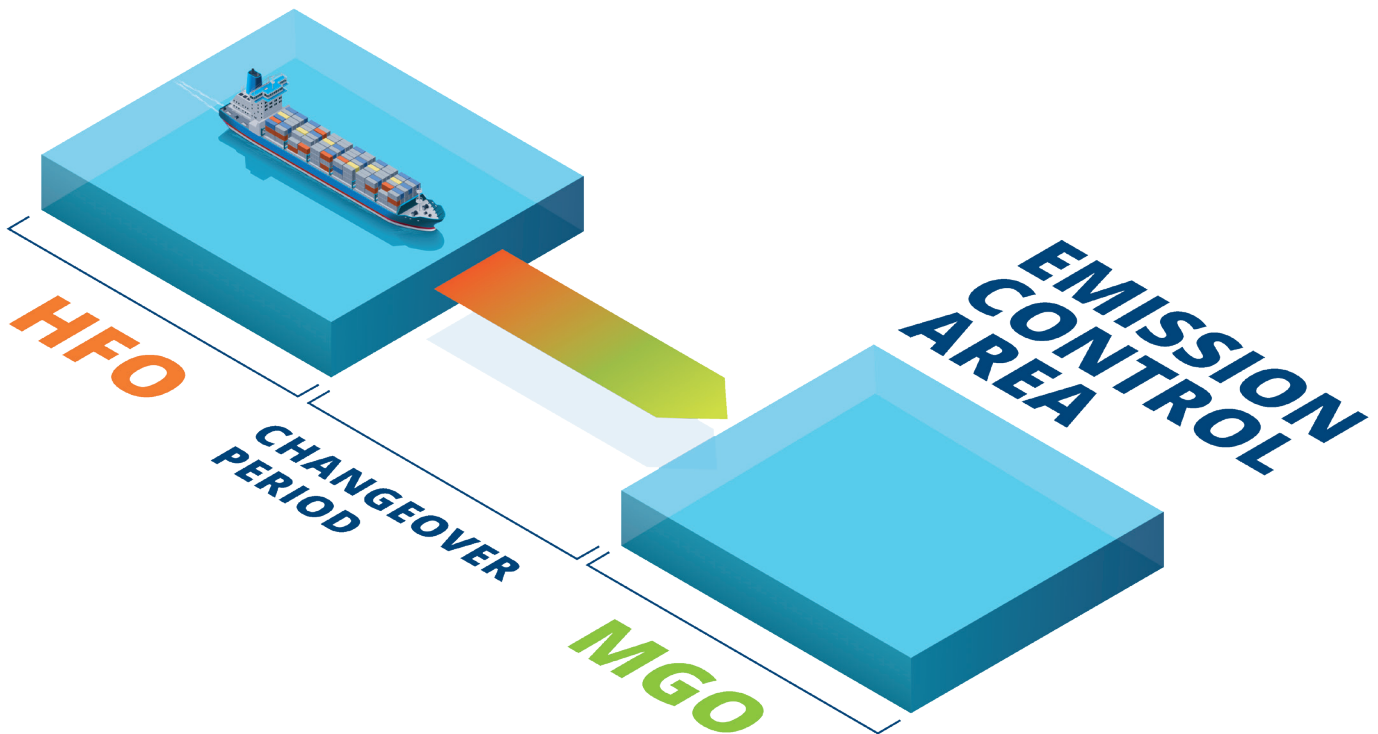


FuelSafe™



**SAFE AND CONTROLLED
FUEL CHANGEOVERS
AT THE PUSH OF A BUTTON**

HFO <> MGO



FuelSafe™

for safe and controlled changeovers

**Do you operate
in sulphur
emission
control areas?**

If you operate in and out of sulphur emission control areas (SECAs) and have to switch between high-sulphur content heavy fuel oil (HFO) and low-sulphur content fuels, then you know that the changeover process is complex and time-critical. Auramarine's FuelSafe™ changeover system offers a cost-efficient, rapid method of complying with SECA requirements if your vessel has segregated tanks for carrying two or more fuels. It is ideal for both newbuilds and retrofits.

