UNIC DF Training

Operation

Content

Control system layout

Engine Safety System gas functions

Signal flows between UNIC and ESS

Engine operation

- Transfer to Gas and back
- Gas interlocks
- Gas trips

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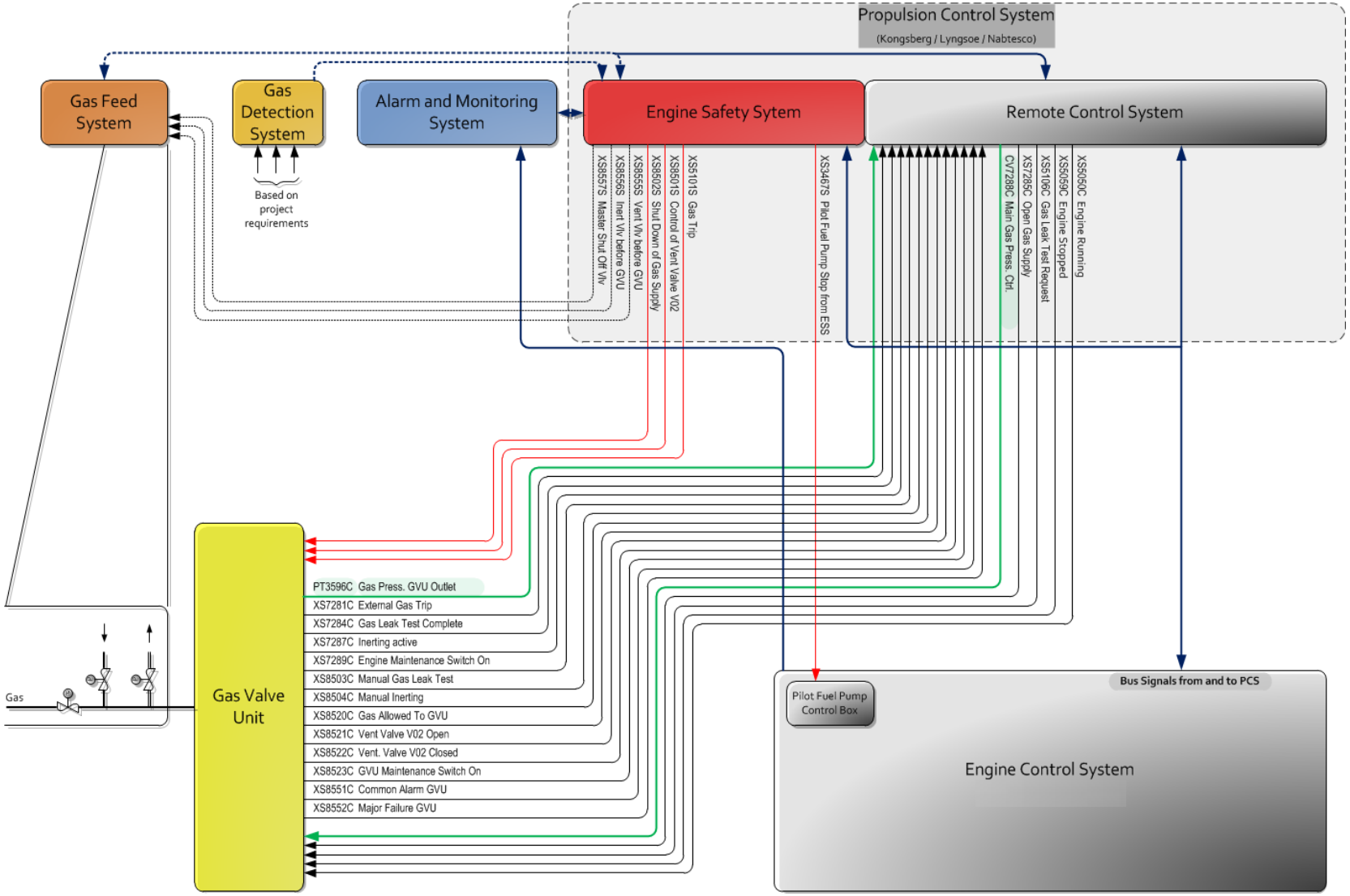
Interface to Gas components



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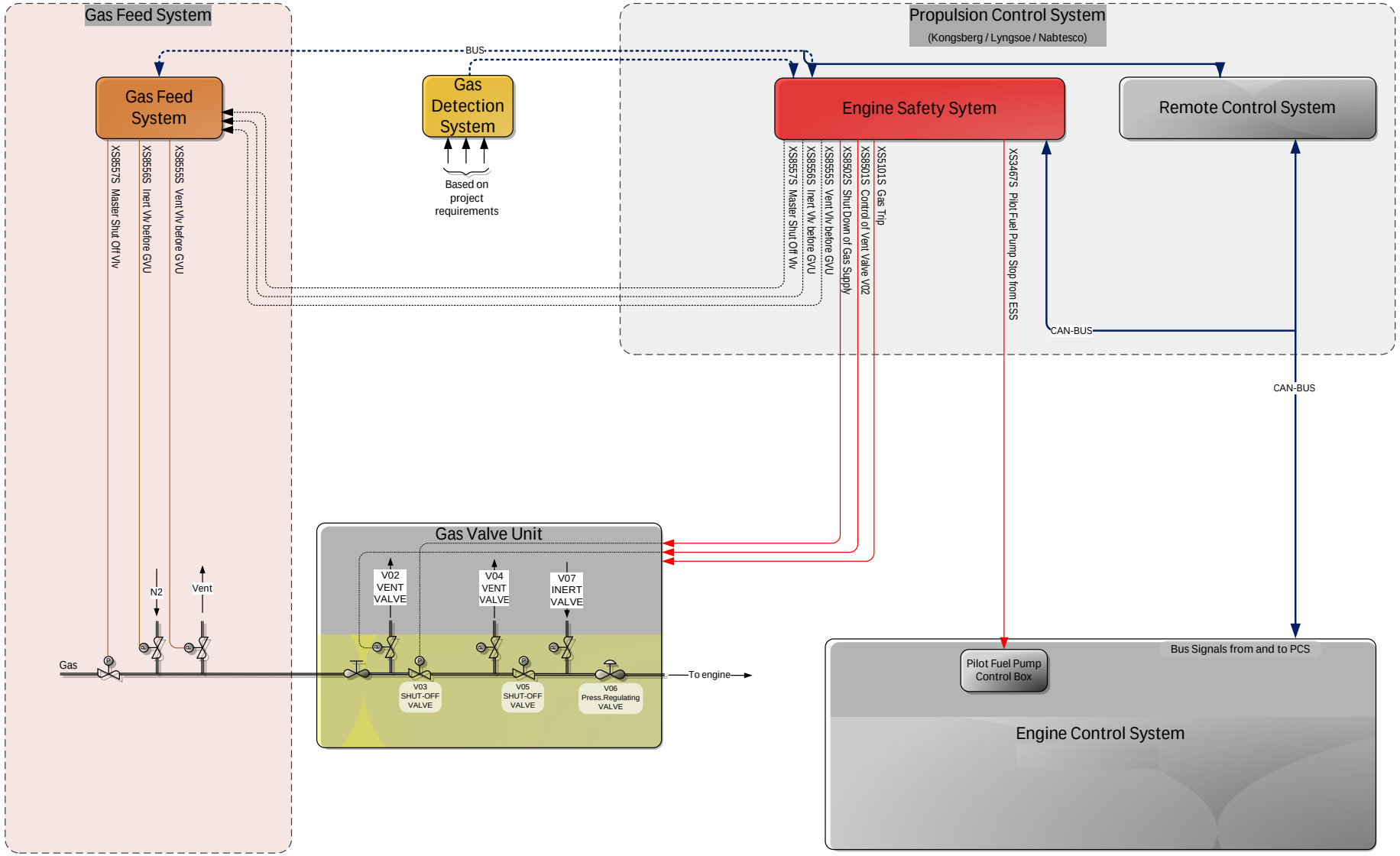
ESS: Valves before GVU



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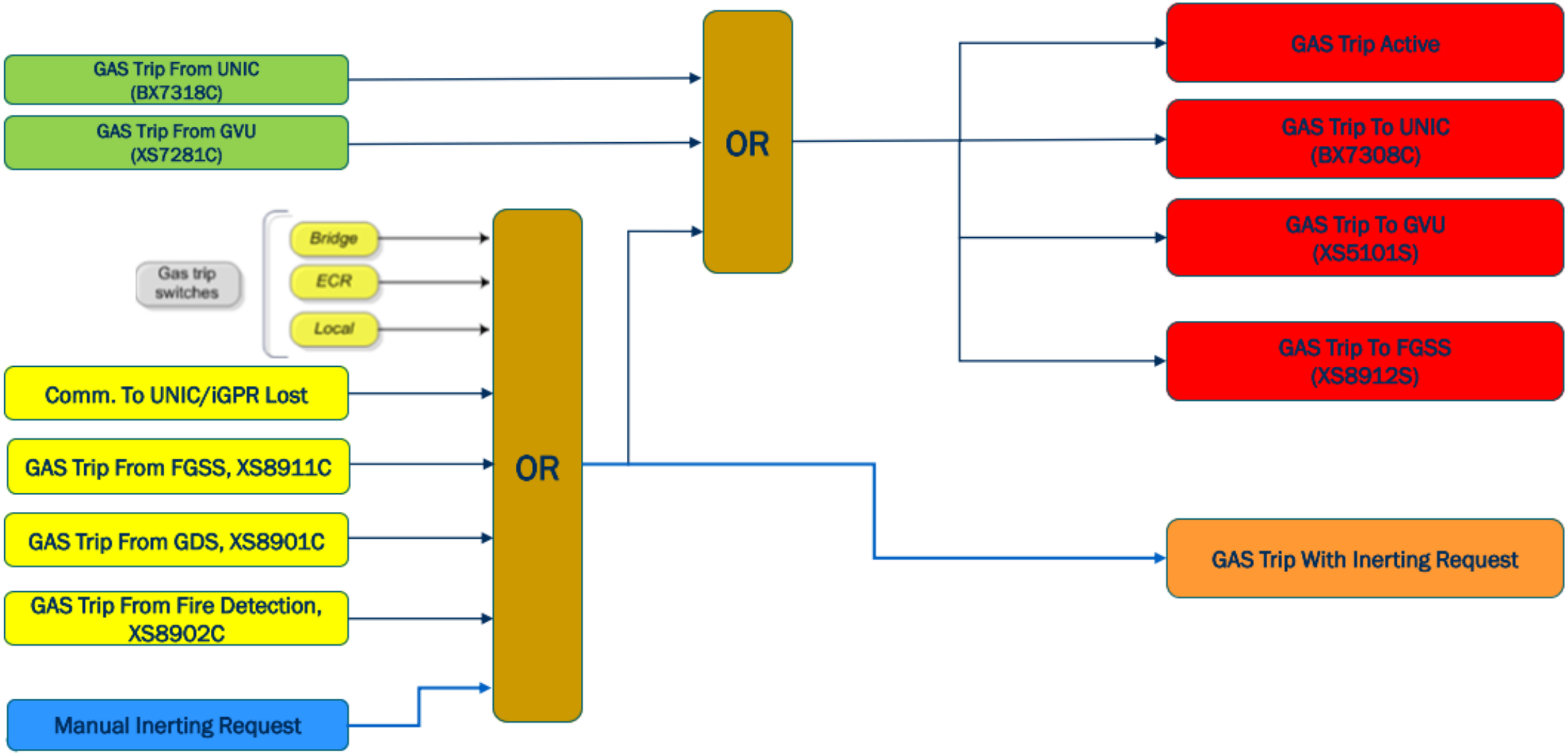
Engine Safety System gas functions

- Slow down
- Shut down
- Over speed protection
- Other standard diesel protections e.g.
- Command to Gas feed system to operate valves before GVU
- Gas trip
- Gas trip with inerting
- Pilot fuel pump shut down

Gas trip by ESS



Engine operation

- Engine starting
- Engine stopping/Reversing/Braking
- Engine shutdown and emergency stop
- Engine ventilation
- Transfers – Diesel to Gas / Gas to Diesel and Gas trip

Engine starting

Possible only in diesel mode:

- Start ahead
- Maneuvering (load less than 10%)
- Running astern

The start is inhibited/interlock if:

- Safety system is off
- Shutdown from safety system activated
- $P_{start.air}$ low in Bridge control
- Main shut off valve is manually closed
- Turning gear is engaged
- Exhaust venting request is active (can be overridden by operator)
- Shaft locking device engaged in case of twin propulsions

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Engine stopping / Reversing / Braking

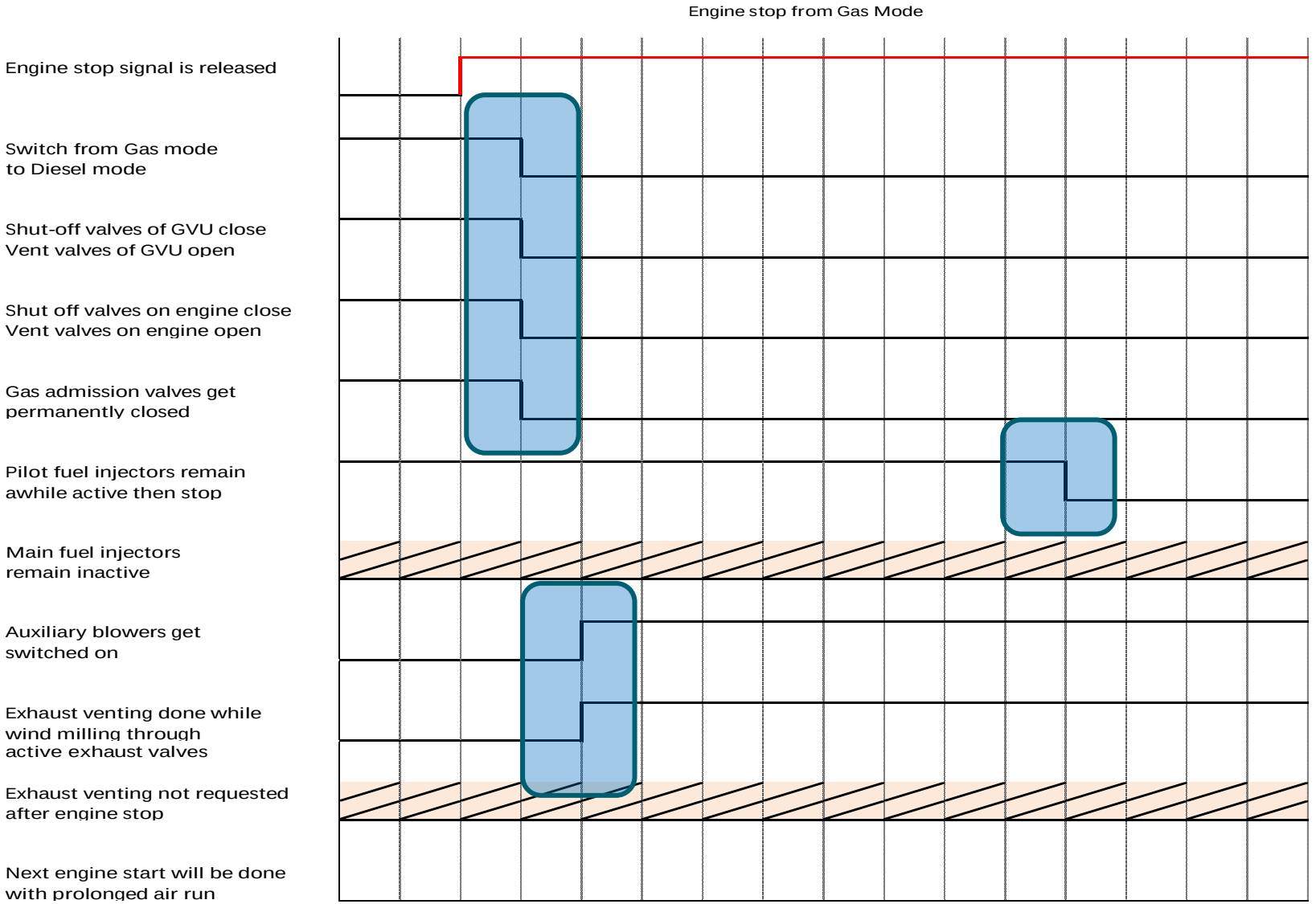
Engine stopping and Reversing

- Stopping possible in gas mode
- Reversing and braking in diesel mode only
- During stopping pilot injection is active until 2 rpm

In case of a normal stop request:

- Engine Control System changes internal mode into stop mode
- Immediately GVU performs gas shut-off and venting
  (gas is depressurised and ventilated).
- The gas admission is de-activated.
- Pilot fuel injectors are operating longer than the gas admission valves to ensure that all gas in the cylinders is burned. Stop sequence is presented in the following graph.

Engine stop from Gas mode



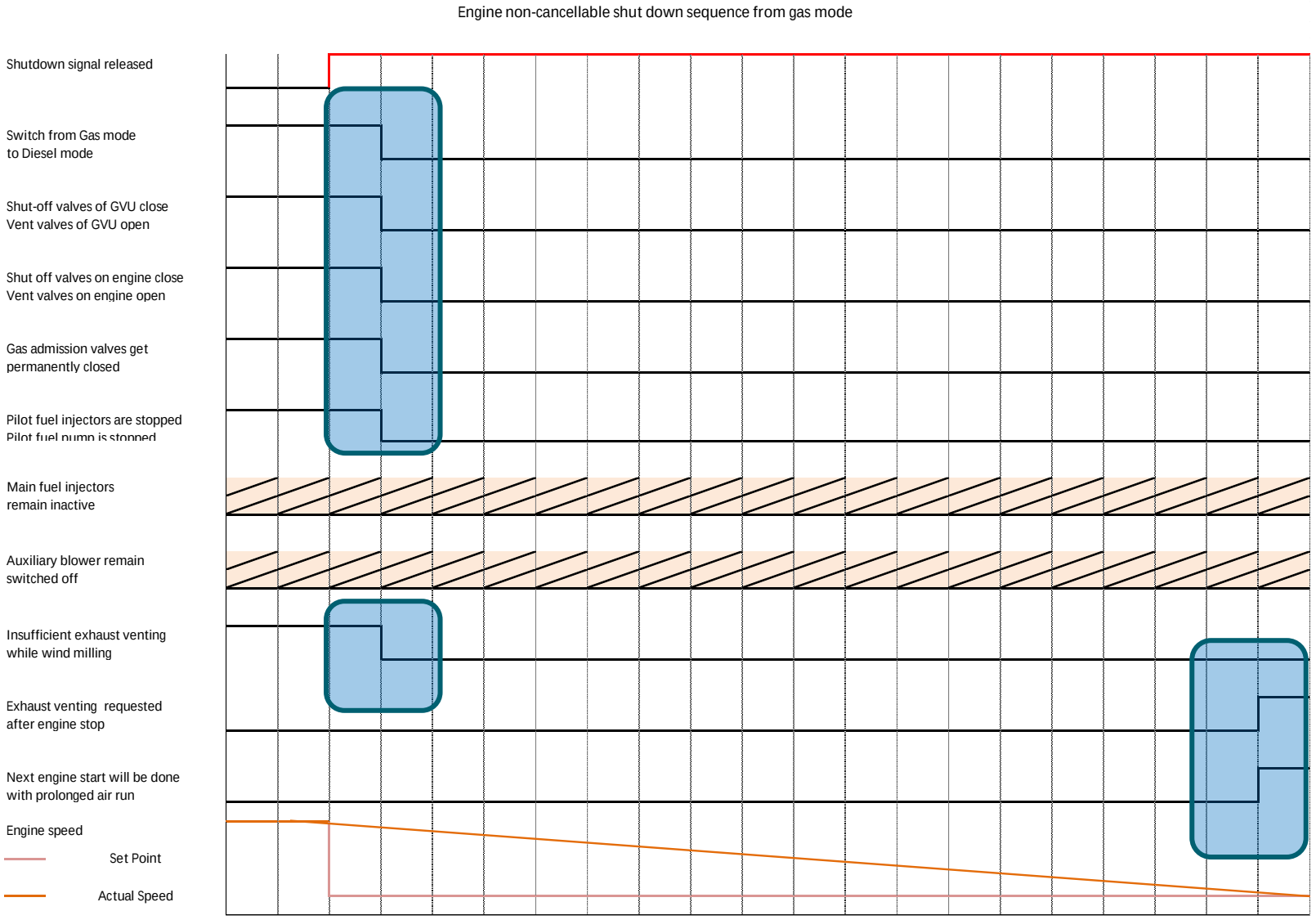
Engine shutdown

Shutdown can be initiated by Engine safety system or Engine Control System.

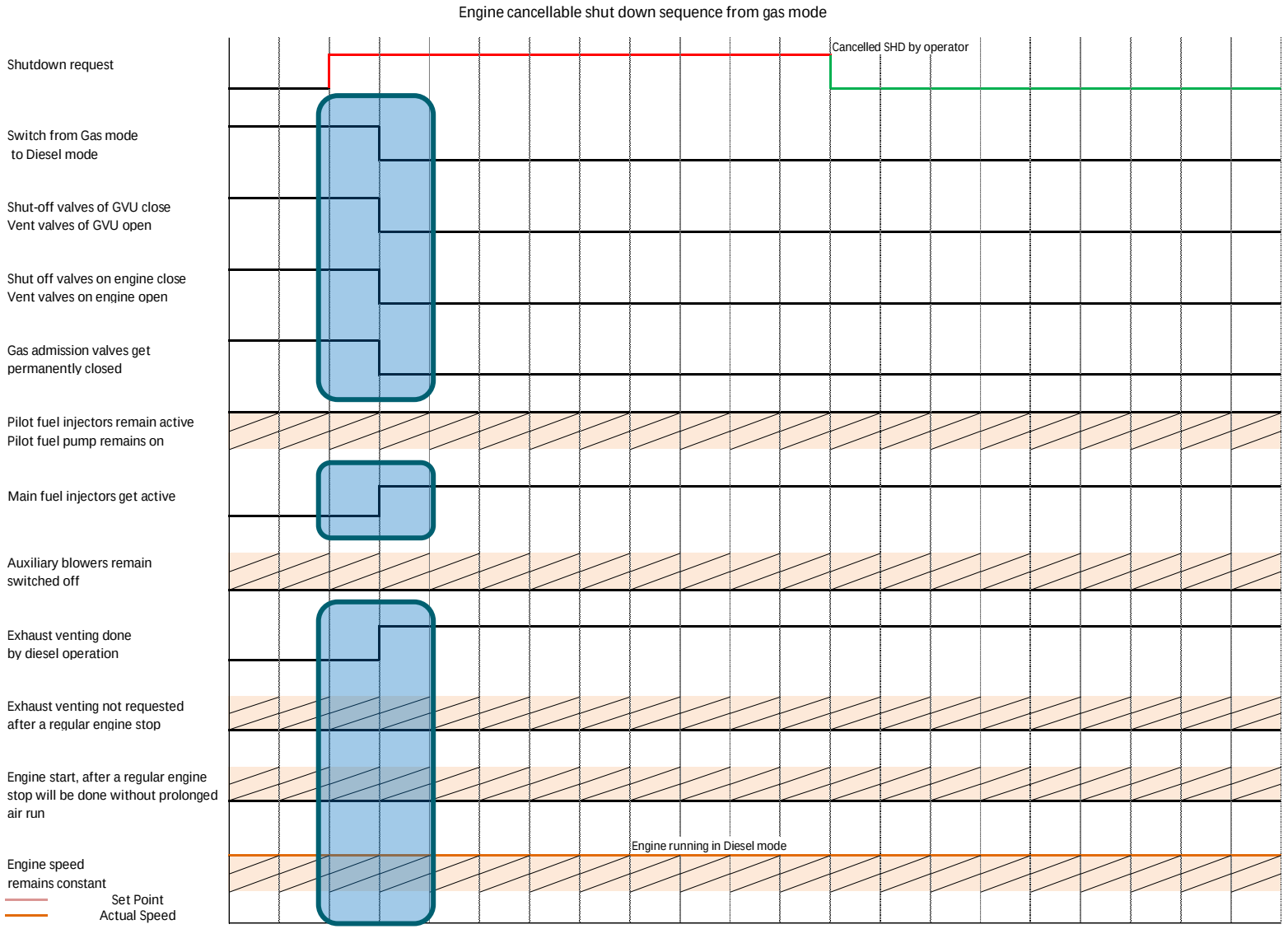
Two groups of Shutdowns:

- Non-cancellable (Overspeed 110% CMCR, Main Bearing Oil Press. very low, Crank Angle measurement failure for cylinders from #2 to n, both CAN system bus failure, Excessive Engine Speed 115% CMCR & Emergency Stop)
- Cancellable (all others)
  - In case of non-cancellable shutdown Exhaust ventilation is requested
  - In case of cancellable shutdown, the operating mode will be changed to diesel mode and the engine will continue running as long as the SHD signal does not become active
    (operator can cancel SHD and continue running in diesel mode).
  - Exhaust ventilation is not required in this situation.

