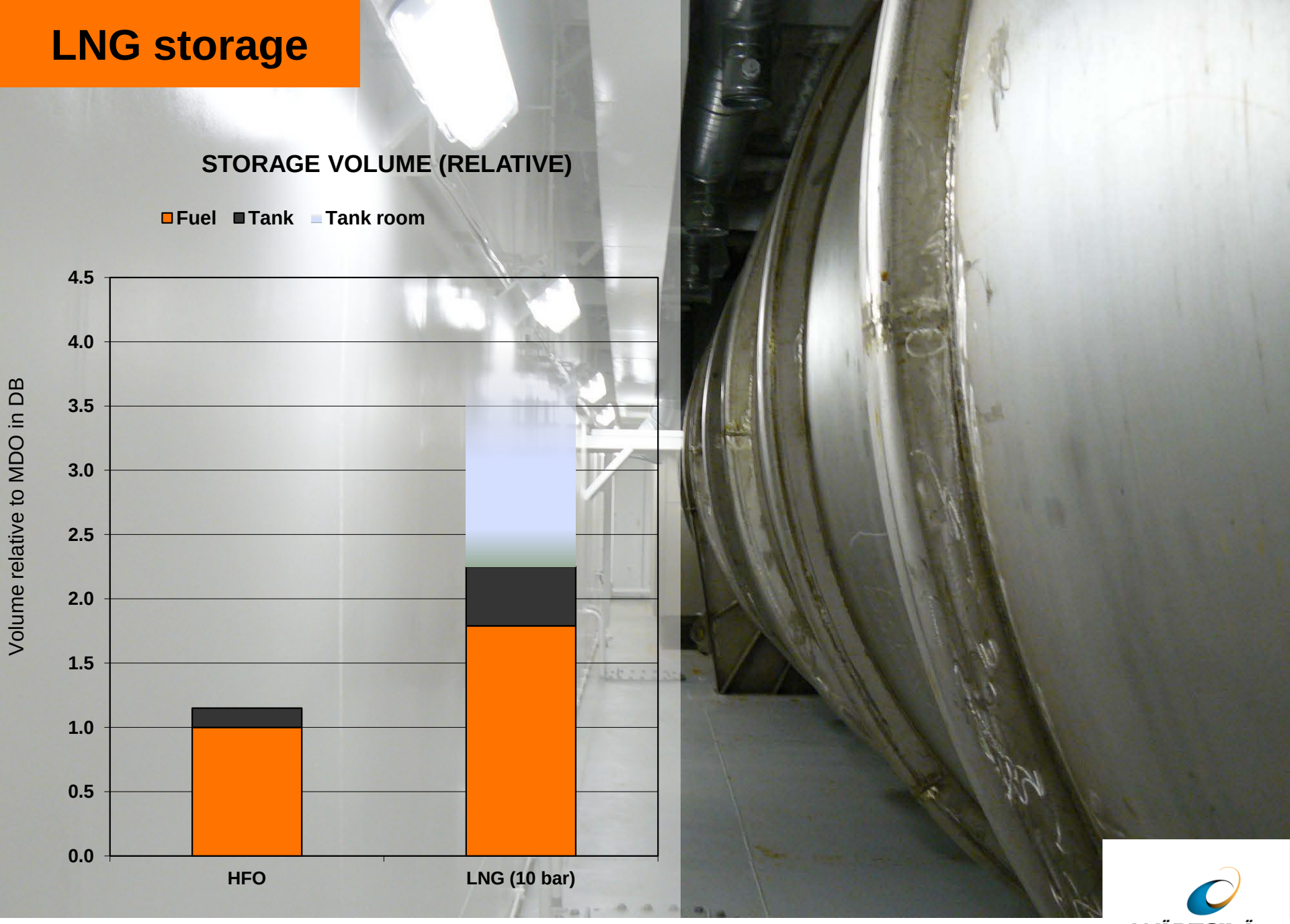
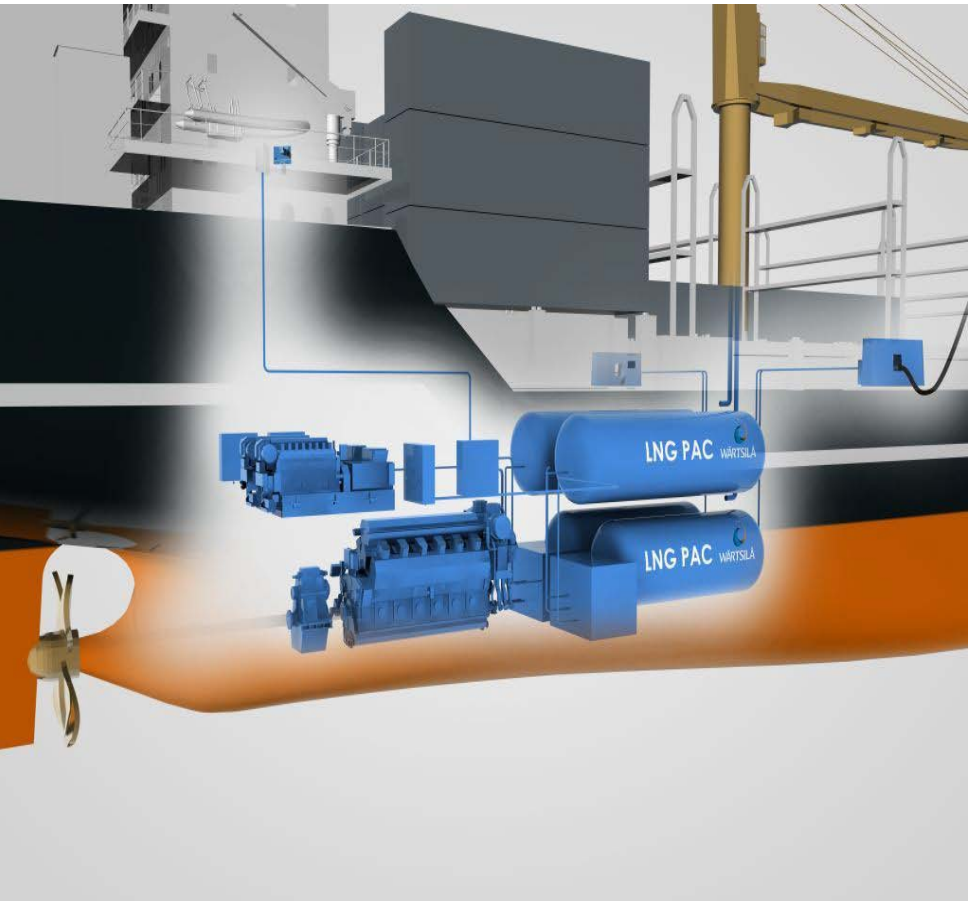
LNG storage