A challenging process

The significantly different properties of HFO and MGO pose a number of challenges that have to be successfully overcome to achieve a controlled, safe fuel changeover. The key is to manage and stabilise fuel viscosity by controlling its temperature; heating or cooling the fuel, which can have an initial temperature difference of up to 100°C. To protect the system from thermal shock, it is essential to keep the temperature change rate to a maximum of 2°C/minute. Fuel viscosity and temperature are crucial for engine and fuel-system health:

- Injection pressure losses caused by too low a viscosity may result in difficulties during start-up and low-load operations.

- Too low a viscosity reduces the fuel's effectiveness as a lubricant, which can result in fuel pumps sticking and working ineffectively.
- In addition to the engine, other machinery with moving parts in the fuel-circulation system have minimum viscosity requirements. For these parts, a low viscosity can also cause malfunctions due to lubrication issues.
- Interruptions in fuel supply during the changeover process can lead to reduced engine power or in the worst case scenario, total loss of propulsion, which could be hazardous for the vessel, its crew, passengers and cargo.

Temperature change rate and viscosity in control

Fuels with a wide range of properties can be used in diesel engines if the process conditions can be adequately controlled by the fuel handling system. These include e.g. high viscosity heavy fuel oil (HFO) fuels such as ISO 8217 standard residual fuels RMK700 or RMG380, or other high viscosity residual fuels or blends. On the other hand the engines can use low viscosity marine diesel fuel (MDF) fuels (such as ISO 8217 DMA often referred to as MGO, or other low viscosity fuels such as ULSFO, LFO, DFO).

The well known challenge in instant fuel changeover is that with a manually controlled fuel changeover system it is almost impossible to simultaneously keep the fuel temperature change rate low enough (e.g. max 2°C/min) and viscosity high enough (e.g. $\geq 2\text{cSt}$) at the engine inlets.

FuelSafe™, consisting of Auramarine Fuel Selector (AFS) and Auramarine Cooler Unit (ACU) as well as a set of key components, controls the fuel changeover in such a way that both problems can be avoided.

The changeover process requires three critical temperature and viscosity control elements:

1. Viscosity must not drop below 2cSt
2. Viscosity must not exceed the engine's maximum limits
3. Temperature change rate at the engine inlet must not exceed 2°C/ minute

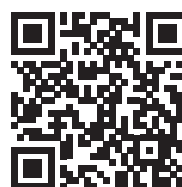
Easy and safe to operate

FuelSafe™ combines the fuel selector with an advanced cooling and heating system. Changeover is initiated at the push of a button and all necessary steps are automatically controlled using continuous viscosity and temperature sensor feedback. With FuelSafe™, there is no need for a vessel to reduce its speed during the fuel changeover process.

It is suitable for various engine loads, fuel consumption rates and fuel system volumes; the minimum required engine load during changeover is 33%.

The flow and proportions of different fuels entering the system from the tanks is regulated by a two-state pulse controlled valve V001.

Scan the QR code to see how it works:



The right scope for your specific needs

The starting point for defining the scope of supply for any system is understanding a customer's specific needs. Auramarine offers three main FuelSafe™ changeover system variants, based on the number of different types of fuel used on board and the extent of automated temperature control that is required. The system can be integrated into a booster system or delivered as separate components.

The default variant is the "variant 2" described in the diagram on page 7. The FuelSafe™ system can be integrated into the Auramarine Feeder-Booster (AMB) system or delivered as loose components.

If there is no sufficiently cool LT-water/seawater available for the ACU-unit or if the MDF fuel type is such that it needs to be cooled down to temperatures below 40°C in order to meet the minimum viscosity specified by the engine manufacturer, an Auramarine Modular chiller (AMC) is needed. The chiller module uses chilled water (cooling water with 20% monoethylene glycol) for additional cooling of the fuel.

Standard delivery

- Control cabinet with 7" touch-screen, mounted on a cabinet door or supplied as an individual component
- Temperature sensors for feedback processes
- Main changeover valves; the number of valves and their sizes are project-specific and defined according to customer needs
- Auramarine cooler unit (ACU), with cooling capacity control

Optional parts and services

These can be specified depending on requirements and system variant:

- Feeder line heat exchanger
- Additional non-return, shut-off and safety valves
- Local pressure indicators
- Data logging
- BUS communication
- IP address customisation
- Installation service
- Fuel system diagram update service
- Commissioning services and turnkey packages

Upgrades and retrofits

For upgrades and retrofits it pays to consult Auramarine's experts for an optimised solution.