Non-cancellable shut down



Cancellable shut down



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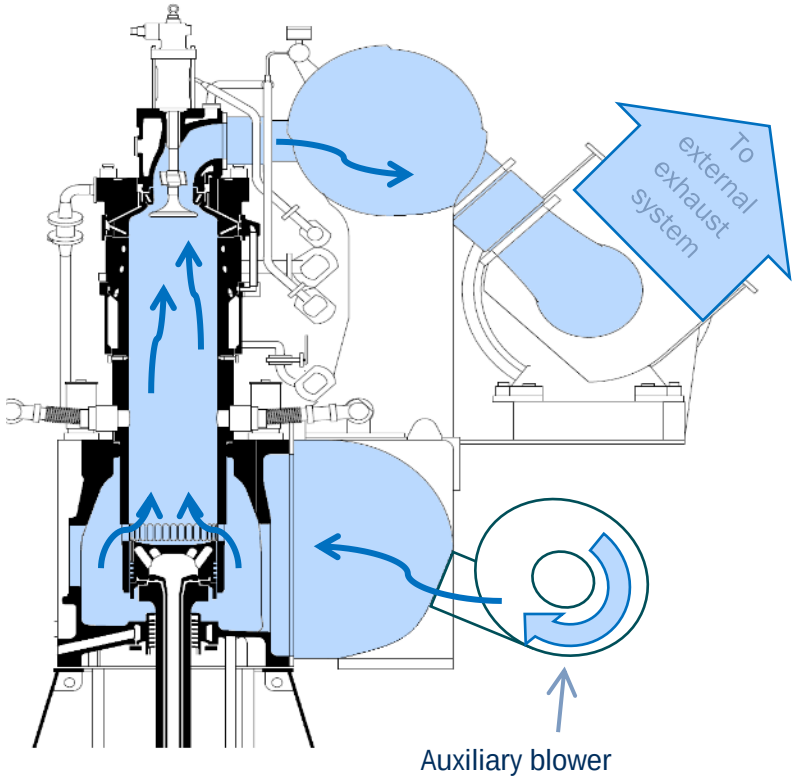
Engine venting

Procedure for eliminating risk of remaining gas explosion in exhaust system



- Ventilation request initiated by ECS after emergency stop or shut down in gas mode
- Ventilation request is cancellable, for example for emergency maneuvering
- Purging with engine auxiliary blowers, no extra blowers for the external exhaust system
- Exhaust valves automatically opened
- In case of failing ventilation sequence:
  - Possible to go through sequence manually
  - Prolonged air run of engine will already considerably reduce the risk of exhaust gas explosions

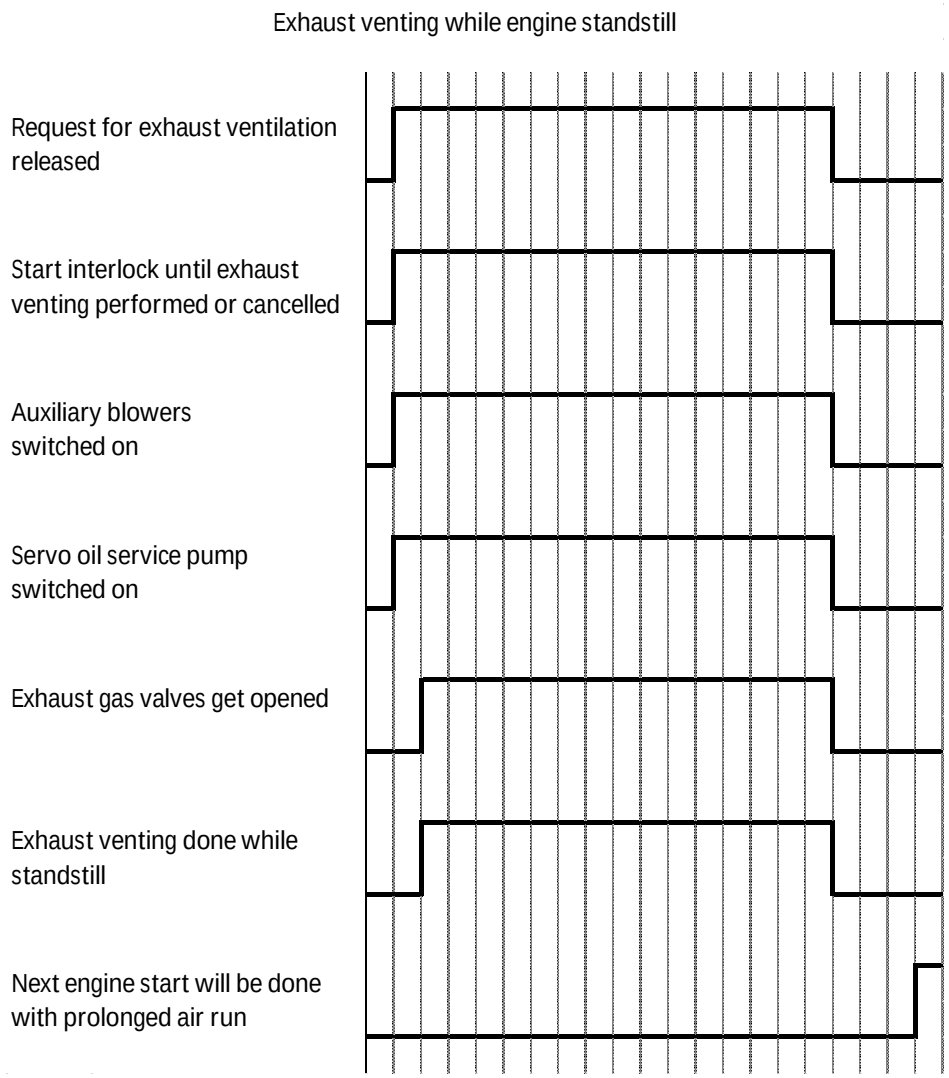
Engine venting

Exhaust ventilation procedure:

The ECS automatically sends the signal for the ventilation sequence

The operator must manually select the applicable function on the LDU-20 and start the ventilation sequence.

- The operator must make sure that the auxiliary blowers operate.
- The servo oil service pump is set to on.
- The exhaust valves open automatically.



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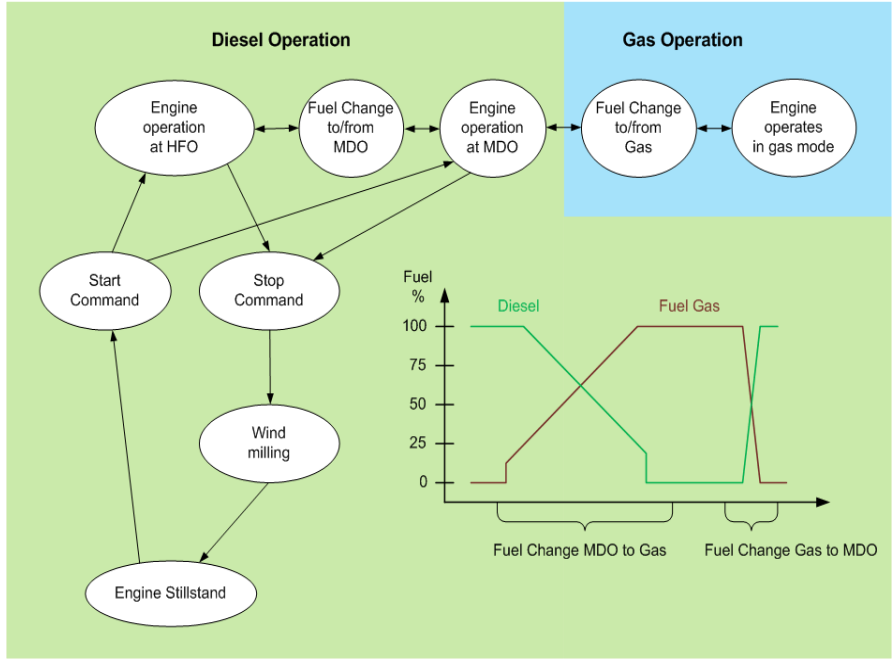
Fuel transfer

For fuel change-over, the operator has to select the required fuel mode and confirm the choice.

Dual Fuel engines can be operated in the following different operating modes:

- Diesel mode
- Gas mode
- Fuel sharing mode (optional)



The transfer takes place without changes in load and speed within the defined load range.
By a fuel change from diesel to gas the gas supply and distribution systems are activated by the gas selection. When ready, the fuel is gradually exchanged.

By a fuel change from gas to diesel the fuel transfer starts almost instantly and is gradually done.

In case of a gas trip the fuel transfer is done instantly.

Fuel Sharing mode

- The fuel sharing mode is an optional feature that allows increased fuel flexibility.
- In this mode, the dual fuel engine operates on a variable share of liquid fuel and gas, which is simultaneously combusted in the cylinders.
- Fuel sharing mode is available above 50% engine load and with a liquid-to-gas ratio of up to 50%.
- The ratio of liquid-to-gas fuel is requested by the remote control system.

Since the fuel ratio can automatically change in fuel sharing mode

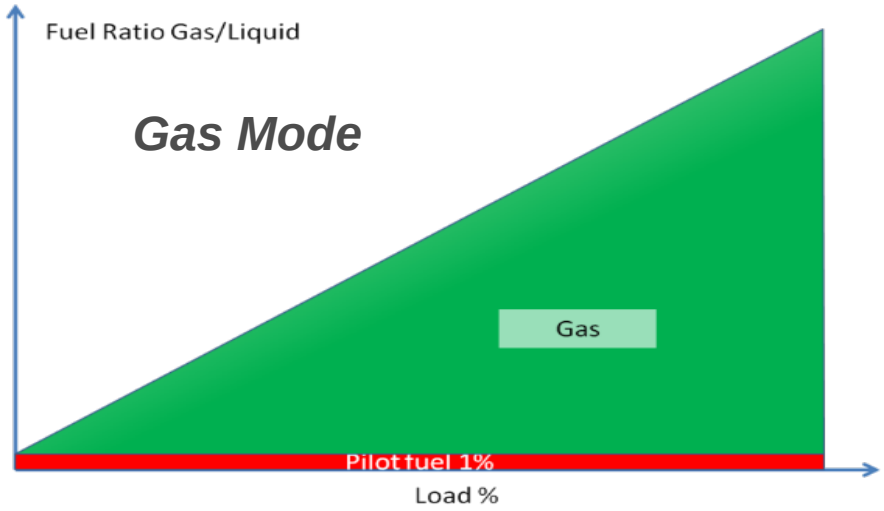
(e.g. if vessel speed changes), the lube oil type is also automatically changed