STORAGE VOLUME (RELATIVE)
Fuel
Tank
Tank room
Volume relative to MDO in DB
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
HFO
LNG (10 bar)

What is Wärtsilä LNGPac?

A ***complete*** and ***modularized*** solution for LNG fuelled ships



- LNG tank (pressurized - IMO type C)
- Bunker station with valves and connections to shore
- Vacuum insulated pipes (liquid LNG)
- Tank room
- Process skid (valves and evaporators)
- Gas Valve Unit (included in engine scope)
- Water/glycol system design
- Automation and controls
- Gas detection system (offered separately)
- Operating manual and class approval

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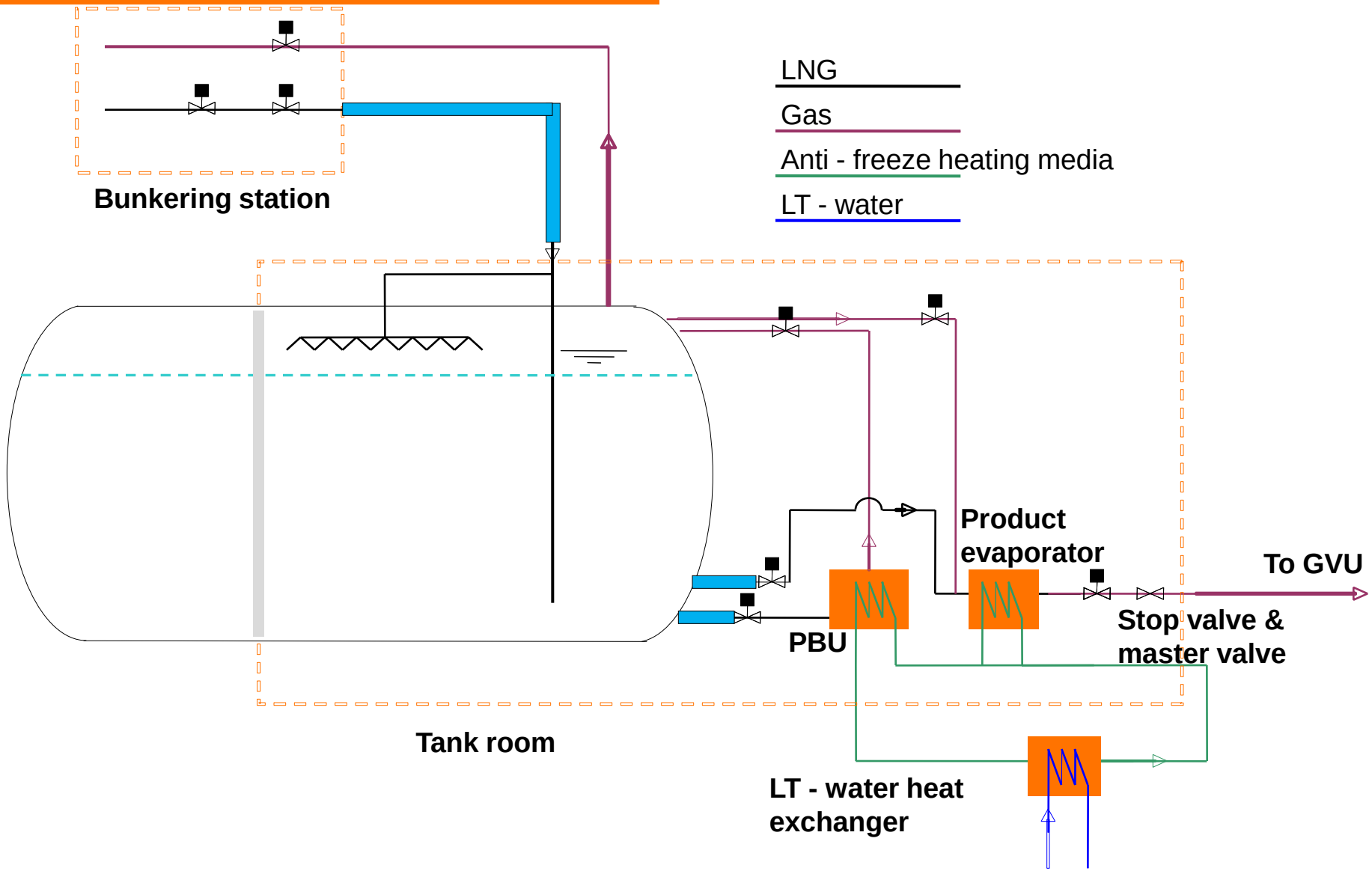
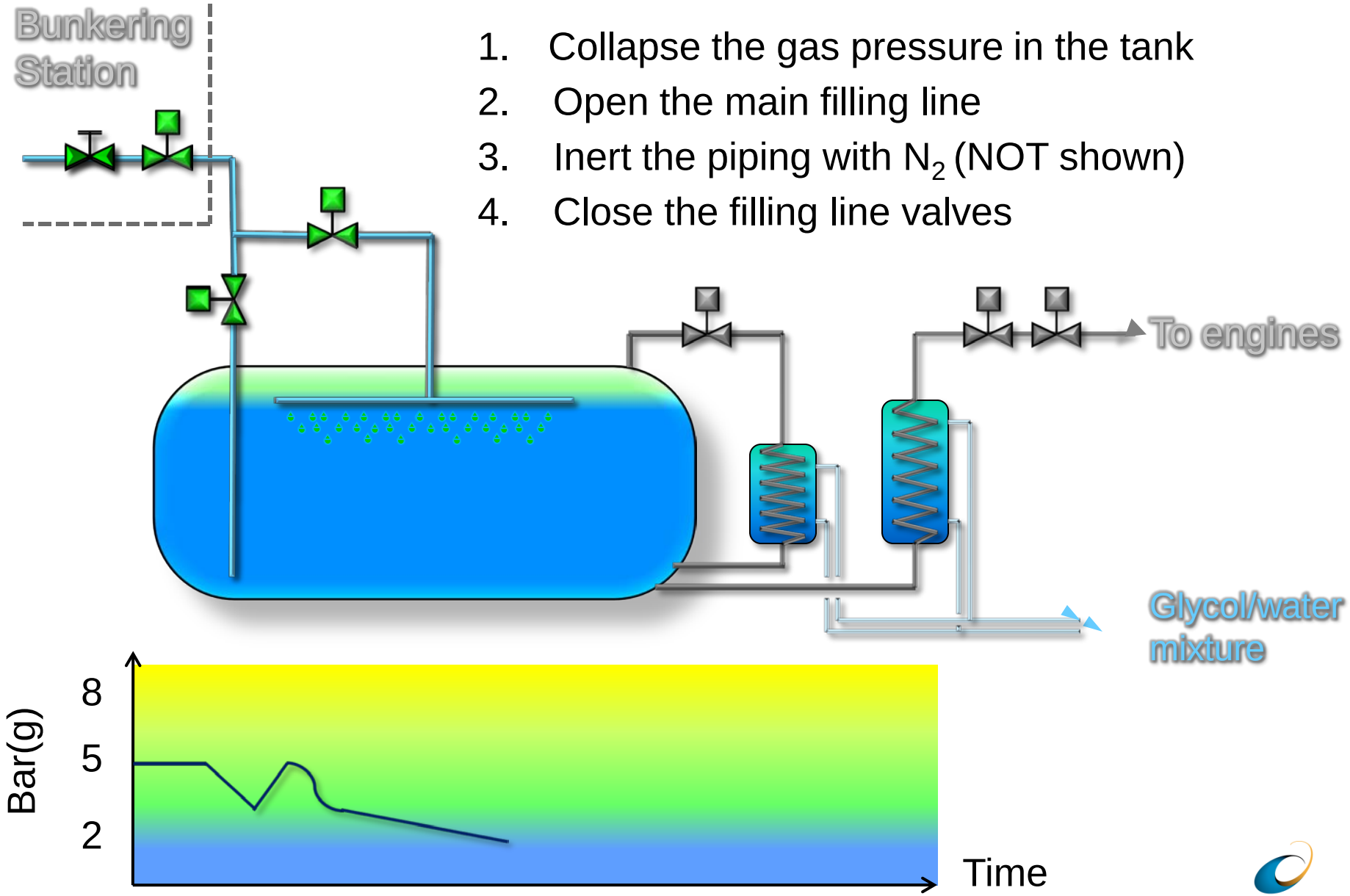
LNGPac Simplified P&ID