- Existing Auramarine cooling units can be upgraded to benefit from all the advantages of its latest FuelSafe™ system.
- Upgrades can be achieved by combining the changeover system with an existing cooler; Auramarine will carefully study each case and work out the most efficient upgrade plan and equipment specification.

Connecting with existing Booster units

Auramarine's FuelSafe™ system must be integrated into the vessel's fuel supply, with new tank selection valves installed at the fuel system inlet. The marine diesel fuel (MDF) cooler by-pass valve is installed with an Auramarine cooler unit. If an existing cooler unit is used, it must have a capacity control system upgrade.

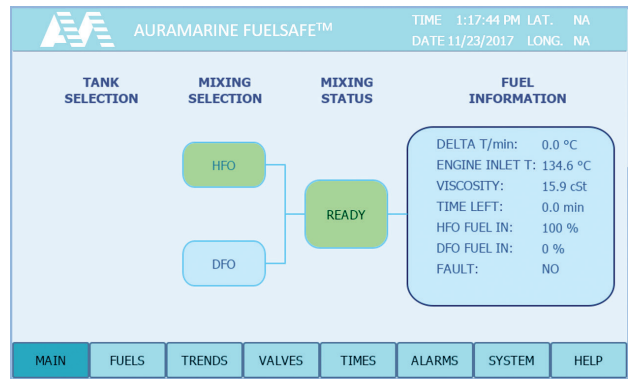
Temperature sensors for feedback processes are installed in the piping. To allow FuelSafe™ to control the HFO heater, the fuel system needs to be modified to enable remote signalling. Furthermore, electrical installation must follow specific FuelSafe™ diagrams.

Value-added services

To ensure that you get the best solution for your specific needs, Auramarine can carry out pre-inspections and surveys as well as provide integrated designs. As this is an automated system, with interconnected processes playing a crucial role, our installation support is strongly recommended.



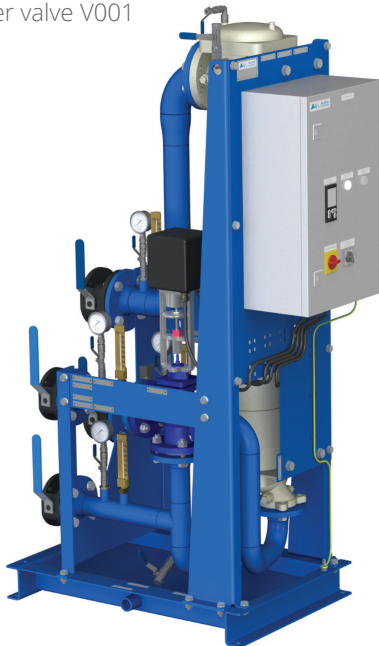
AFS control cabinet. The touch screen is mounted on the door or delivered as a loose component.



The changeover process is controlled from a user-friendly 7" touch-screen.