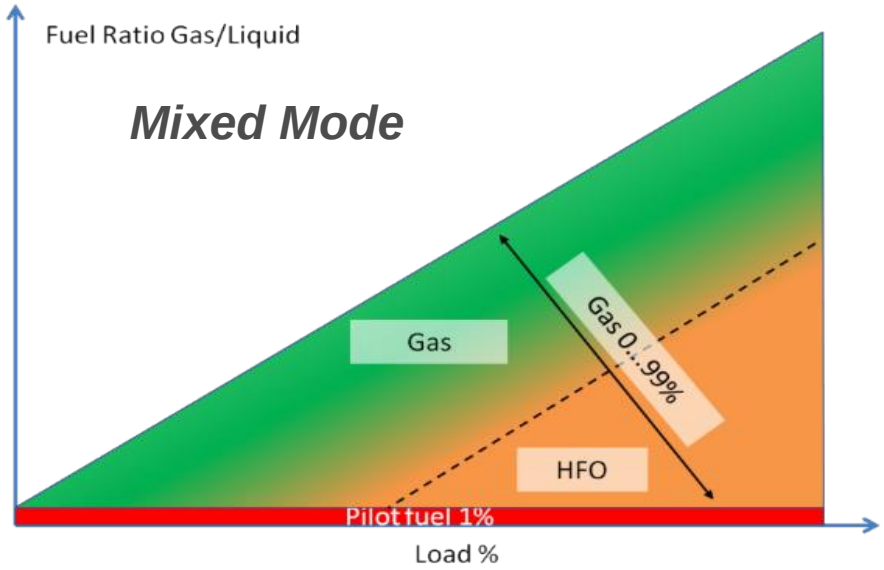
- Two oil types are specified(BN 15-25 & BN100). The choice of the oil type in operation is based on the fuel ratio and the type of liquid fuel in use
- The cylinder oil feed rate is not changing based on the fuel ratio. The fine tuning of the feed rate is still done by the crew according to the principles applied on any diesel engine

Fuel Sharing mode

Concept

- The X-DF Engines may be operated either in:
  - Gas Mode with 1% MDO pilot and Gas
  - Diesel mode with 100% MDO/HFO
- In addition, development of mixed mode
  - ('Fuel sharing') with adjustable ratio of gas to HFO. Can be used to balance between available boil-off and desired ship speed
  - Control parameters are set in engine control system based on liquid/gas-ratio signal from RCS





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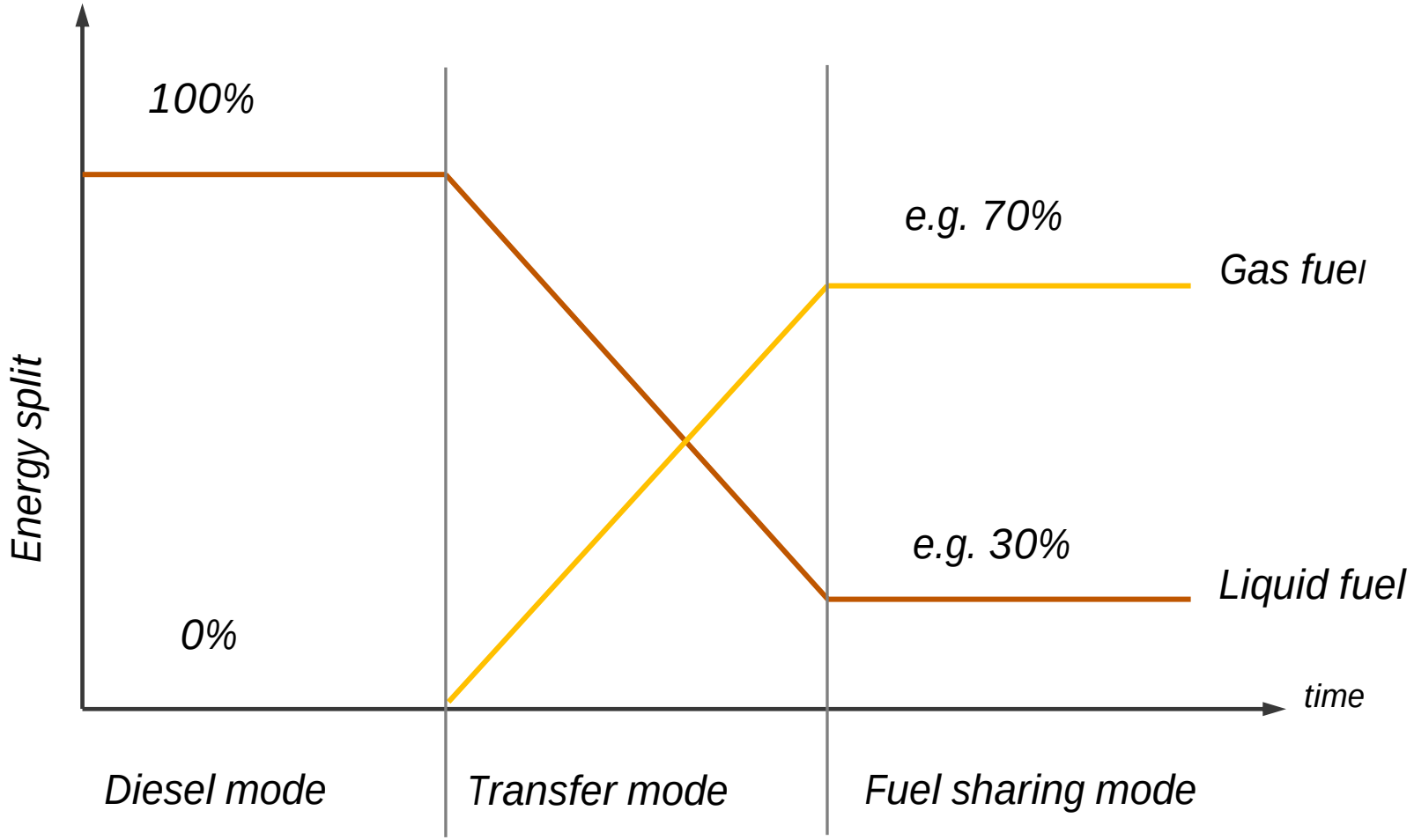
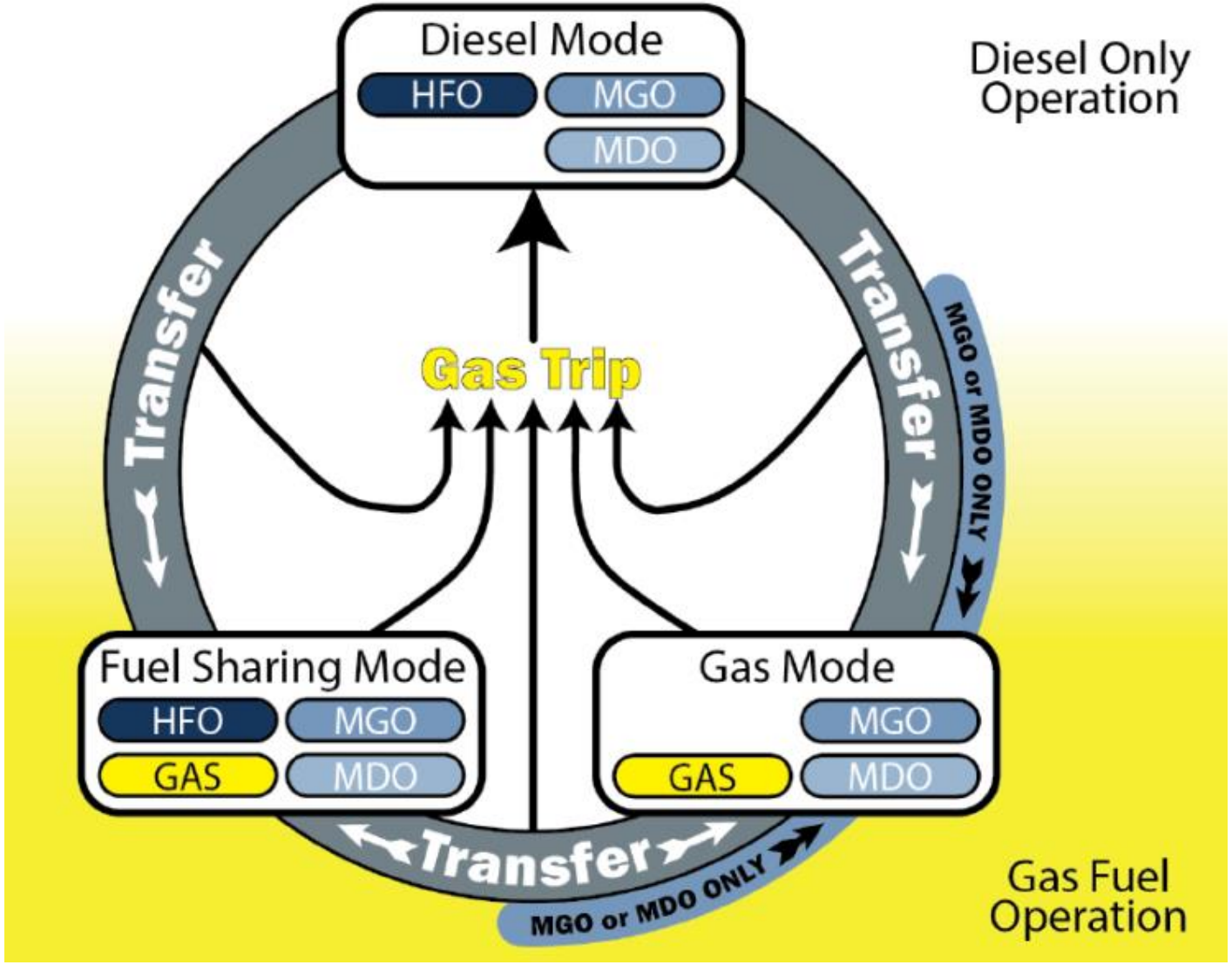
Fuel Transfer

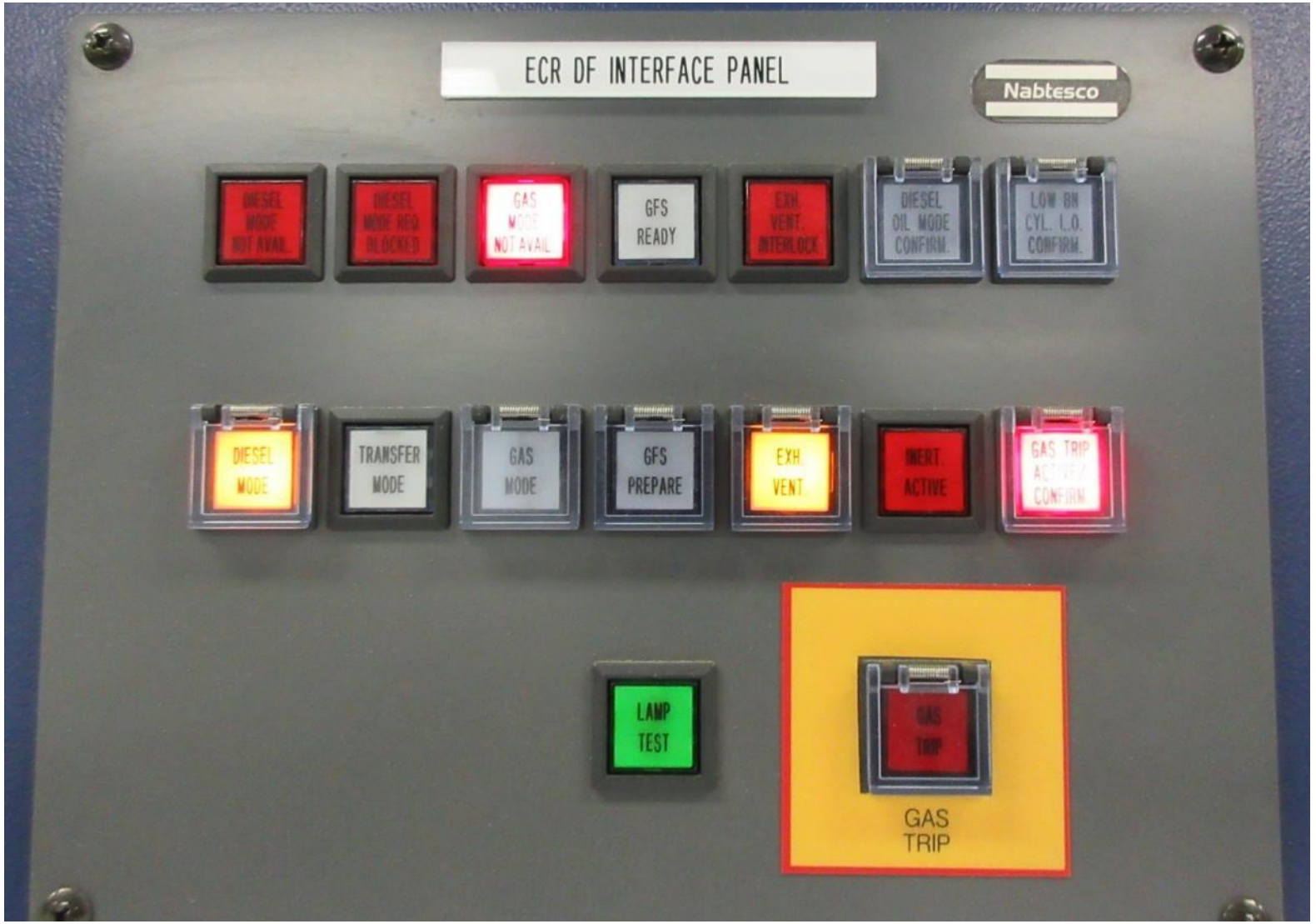
Fuel Transfer from Diesel to Fuel Sharing mode