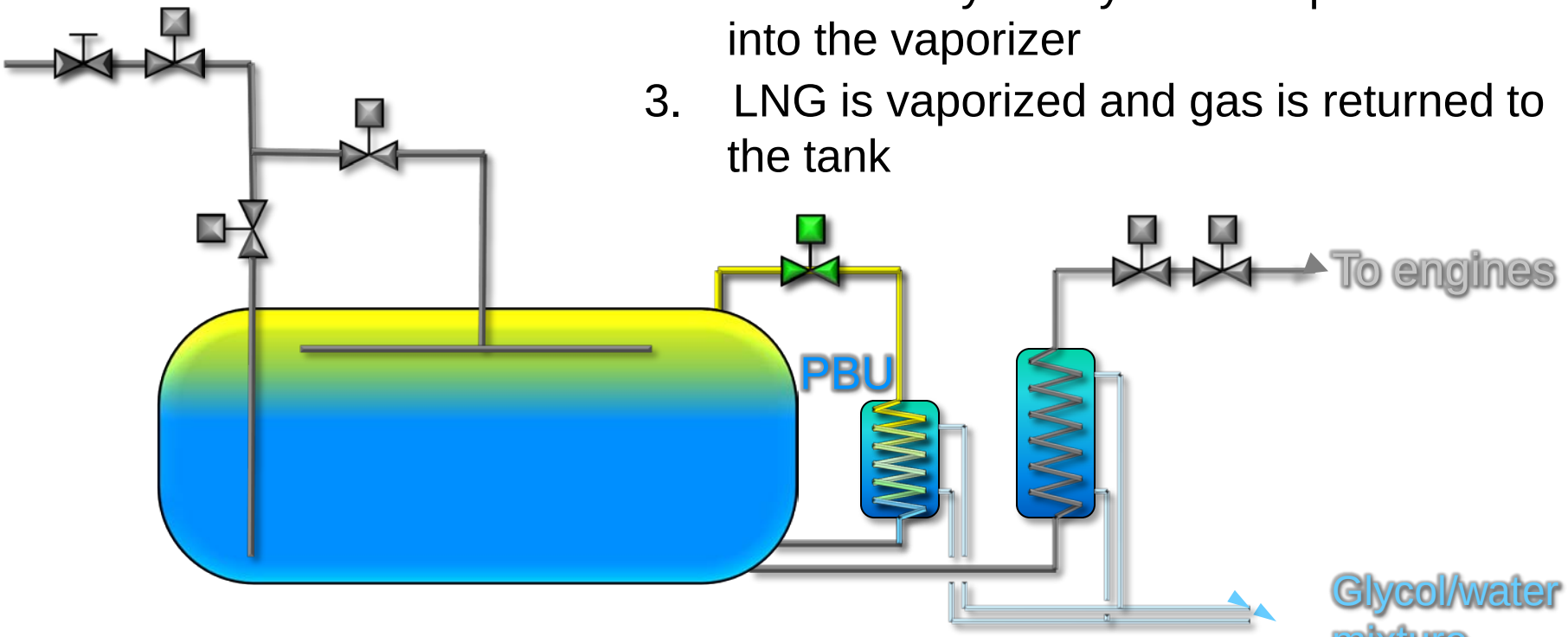


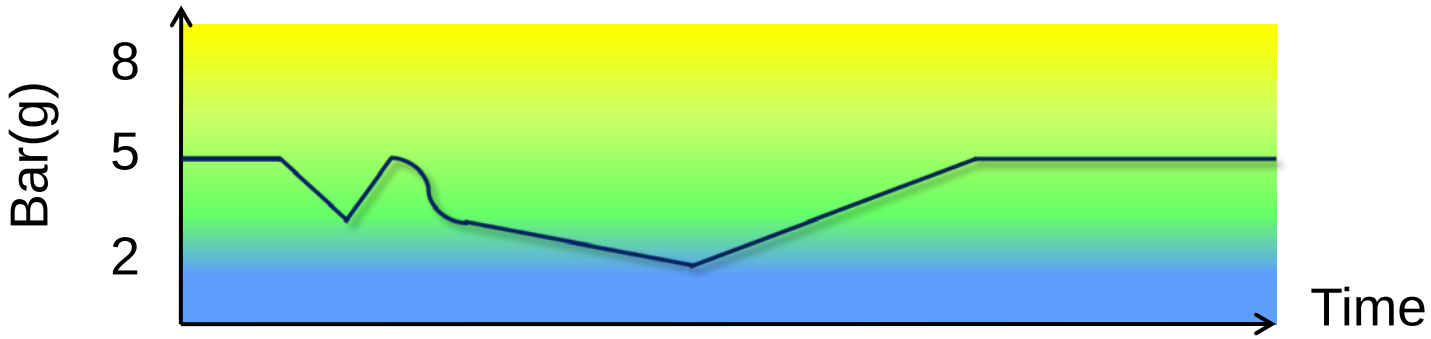
Bunkering procedure



Tank pressure increase

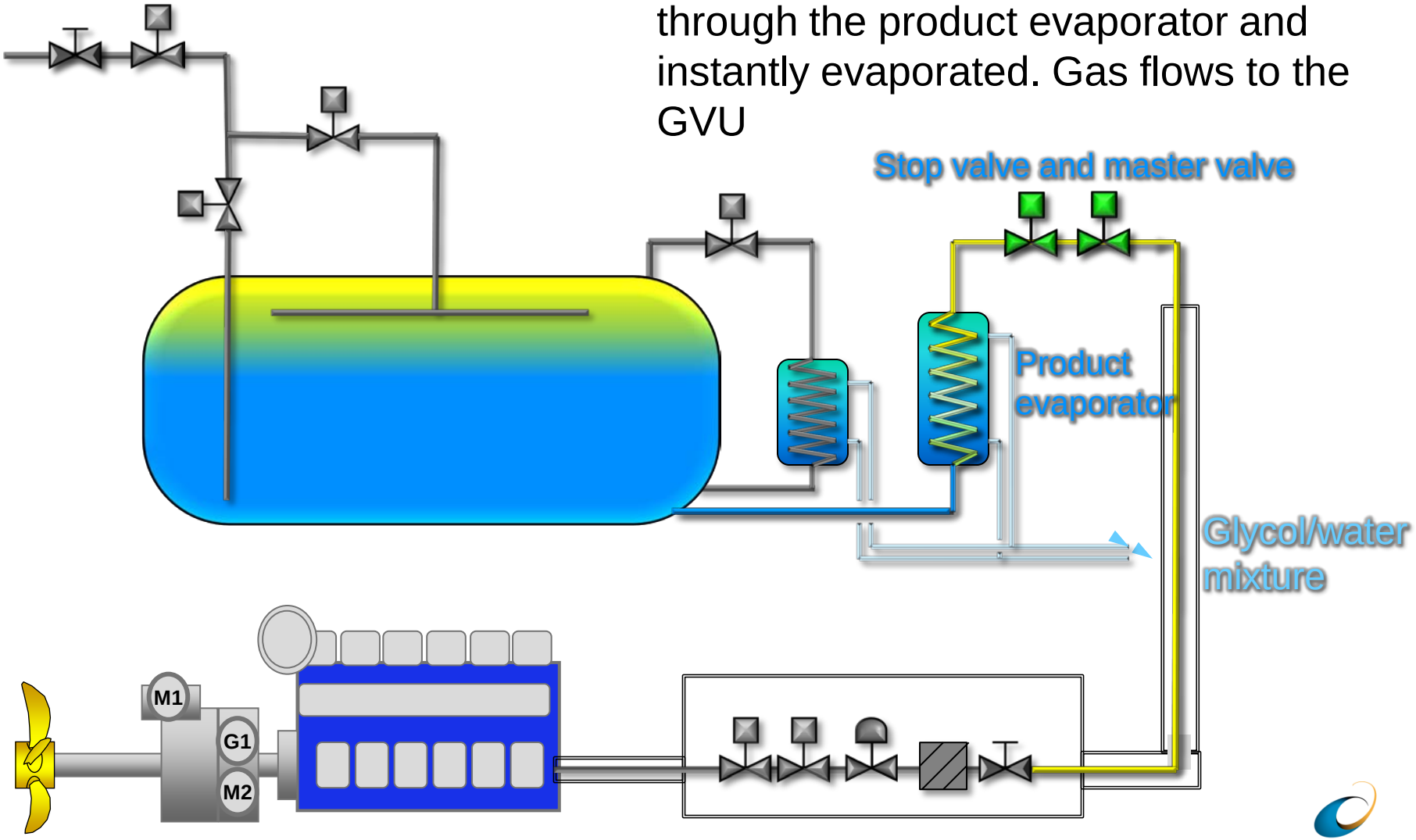
1. Open pressure control valve
2. LNG flow by the hydrostatic pressure into the vaporizer
3. LNG is vaporized and gas is returned to the tank





