

CBT 13 includes the following modules:

1. Ammonia as a fuel for marine 2-stroke DF engines - Introduction
2. Methanol as a fuel for marine 2-stroke DF engines - Introduction course
3. Electronically controlled low speed diesel engines

1. Ammonia as a fuel for marine 2-stroke DF engines



This e-learning module discusses in detail the role of ammonia (NH₃) as a key, carbon-free alternative fuel in maritime transport, introduced to meet the International Maritime Organization's (IMO) 2050 decarbonization goals.

It presents the physicochemical characteristics of ammonia, its production pathways (grey, blue, green), and global market forecasts up to 2050.

2.3 Ammonia production pathways

The nitrogen is purified from the air. The Haber-Bosch process is then used to produce ammonia: hydrogen and nitrogen are combined at a high temperature (350-500 °C) and pressure (100-400 bar) in the presence of an iron catalyst.

Based on: International Renewable Energy Agency and Methanol Institute (IRENA), 2021

Ammonia as a Fuel
2. Characteristics of ammonia as a fuel
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It describes the architecture and components of the marine fuel system (e.g., bunkering stations, Fuel Valve Units (FVU), ventilation, and venting systems) and the design criteria for dual-fuel engines (e.g., WinGD X-DF-A) operating in diesel and ammonia modes.

4.2 Ammonia Fuel System components

Fuel Valve Unit

The Fuel Valve Unit (FVU) acts as the interface between the engine and ancillary systems. It is located outside the machinery space, in the fuel preparation area.

Main functions:

- Isolate the engine from the FSS
- Control the return of ammonia flow to the catch and purge tanks
- Connect the inert gas supply system and hot air

The FVU performs an ammonia leakage test before the engine starts operating on ammonia fuel to ensure the tightness of valves and the proper functioning of components.

Based on: X-DF-A Concept Guidance by WinGD

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4. Ammonia Fuel System
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It focuses heavily on safety aspects, analyzing ammonia's toxicity, fire and explosion hazards, hazardous area zoning, leak detection systems, emergency response protocols, first aid, and firefighting techniques.

3.4 Safety and first aid

Portable ammonia detectors must be worn when entering the main engine machinery space, where there must also be enough **emergency escape breathing devices (EEBD)**.


If vapours are inhaled, move the casualty to fresh air. **Medical intervention** may be required (supplemental oxygen or assisted ventilation).

If there's skin contact, immediately **flush the affected area with lukewarm water** for at least 15 minutes in an emergency shower. Carefully **remove contaminated clothing and shoes**, noting that ammonia can freeze them to the skin. Seek medical attention immediately.

Ammonia causes severe irritation, chemical burns, and potential permanent blindness. If contact with eyes occurs, take immediate action: **rinse eyes** with lukewarm water for at least 20 minutes without stopping, then seek medical care to prevent lasting damage.

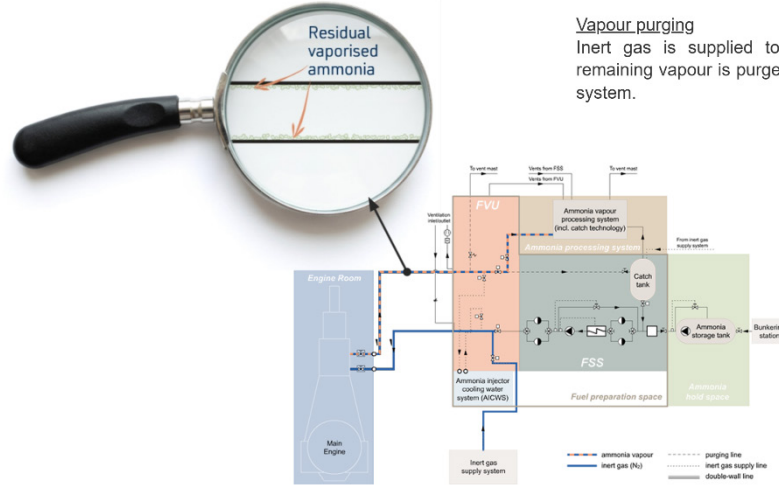
Ammonia as a Fuel
3. Safety Aspects
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It provides precise instructions regarding normal system operation (fuel mode transitions, normal stop, and purging procedures) as well as maintenance workflows, including gas-freeing procedures and pressure testing.