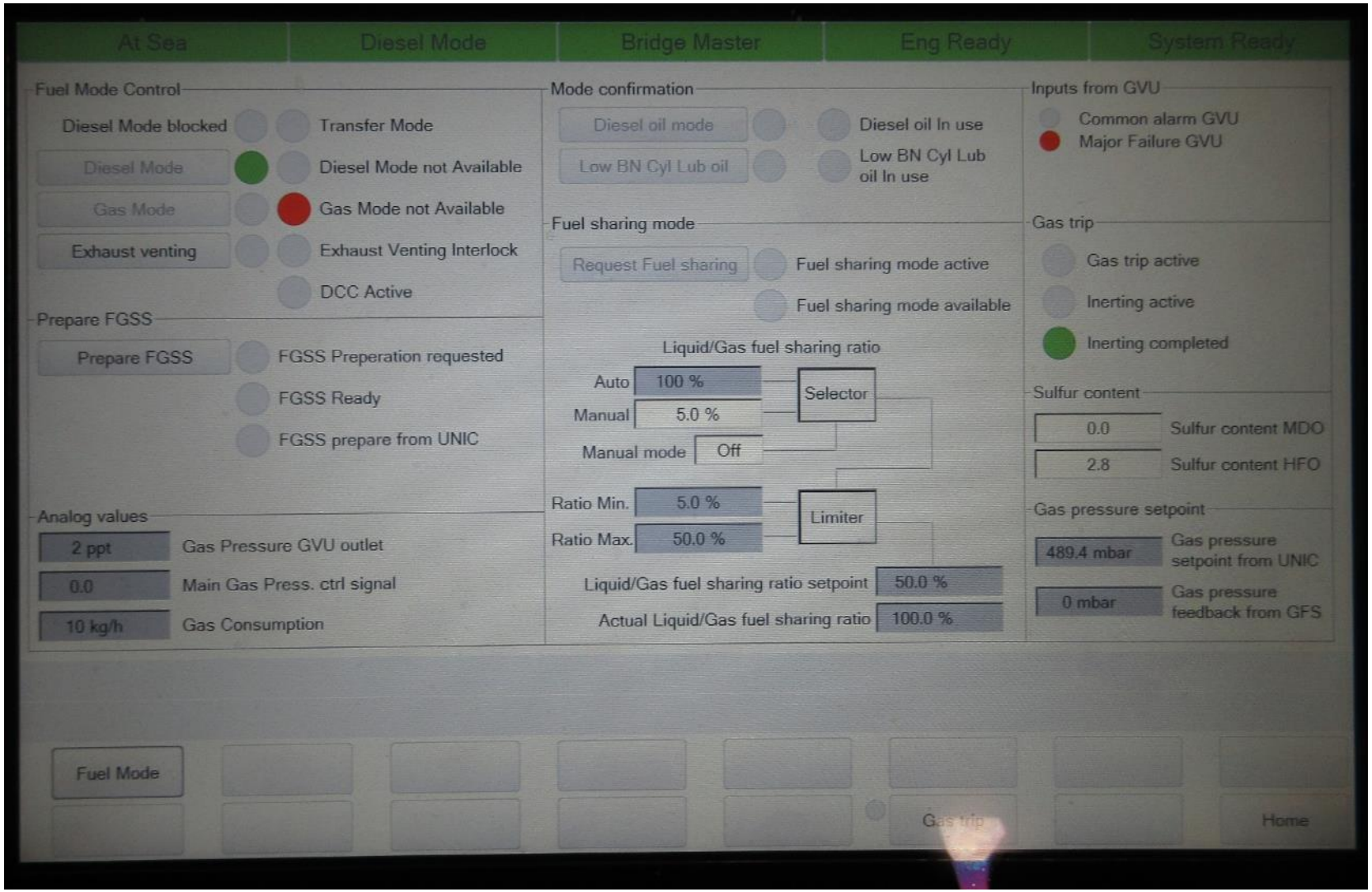
Fuel Transfer



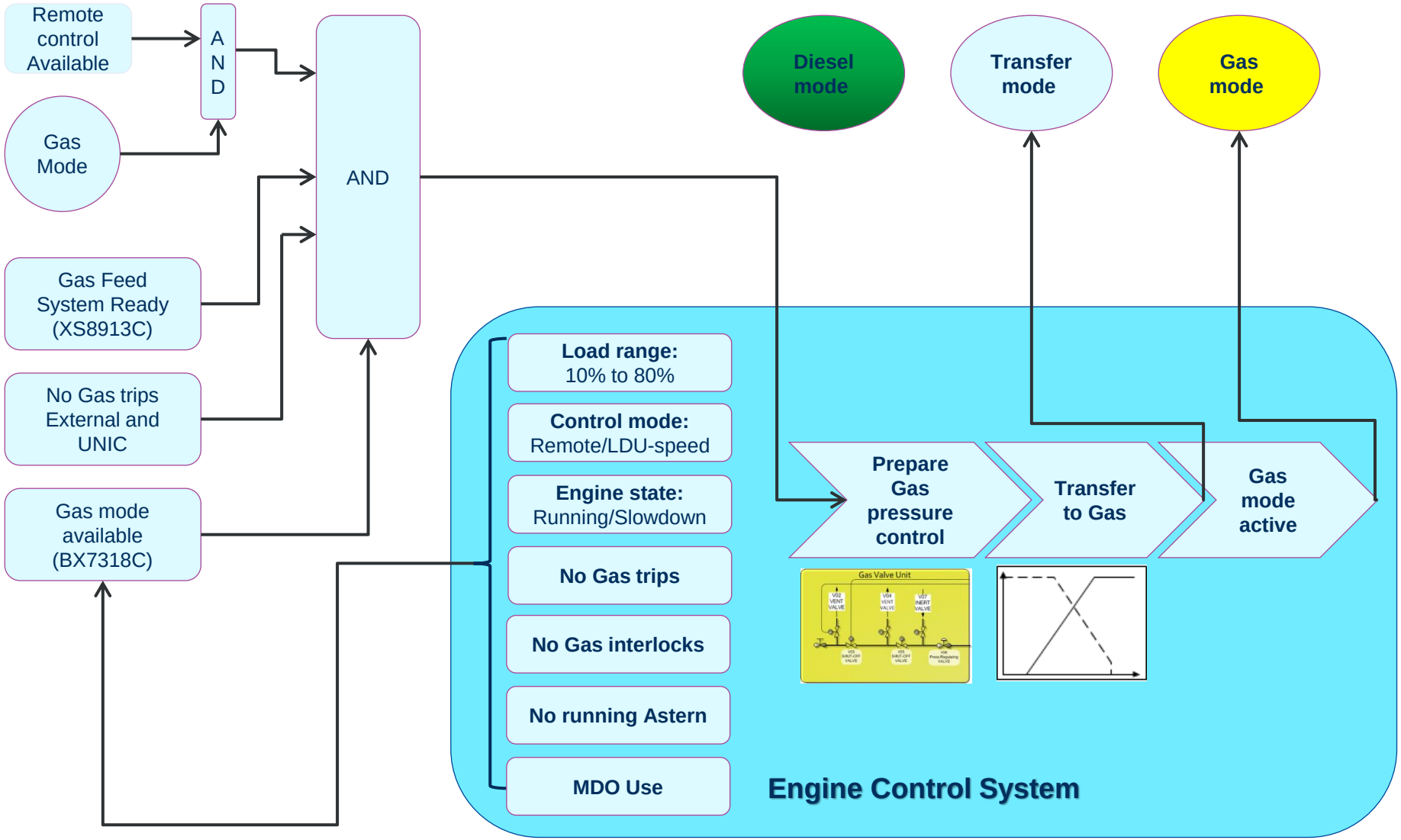
ECR DF Interface - Nabtesco



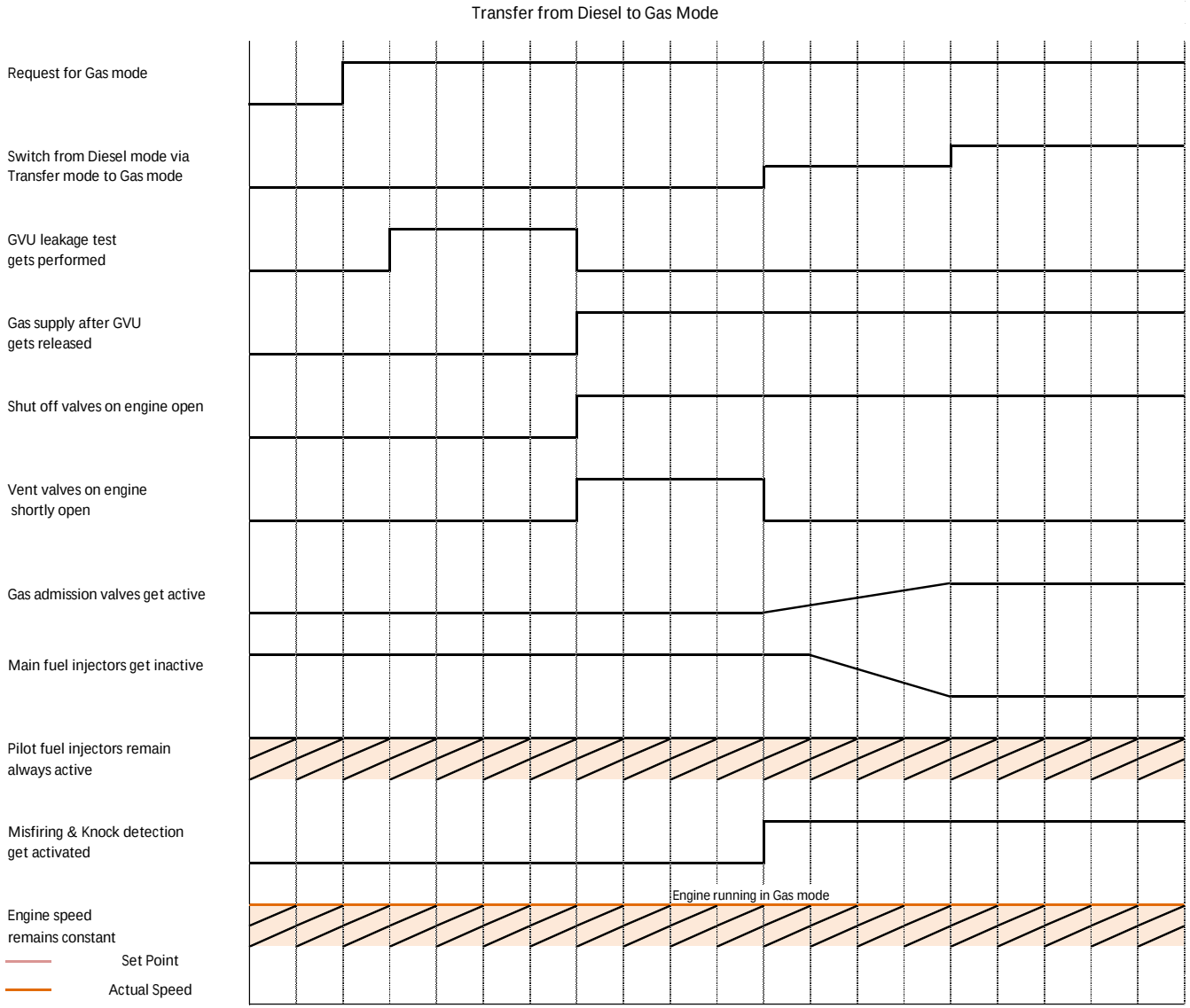
ECR DF Interface - Kongsberg



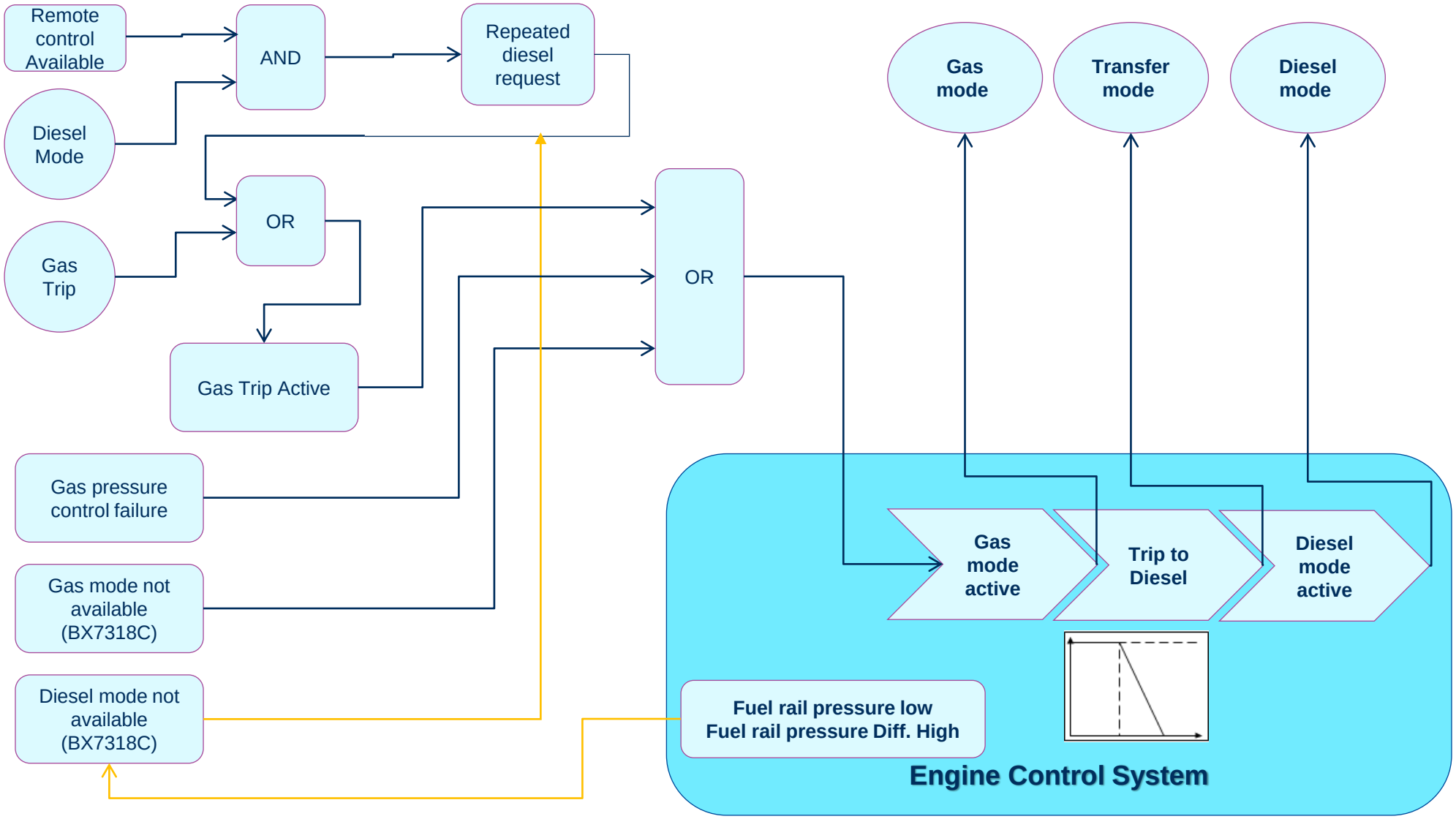
Fuel mode transfer: Diesel to Gas



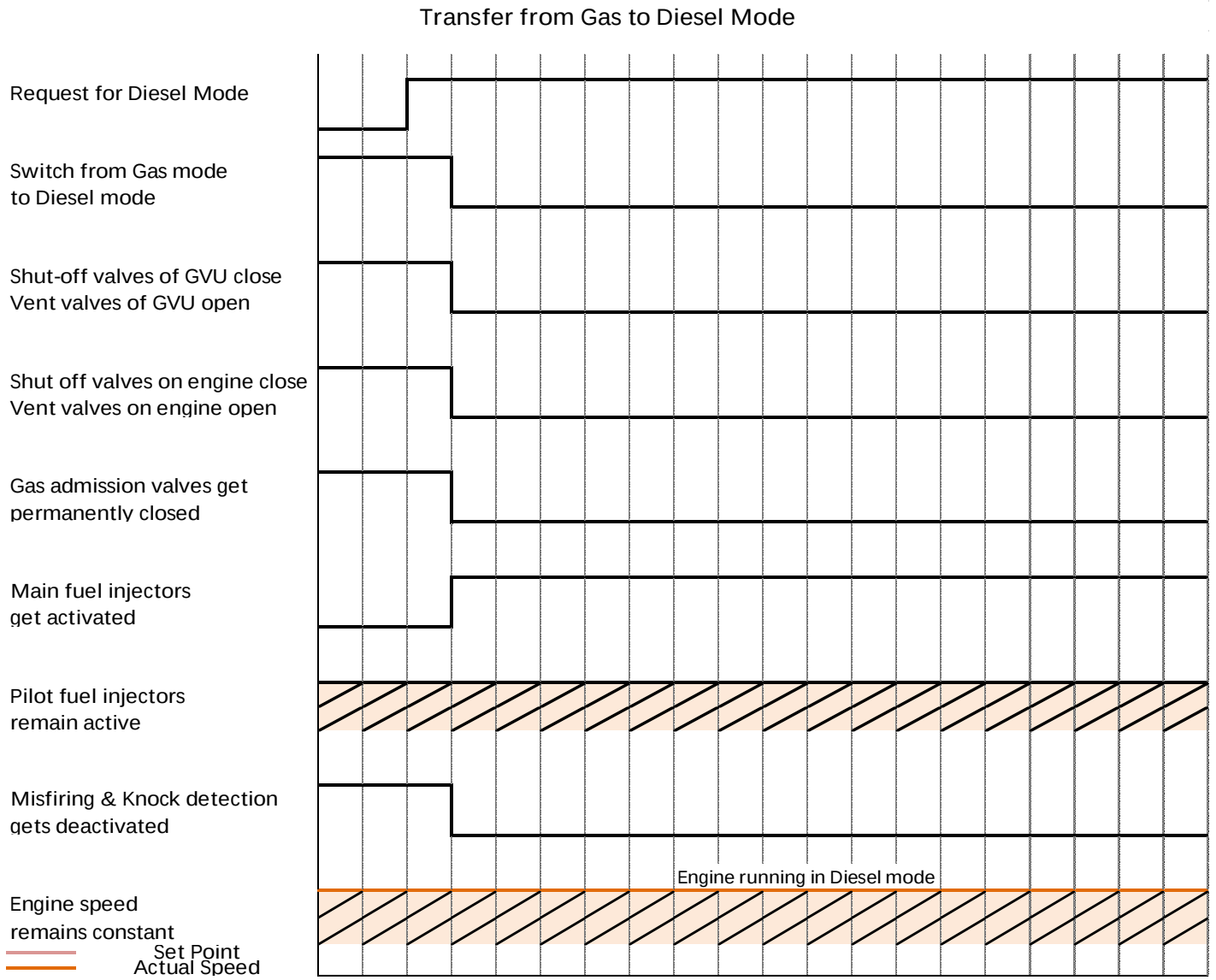
Fuel mode transfer: Diesel to Gas



Fuel mode transfer: Gas to Diesel



Fuel transfer mode Gas to MDO, and GT



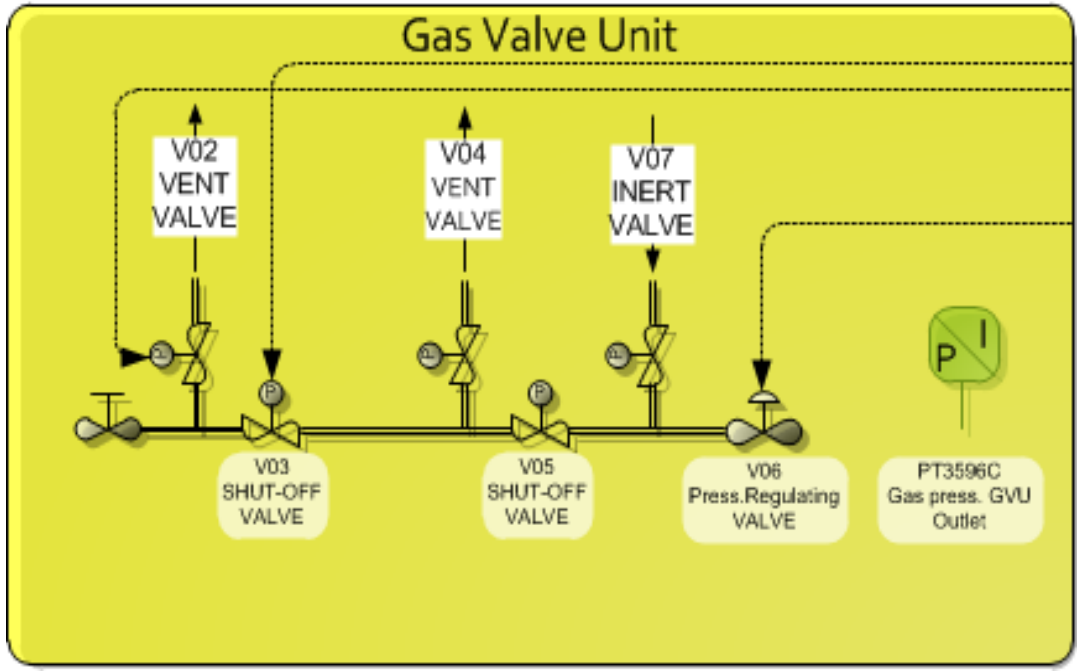