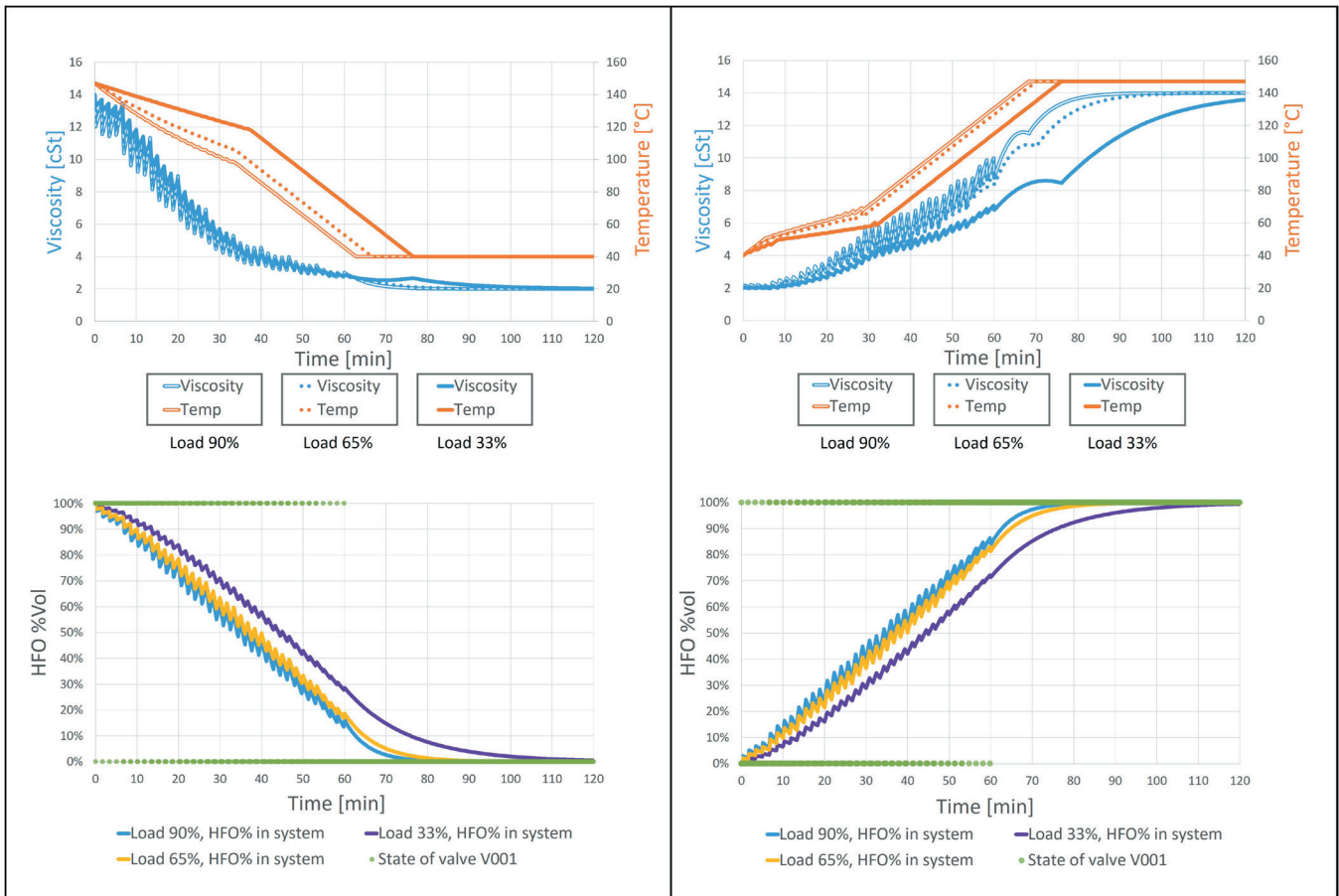


Changeover valve V001



Auramarine cooler unit with tube or plate heat exchanger

A number of additional technical features are available for fuel flow control and monitoring. We strongly recommend our installation support for this automatised system where the connections play a crucial role. In case of a fuel system update, we can also handle the necessary fuel system diagram updates.