6.1 Normal operation


Ammonia normal stop and purging procedure

Vapour purging
Inert gas is supplied to the system at 5 bar(g) and the remaining vapour is purged to the ammonia vapour processing system.



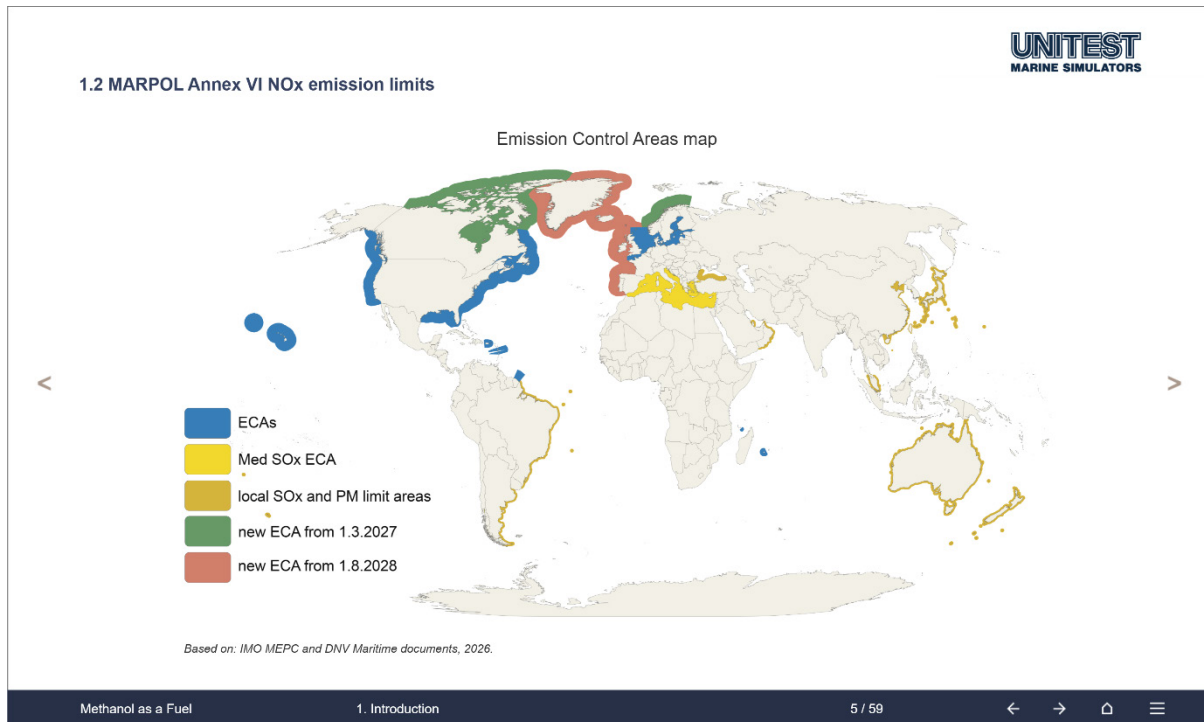
Ammonia as a Fuel
6. Ammonia fuel system operation
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Educational objectives:

- Understanding the environmental and regulatory context: familiarizing the reader with greenhouse gas reduction targets and MARPOL Annex VI NO_x emission limits in Emission Control Areas (ECAs).
- Learning the design and operation of modern marine machinery: developing technical knowledge regarding the management of ammonia fuel supply systems, injection mechanisms, and ancillary equipment like the Ammonia Vapour Processing System (AVPS).
- Mastering safety and risk management protocols: preparing crew members and engineers to work safely with a highly toxic substance by training them to interpret sensor data, handle minor and major leaks, administer first aid, and safely isolate and purge piping systems before maintenance.

2. Methanol as a fuel for marine 2-stroke DF engines

The e-learning module 'Methanol as a Fuel for Marine 2-Stroke DF Engines: Introduction Course' is a technical training guide detailing the maritime industry's transition to alternative energy sources in order to comply with global emission regulations.



The text highlights the global demand for low-carbon fuels in order to meet the IMO's greenhouse gas reduction targets by 2050, as well as ensuring compliance with the strict air pollution limits set out in MARPOL Annex VI within designated Emission Control Areas (ECAs).

It highlights methanol's physical advantages - e.g. easy ambient-temperature storage and engine compatibility - while clarifying that its true sustainability depends on its production pathway.

The text details the operational safety protocols for methanol, including mandates for explosion-proof equipment, nitrogen tank blanketing, first aid and alcohol-resistant foam for firefighting.