Gas pressure system: preparation

Initiated by fuel mode control, when Gas request is active

Gas Valve Unit: preparation

GVU performs gas leak test in 4 steps:

- Check Shut-off valve V03
- Check valves V05, V02 and V04
- Check valve V04 and V05
- Prepare for operation



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Gas Valve Unit: gas leak test

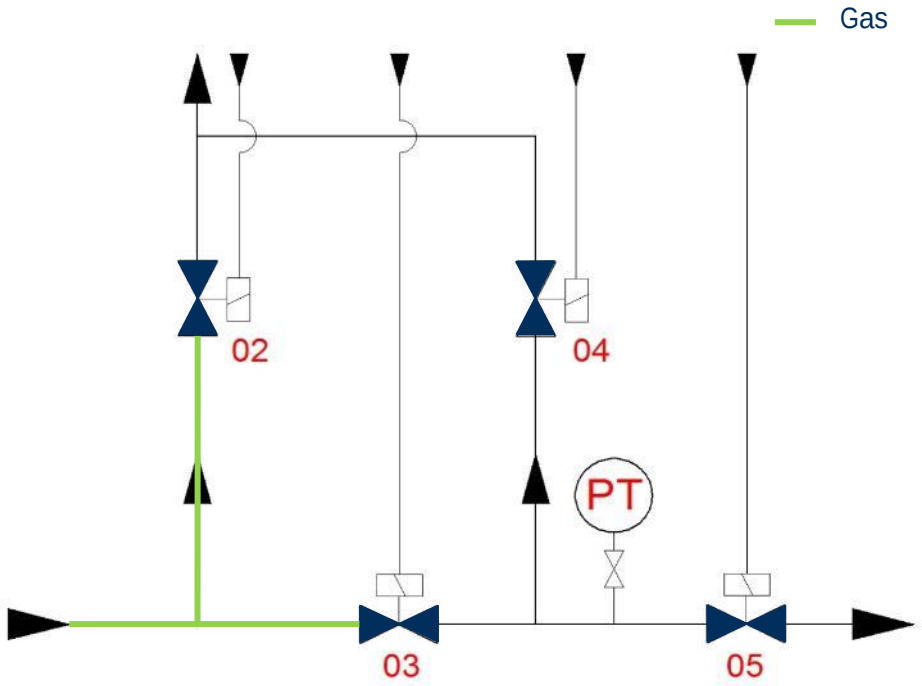
Step 1

- Shut-off valves: closed
- Venting valves: closed
- PT monitoring of blocked space for pressure rise:

  If 1st shut-off valve is leaking:

  → An alarm/Gas interlock

Otherwise step 2



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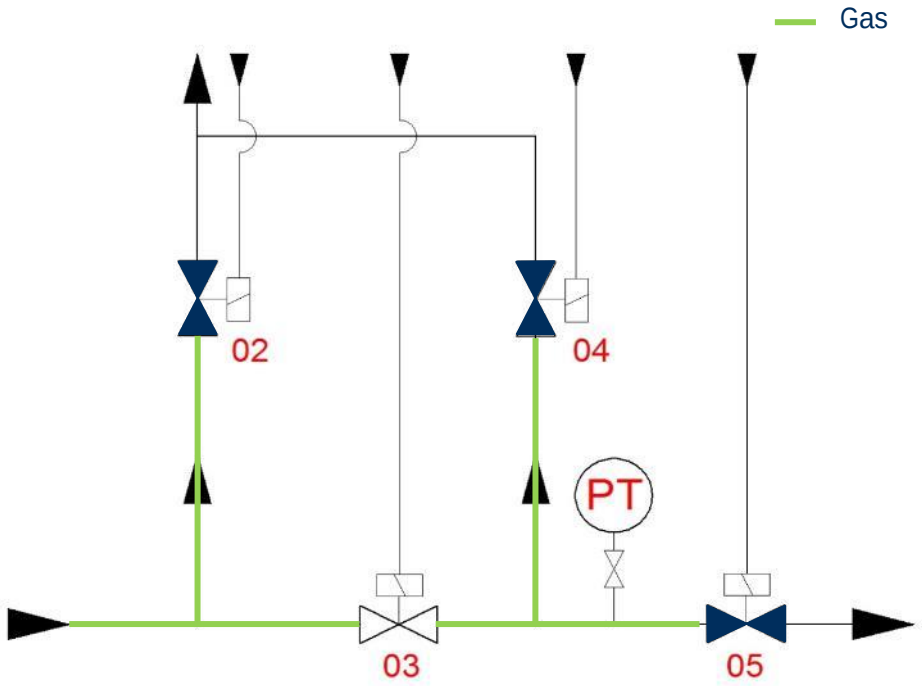
Gas Valve Unit: gas leak test

Step 2

- V03 shut-off valve: open
- V05 shut-off valve: closed
- Venting valves V02, V04: closed
- PT monitoring of blocked space for pressure rise

  If no pressure increase,
  transmitter or V03 shut-off valve or
  venting valve(s) is malfunctioning:
  → An alarm/Gas interlock

Otherwise step 3



Gas Valve Unit: gas leak test

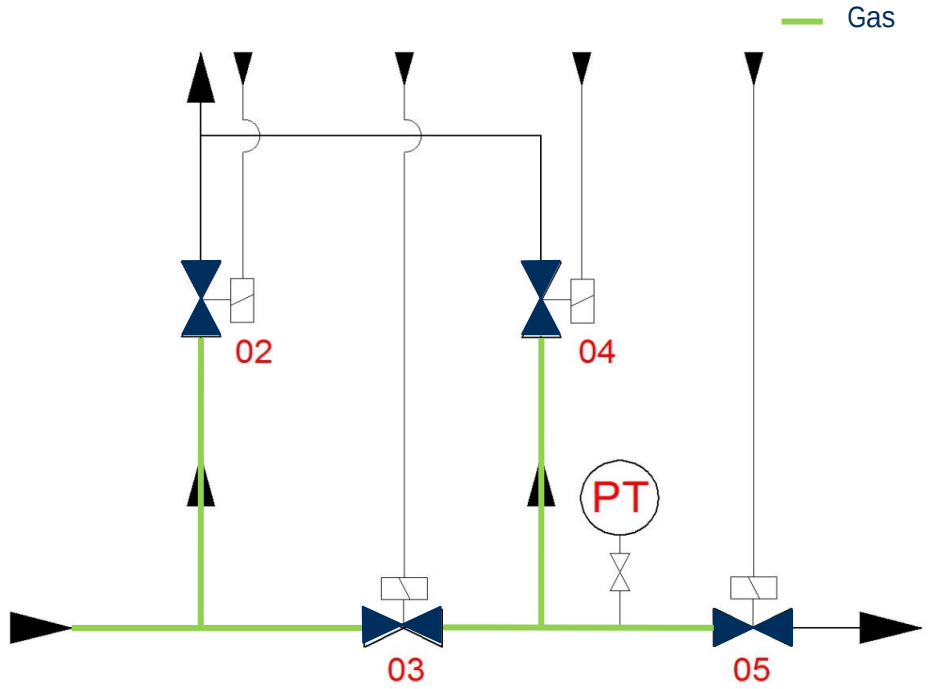
Step 3

- Shut-off valves: closed
- Venting valves: closed
- PT monitoring of blocked space for pressure drop

If pressure drops, 2nd shut-off valve or venting valve is leaking:

→ An alarm/Gas interlock

Otherwise step 4

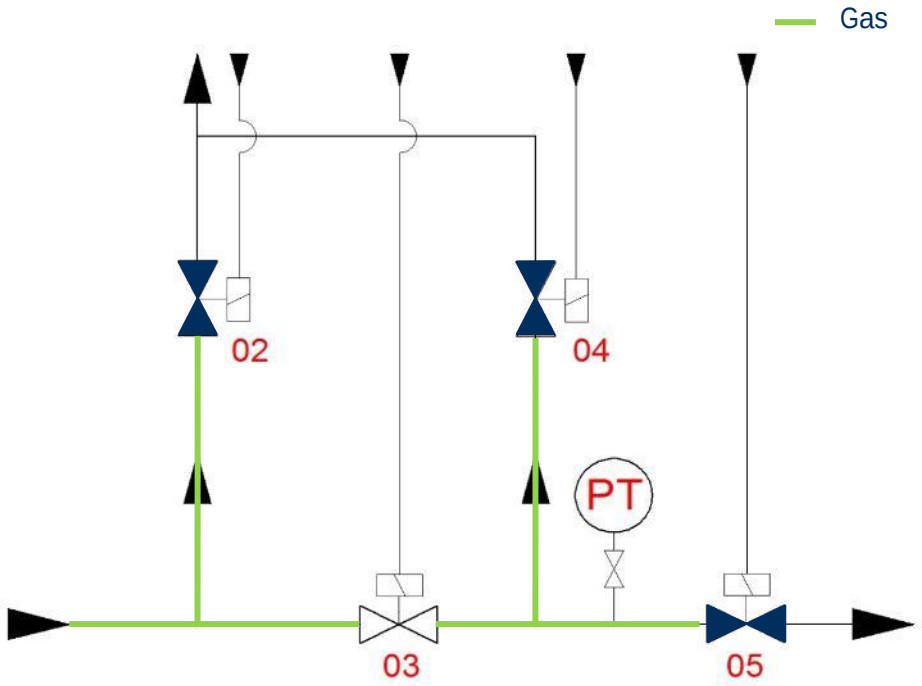


Gas Valve Unit: gas leak test

Step 4

- 1st shut-off valve: open
- 2nd shut-off valve: closed
- Venting valves: closed
- Gas leakage test successfully Passed

The gas leakage test sequence ended



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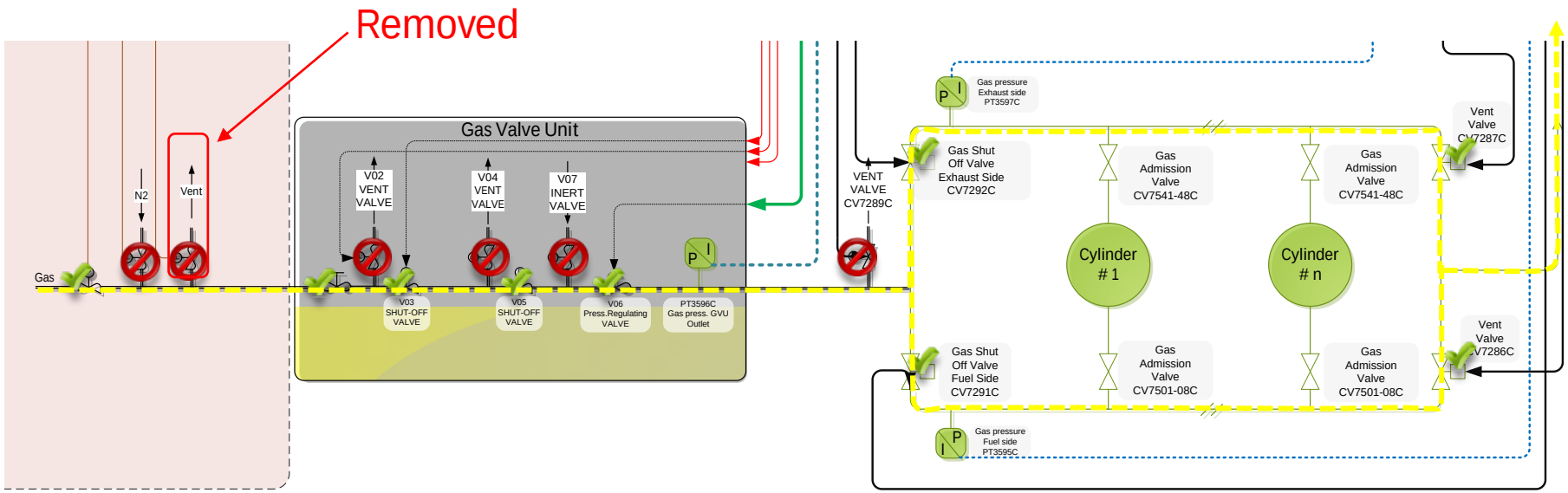
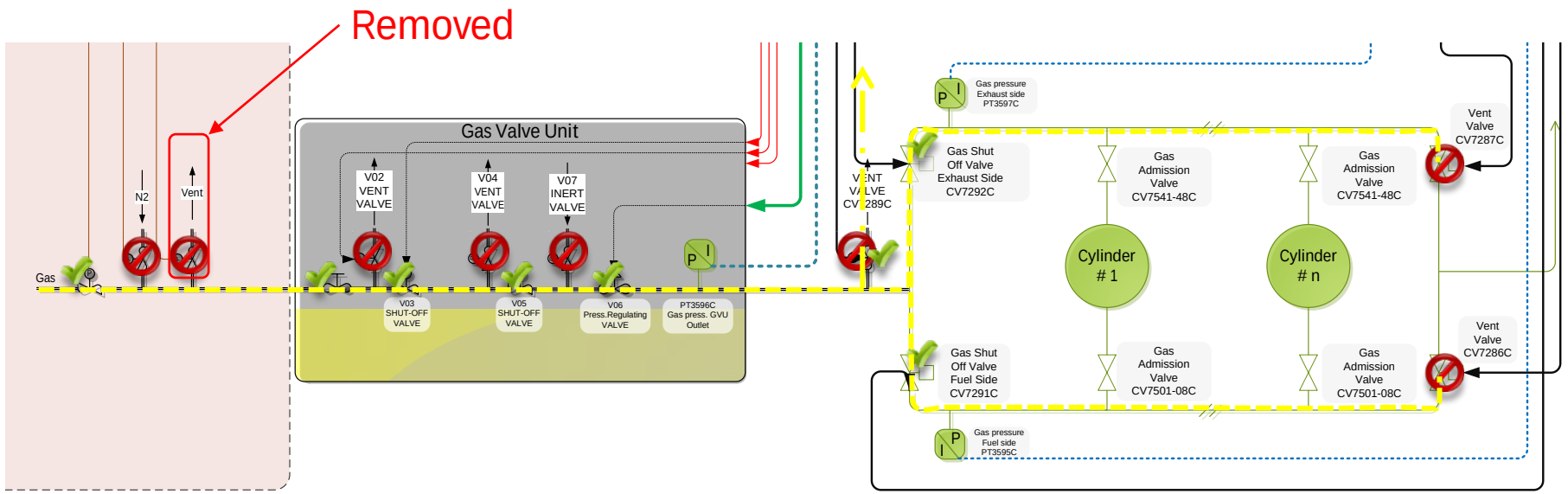
Flushing