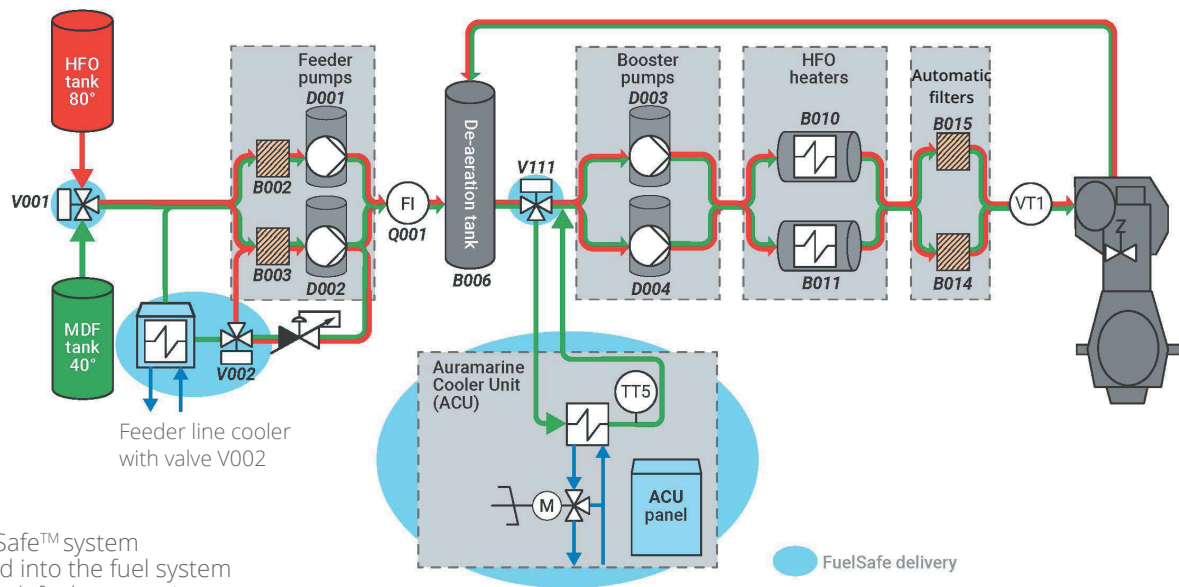
Operation sequence

Auramarine's recommendation for fuel oil consumption during changeover procedures is in the range of 33-100% of maximum fuel consumption. Fuel oil heating in AMB unit should be controlled in such a way that unnecessary heating of mixed fuel containing MDF is avoided. The user must also take into account the compatibility of different fuel oils by, for example, following compatibility test procedures defined in ASTM D7112 standard.

Changeover time for HFO/MDF changeover valve (V001) can be changed but normally this should be between 30-80 minutes, depending of the fuel system properties (e.g. engine load). FuelSafe™ contains also other changeover parameters, which are to be changed to a value that the changeover is achieved according to recommendations by the engine manufacturer (e.g. maximum temperature change rate).

In above figures the changeover time of V001 was 60 minutes, engine load 90%, changeover mode PCM and temperature change rate was limited to max. 2°C/min.

The figure demonstrates that even though the changeover time of V001 is 60 minutes, it takes approx. 80 minutes until the HFO is fully used from the fuel supply circulation. This of course depends on the engine load during changeover and circulation volume. The viscosities and temperatures in addition depend on the fuel oils in use and their respective injection viscosities.



The FuelSafe™ system integrated into the fuel system (variant 2 default content)

Changeover from HFO to MDF

1. The changeover process is started from the AFS panel. This initiates the HFO/MDF changeover valve (V001) to turn so that also MDF starts to flow into the system.
2. The hot HFO and cold MDF start to mix slowly in the fuel supply system. At the same time, the FuelSafe™ has started to lower the HFO heaters heating temperature. This starts to lower the fuel temperature by max. 2°C/ min.
3. The MDF concentration in the fuel supply system starts to rise at a rate depending of the engine load and volume of the fuel system. The larger the fuel consumption in the system, the faster the remaining HFO is consumed.
4. When the viscosity drops below the viscosity trigger level at engine inlet, FuelSafe™ turns the V111 valve towards Auramarine Cooler Unit (ACU). The ACU starts actively to cool the fuel with LT-water by opening the closed water control valve.
5. Finally, the V001 valve has turned fully and only MDF is flowing into the system. This starts a timer to turn the V002 towards feeder line heat exchanger, which cools the MDF in case there is no consumption at the engine. Finally, there is only MDF left in the fuel circulation and the fuel temperature and viscosity in the system have reached their target levels.

Changeover from MDF to HFO

1. The fuel changeover process is started from the AFS panel (MDF->HFO). This starts the V001 to turn towards HFO and at the same time turns the V002 towards feeder pumps suction side.
2. The ACU starts to close the LT-water cooling capacity valve and fuel temperature and viscosity start to rise.
3. When the cooler control valve has closed fully, ACU can't cool down the fuel anymore and it is time to turn the fuel toward main line by turning the V111.
4. The HFO heaters heating is started, raising the fuel temperature at engine inlet by max. 2°C/min.
5. Finally, the V001 has turned fully and only HFO is flowing into the system. Depending of the fuel consumption, the remaining MDF is eventually used at the engine.
6. The change is complete and only HFO is present in the system.

Auramarine is your trusted fuel systems expert for marine and power industry. Our proud heritage stems from the founding of the company in Finland in the early 1970's. Since then we have delivered over 14 500 robust and reliable auxiliary systems to our customers all over the world, continuously aiming for superior service and customer value.

WE ARE THE PIONEERS IN FUEL SYSTEMS.

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