It outlines the essential mechanical layout required on board a ship to safely handle fuel. Key components that are highlighted include the fuel supply system (FSS), fuel valve unit (FVU) engine interface, double-wall piping and the purging water supply system (PWSS), which is used to flush lines safely before maintenance.

4.1 Methanol fuel system - overview

The methanol fuel system consists of the following main components:

- bunkering station
- storage and service tanks
- Fuel Supply System (FSS)
- Fuel Valve Unit (FVU)
- methanol piping system
- venting system
- ventilation system
- purging water supply system
- inert gas supply system.

The diagram shows the Engine Room, FVU, FSS, Fuel preparation space, Purging tank, Methanol service tank, Methanol storage tank(s), Bunkering station, Main Engine, Methanol purging water system, and Inert gas supply system. Vent in/out points are also indicated.

The individual elements of the system will be discussed on the following pages.

Based on: X-DF-M Concept Guidance by WinGD

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The course focuses on the WinGD X-DF-M engine model and explains how dual-fuel engines can seamlessly switch between conventional diesel mode and methanol mode, which uses a 5% pilot fuel ignition.

5.2 Fuel operating modes

Operation in methanol mode

The engine operates in methanol mode according to the diesel cycle. A small amount of pilot fuel is injected through the diesel injectors to ignite methanol. The pilot fuel ignites the injected methanol fuel. The amount of injected pilot fuel is approximately 5% of the total energy consumption of the engine at 100% CMCR engine power (Contracted Maximum Continuous Rating).

At any time, **methanol operation can be immediately stopped** by initiating a methanol trip.

Operation in diesel mode


In general, **diesel mode is always available**. If the methanol system fails or the engine output in methanol mode is insufficient, the diesel mode provides operational flexibility and a fail-safe.

The main fuel can be changed over from either MDO or MGO to HFO.

Engine power [%]	Pilot fuel [%]	Methanol [%]	Total fuel [power %]
0	0	0	0
100	5	95	100

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It provides details of the automated safety fail-safes, known as 'Methanol Trips', and the role of the cylinder-specific Methanol Booster Units (MBUs), which hydraulically amplify the fuel pressure to up to 600 bar to ensure optimal combustion.



5.3 Injection concept

Methanol supply and high-pressure piping

Actuation oil system

- Pressurised by mechanical pumps connected to the crankshaft gear, the rail provides constant pressure of up to **300 bar**.
- A rail valve controls the opening of a slide valve within the MBU (Methanol Booster Unit), enabling the actuation oil to flow through the unit and press the piston, thereby amplifying the pressure **from 13 to 600 bar**.
- The high-pressure methanol then opens the injector needle and combusts in the cylinder.

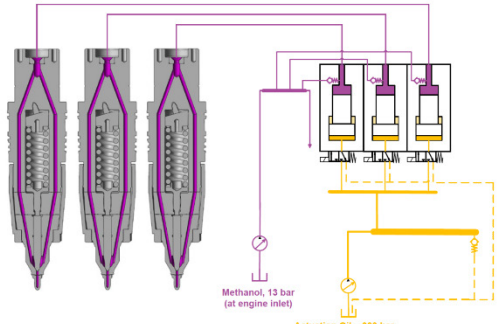


Image © WinGD

Methanol as a Fuel
5. Engine design criteria
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Educational objectives:

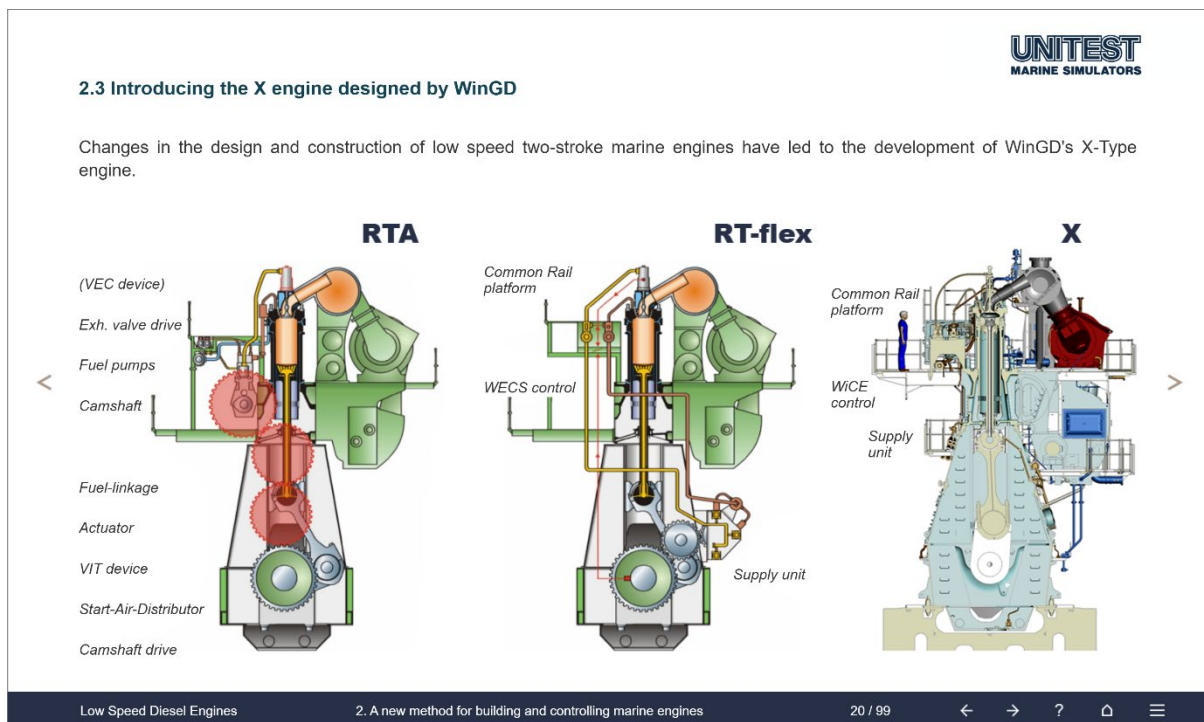
- The material takes a top-down approach to education. First, it covers the global environmental 'why' (e.g. International Maritime Organization (IMO) goals and MARPOL regulations), and then the technical 'how' (e.g. engine design and fuel properties). This helps learners understand the real-world necessity of engineering modifications.
- Safety is not treated as an afterthought, but is woven directly into every technical description. By linking specific chemical hazards (e.g. invisible flames or toxicity) with engineering solutions (e.g. double-walled pipes, AR foam or N₂ padding), the text encourages readers to consider risk management in advance.
- Marine machinery is broken down into sub-systems (bunkering, FSS, FVU and MBU). This helps learners understand individual components and how they interact.
- Diesel engines are used for reference. New technology is presented as an extension of a 'proven diesel design' to facilitate understanding of the dual-fuel systems.
- Procedural, rule-based training provides learners with explicit, actionable parameters (e.g. exposure limits of 200ppm, purging recommendations of 10 minutes, and deck vent heights of 3m). This approach fosters a disciplined compliance mindset, which is paramount in high-risk seafaring environments.

3. Electronically controlled low speed diesel engines

This e-learning module introduces the fundamental concepts, control systems and key components of electronically controlled, low-speed, two-stroke marine diesel engines developed by Winterthur Gas & Diesel (WinGD). It also provides introductory context for the X-92B Marine Engine Room Simulator.

Key themes covered:

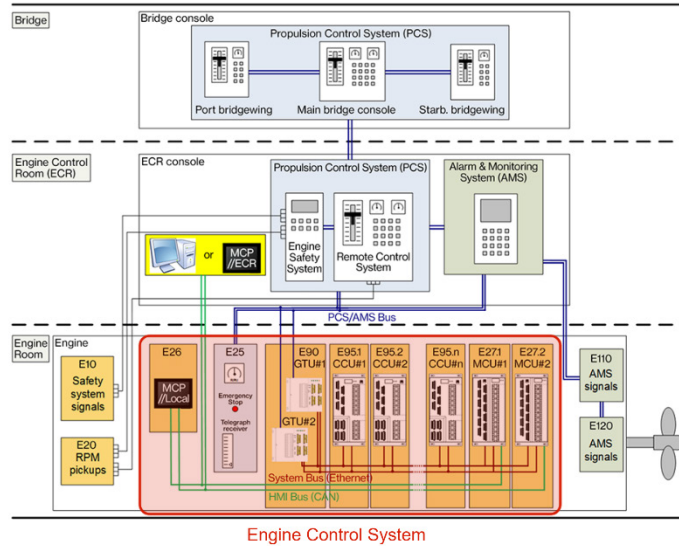
- The material discusses how to ensure merchant vessels meet international environmental legislation and maintain high propulsion efficiency and reliability. This includes meeting the Energy Efficiency Design Index (EEDI) and adhering to MARPOL Annex VI NO_x and SO_x emission tiers within designated ECAs.
- It outlines the shift from traditional mechanical propulsion (like the Sulzer RTA) to advanced common rail platforms (RT-flex and WinGD X-Type). Key modifications include eliminating the fuel camshaft and introducing electronic control over fuel injection and exhaust valve operations via ICU and VCU.