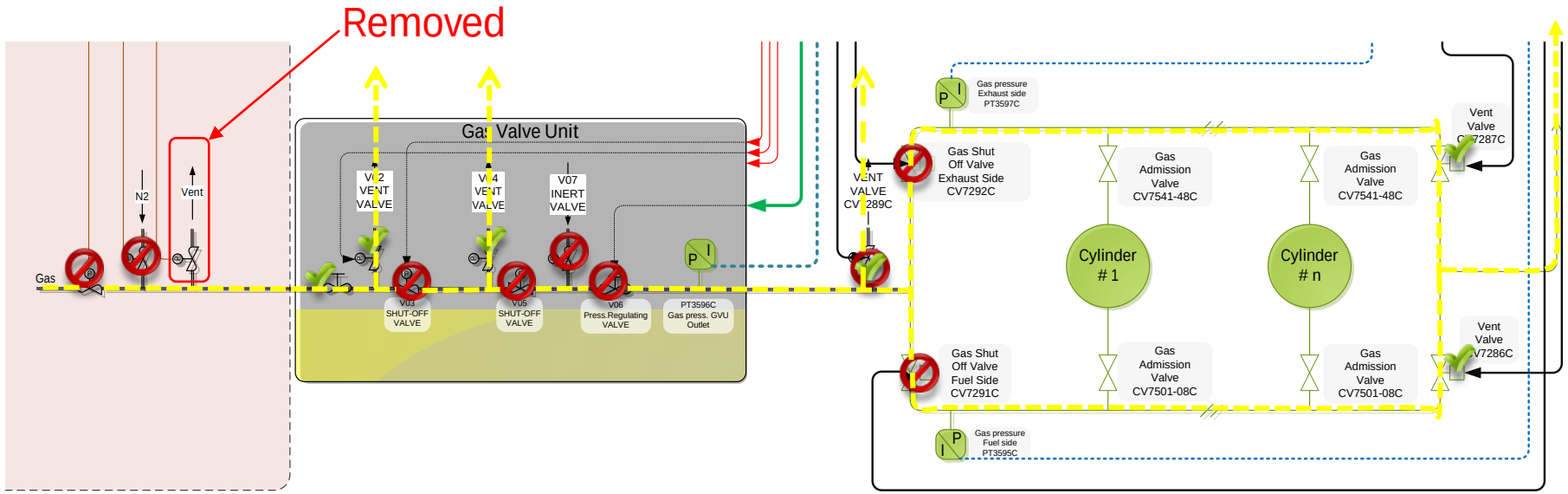
- Flushing – filling of gas rails with gas
- Gas pressure max 5 bar
- Flushing duration is about 10 s

Pressure stabilization



- Stabilization of the gas pressure before gas admission
- Pressure to be ± 0.5 bar from the set point
- If time elapses remains in diesel mode and Degassing is requested
- Gas set point corresponds to the engine load at transfer

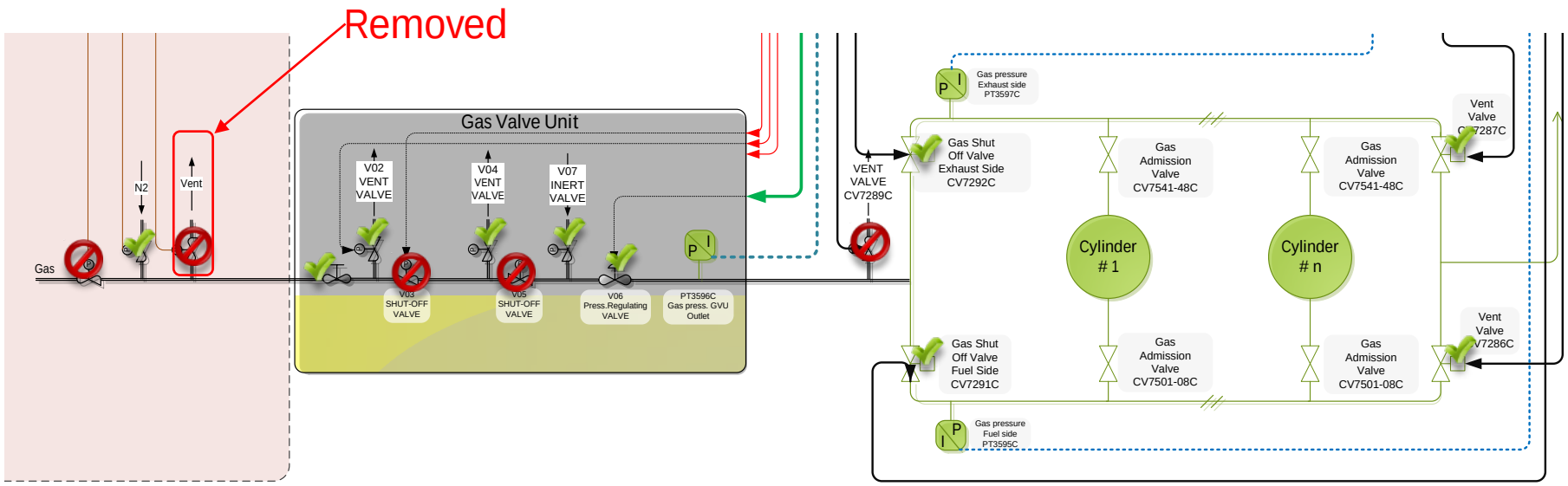
Degassing



Degassing – pressure release from gas rails and before GVU at:

- Engine stop
- Engine shutdown

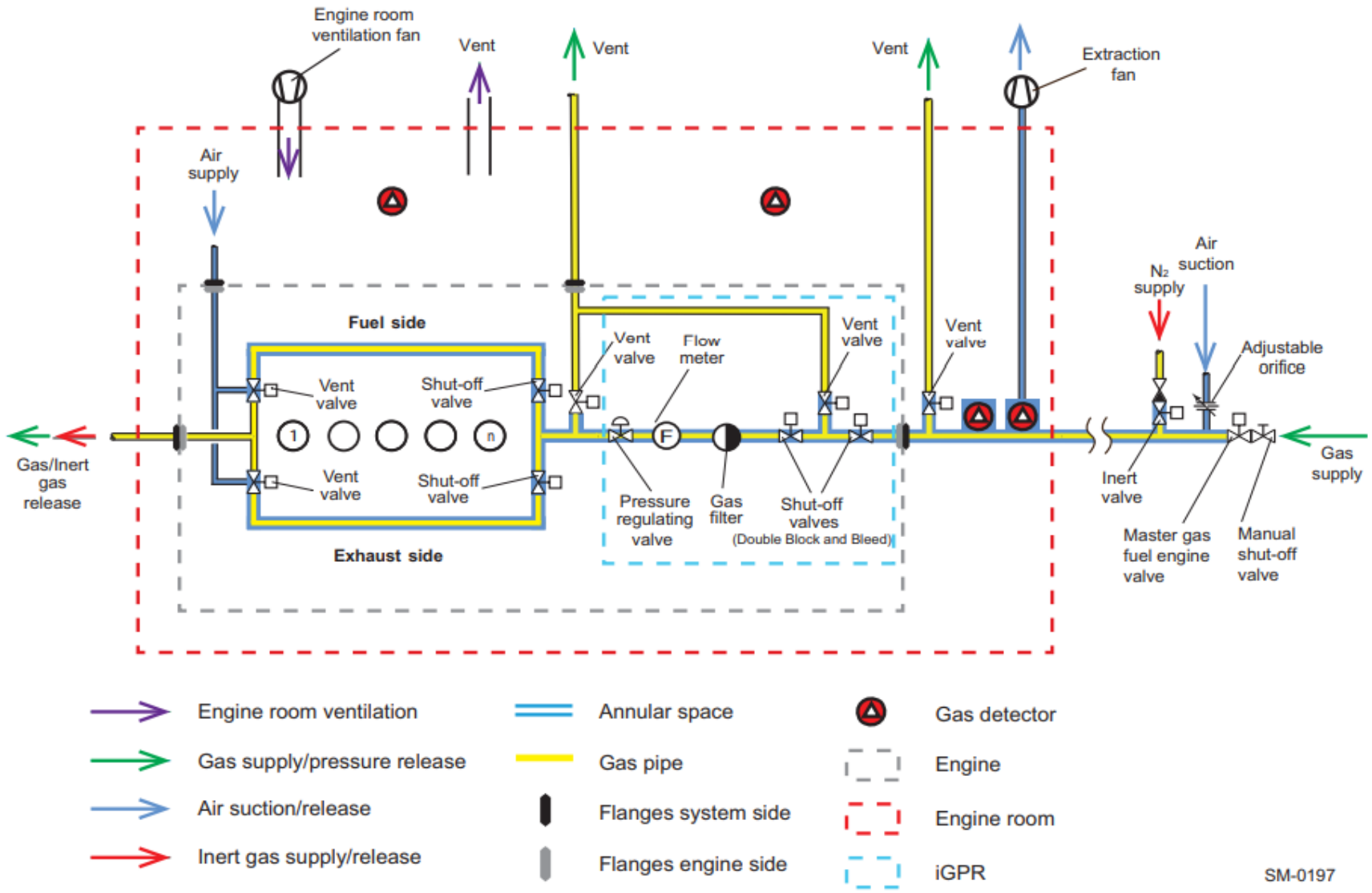
Inerting



Inerting – filling gas lines and rails with inert gas e.g. N_2 or CO_2

- In Gas mode when gas trip with inert signal is active
- In Diesel mode by request
- At engine stand still by operator request

iGPR



Gas Interlocks

- **Modules failure (CCM, MCM, IOM)**

- **Wiring and sensors failure**
  - Both Gas fuel pressure sensors fail
  - Both pilot fuel rail pressure sensors, inlet pressure and temperature sensors fail
  - Pilot fuel pressure control v/v open/short circuit
  - GAV sealing oil pressure sensor fail
  - GAV sealing oil shut-off valve open/short circuit
  - Any gas rail vent or shut-off valves fail (Fuel or Exhaust side)
  - Exhaust waste gate control valve open/short circuit
  - Crank angle measurement failures on CCM and MCM modules
  - CAN bus to PCS #1 & #2 communication fail
  - Any pilot fuel injector S/V open/short circuit
  - Two or more cylinder pressure sensors fail
  - Both Scav. Air pressure sensors fail

Gas Interlocks cont.

- **Process related**
  - Turbo charger speed very high
  - Knock detection fail (Cylinder pressure & Knock sensor fail on any cylinder)
  - Gas pressure out of limit, high measuring difference
  - Gas rail inerting, degassing, flushing failed
  - Pilot fuel pressure out of limit, high measuring difference(300 bar)
  - Pilot fuel inlet low pressure(less than 1 bar) or high temperature(Above 50 ℃)
  - GAV sealing oil pressure low or very low
  - Scavenge air pressure very high, high measuring difference
  - Control air pressure low
  - Gas detection system – too high concentration in piston underside
  - Any cylinder abnormal condition

    (Fuel injection manual cut-off, exhaust valve fail, cylinder pressure too high, exhaust gas temperature high or deviation high)

Gas trips

- Gas trip from ESS
  - Manual push buttons
  - Gas detection system
  - Gas feed system
  - GVU
  - UNIC
- Gas mode is not available
- Any GAV stays opened

Gas trips (cont.)

- Misfiring
- Knocking
  - Heavy knock
- Most of gas interlocks