Normal operation

1. The “stop valve” and “master valve are opened (double block valves with bleed in between)
2. LNG is forced by the tank pressure through the product evaporator and instantly evaporated. Gas flows to the GVU



What is a gas valve unit?

- **The main functions of the GVU:**
  - Pressure regulation to the engine, according to engine load. One unit is required per engine.
  - Safety (block valves, filters, inerting and venting)

- **A GVU is located between the LNG storage system and the engine**
  - Max. recommended distance from engine is 10 m

Installations today

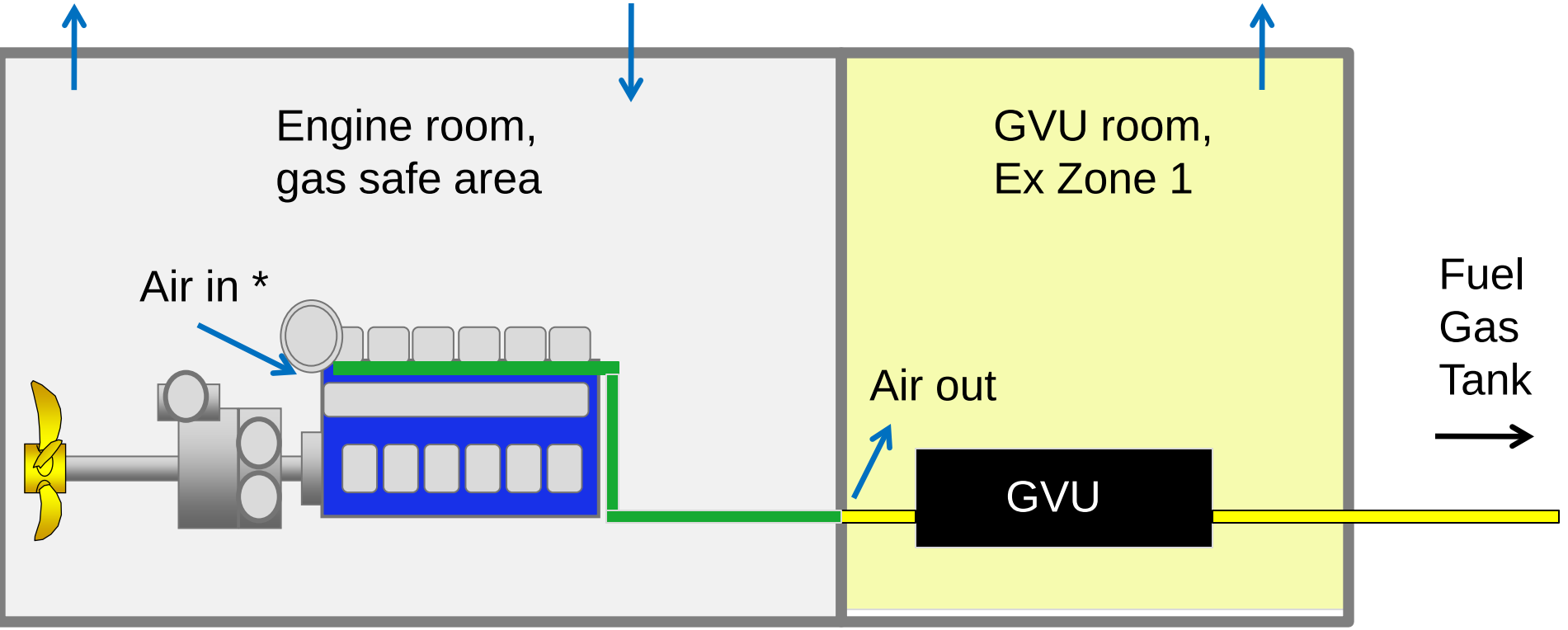
Forced ventilation

Single wall fuel gas pipe