- The text provides a detailed overview of the WinGD Integrated Control Electronics (WiCE) system, including its interaction with external shipboard networks such as the Propulsion Control System (PCS) and the Alarm and Monitoring System (AMS). It also defines the specific roles of the system's redundant hardware modules, including Cylinder Control Units (CCUs), Main Control Units (MCUs) and Firewalled Gateway Units (GTUs).

3.3 Engine Control System (ECS) - functional diagram

The diagram shows the functional operation of the ECS system and the associated external control systems.



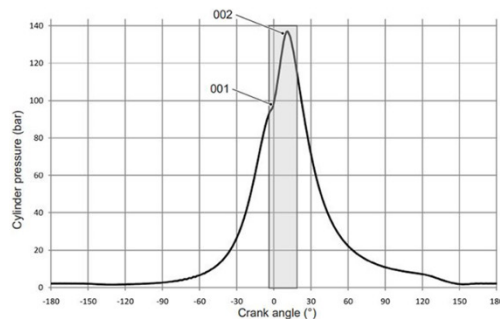
- Features like Intelligent Combustion Control (ICC) are explained, detailing how the system automatically balances and fires the cylinders to optimize engine load and reduce emissions. The text also covers the WinGD Integrated Digital Expert (WiDE) for continuous diagnostics.

3.8 Engine Control System (ECS) - included functionality

Intelligent Combustion Control (ICC)


A pressure transducer is installed on each cylinder cover to monitor the cylinder pressure. The pressure data from each cylinder is transmitted to the Engine Control System (ECS) as an analogue input signal. The ECS filters these signals from the sensors and sends them to a controller. The measured value is adjusted to match the correct setpoint, which is determined based on engine load. This real-time correction and comparison process is performed for every engine cycle.

The ICC Engine Control System allows the ship's main engine to be optimally controlled to improve efficiency, manage load and reduce emissions. Engineers can also compare specific combustion process parameters with shop test results and perform appropriate engine maintenance.



Legend
 001 Pressure at start of ignition (p_i) 002 Maximum firing pressure (p_f)

- The text outlines the physical sub-systems (e.g. fuel and servo oil pumps), high-pressure rail components (including the pressure control valve) and cylinder pressure sensors. Finally, it explains the alphanumeric naming system used to identify engine signals and components.



6.1 WinGD X92-B marine engine – mechanical components

An identification system has been implemented to ensure accurate identification of the signals and elements involved in the operation, monitoring and control of the engine.

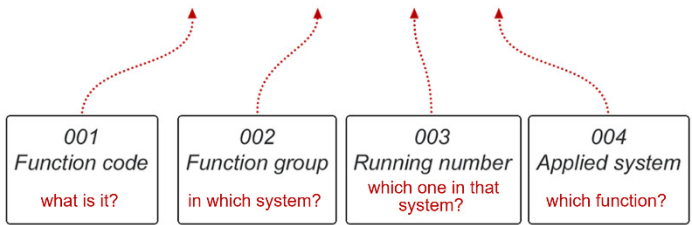
Let's look at the organisation of this system.

Each signal or component is assigned a unique identifier:

- the first two characters represent the function code,
- the next two characters represent the function group,
- the next two characters represent the running number,
- the last character indicates the system applied.

Signal/Component Codes - Identification (example):

PT 1012 C



<i>001</i> Function code <i>what is it?</i>	<i>002</i> Function group <i>in which system?</i>	<i>003</i> Running number <i>which one in that system?</i>	<i>004</i> Applied system <i>which function?</i>
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PT 1012 C = Pressure Transmitter, Signal from the Engine/Cooling water, the 12th Transmitter, Control system

Details of the functions, groups and associated systems can be found in the corresponding tables on the following pages.

Low Speed Diesel Engines
6. Engine numbering and designation
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