Double wall fuel gas pipe

Gas safe area

Gas hazardous area



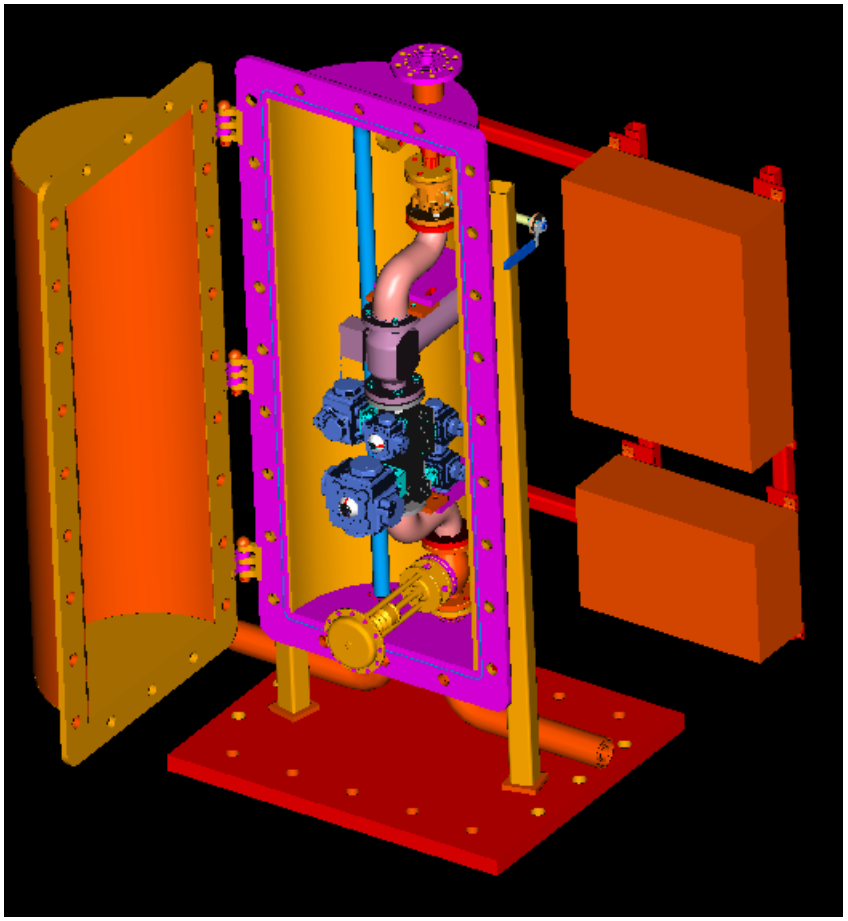
* to double wall fuel gas feed pipe annular space

Gas Valve Unit in enclosure benefits

THE ROAD AHEAD

Main features

- Can be located in the same engine room, dedicated compartment not needed
- Compact design and easy installation (plug-and-play concept)
- Integrated ventilation system when combined with LNGPac
- Lower total investment cost compared to existing GVU
- Optimal for retrofit installation, due to compact size



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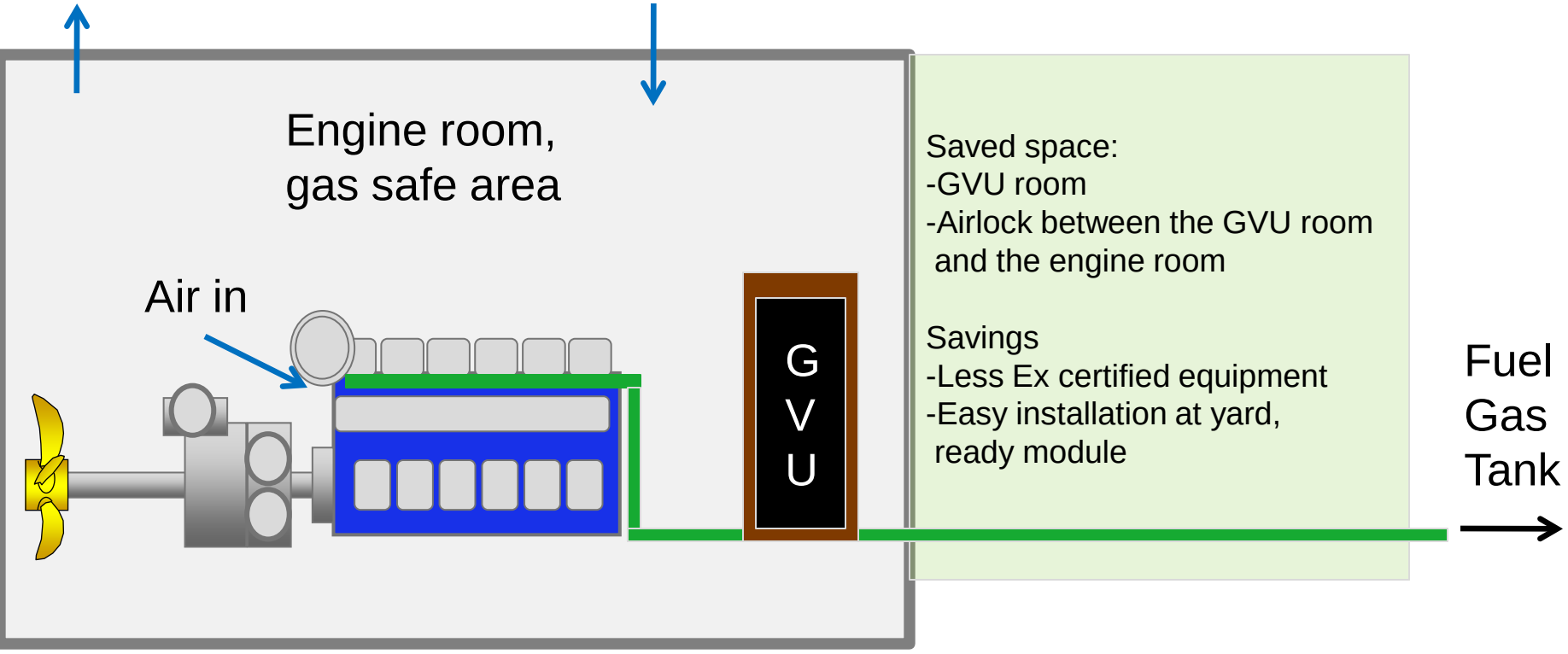
Installation with GVU enclosure

Forced ventilation

Double wall fuel gas pipe

Gas safe area

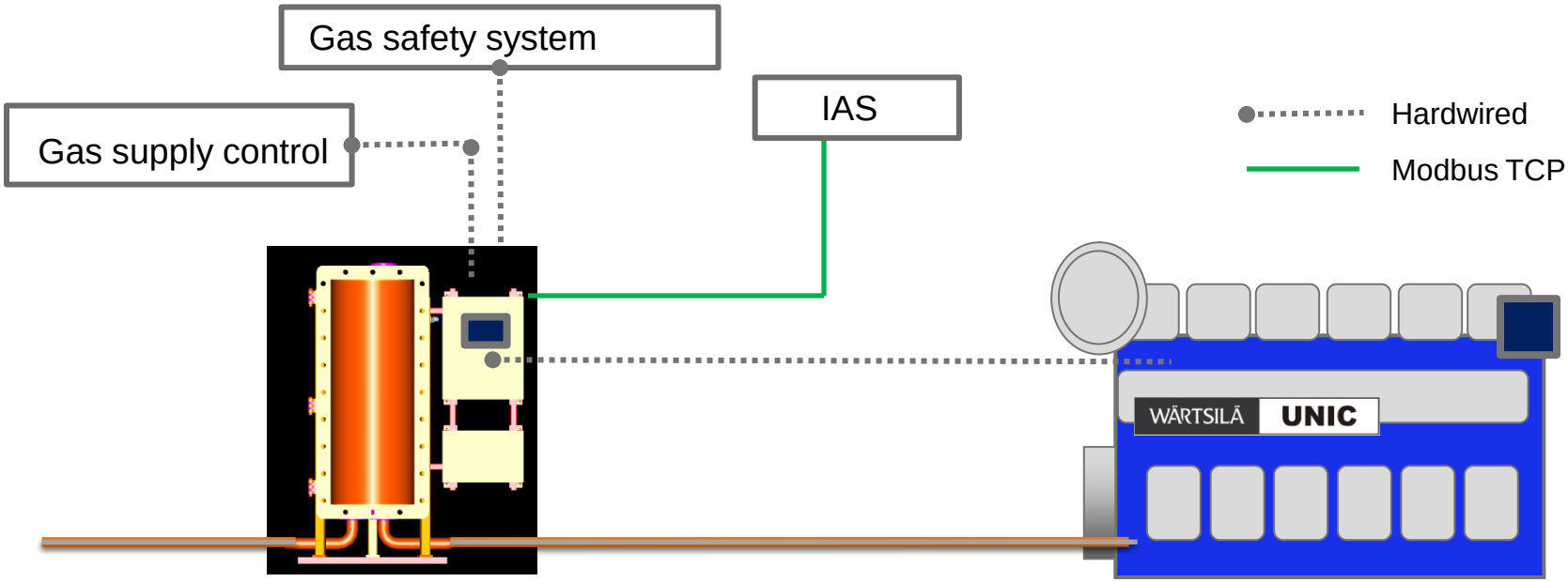
Enclosure



GVU-enclosure control system features

The Gas Valve Unit has built-on controls:

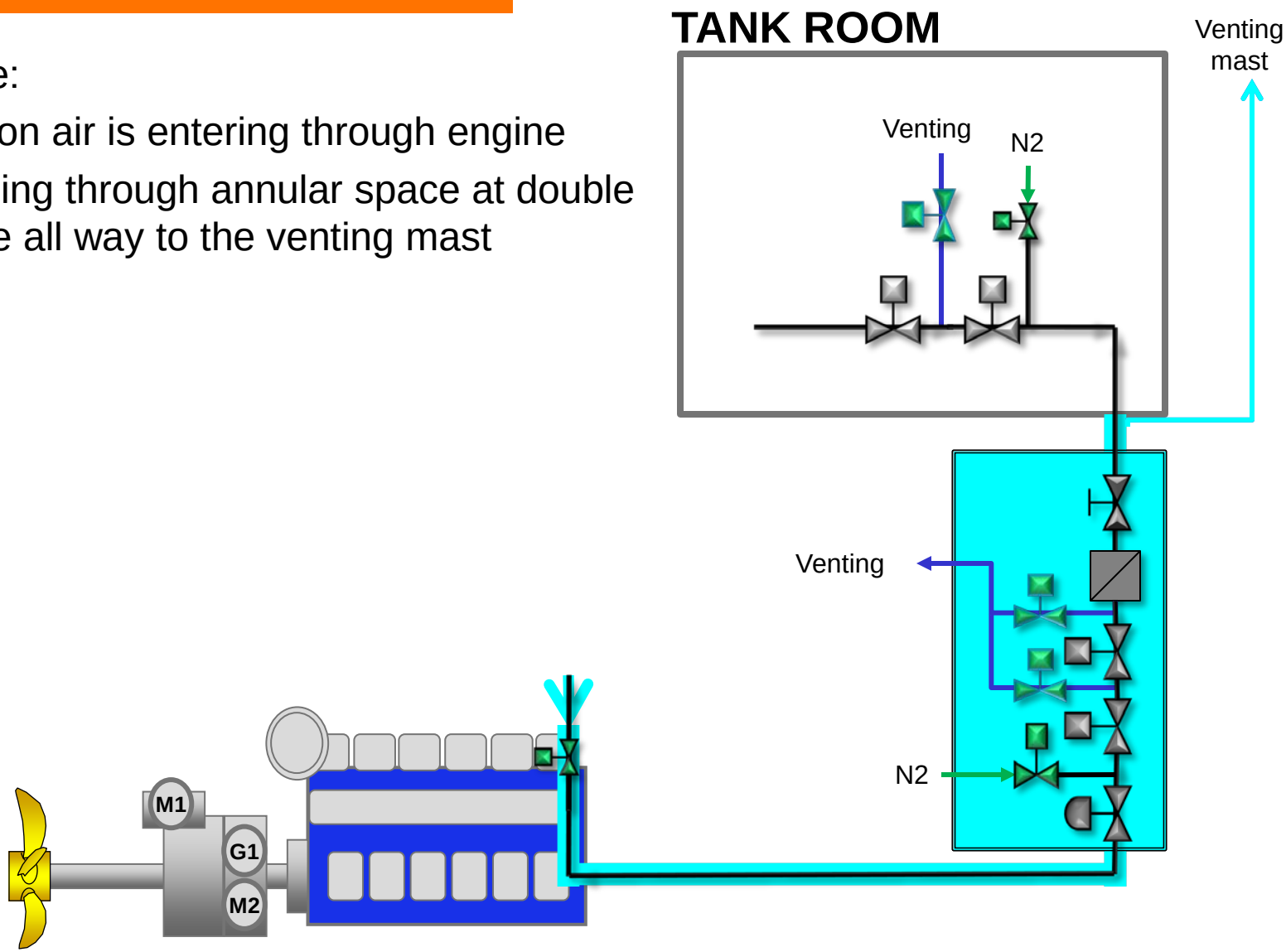
- Valve sequencing (gas leak test, shut-off, venting, inerting)
- Exhaust fan control
- Process supervision and local display
- Hardwired interface with engine, gas supply- and gas detection systems
- Modbus TCP interface with ships integrated automation system (IAS) for alarm & monitoring functions
- Pretested at factory



Ventilation arrangement

Procedure:

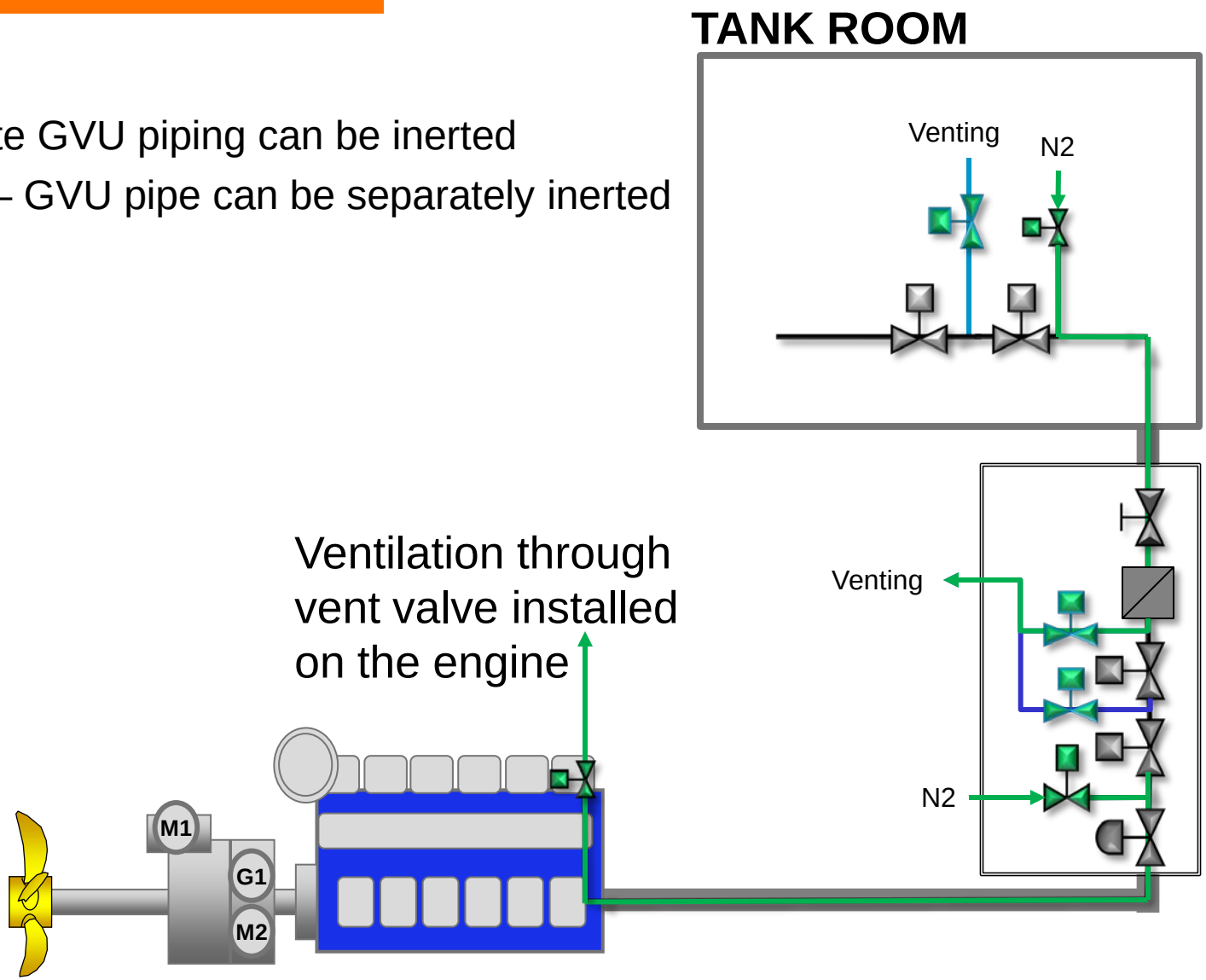
- Ventilation air is entering through engine
- Air is going through annular space at double wall pipe all way to the venting mast



Inerting procedure

Features:

- Complete GVU piping can be inerted
- Engine – GVU pipe can be separately inerted



LNG Bunkering

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Bunkering

- LNG Terminal
- Tanker truck
- Tanker ship / barge
- Land based storage tank

Bunkering of LNG for *Viking Energy*

Viking Energy

- Dual-fuel electric machinery.
- 4 x 6L32DF

- Engines in gas mode 95% of time.
- Once a week the vessel comes in to bunker LNG and then the engines are in diesel mode.

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LNG bunkering


ABUS
0017 M BUNKERS STASJON
0002 17-JUN-11 20:27:25

Bunker station in port

Gas storage tanks

QUESTIONS?

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