VPS

Fuel Combustion Analysis

## Discover the Key to Optimal Marine Engine Performance

As the maritime industry navigates through diverse fuel options, ensuring reliable ignition and combustion is crucial. Uncover the impact of fuel properties on engine reliability and performance with our Fuel Combustion Analysis service.

Join us in achieving UN Sustainable Development Goals by burning fuel efficiently, reducing GHG emissions, and contributing to cleaner coastal air. Read more and enhance your vessel's performance with our Fuel Combustion Analysis.

EXPERIENCE ▶ INNOVATION ▶ SUSTAINABILITY

Moving Forward

Leading the way for sustainable solutions
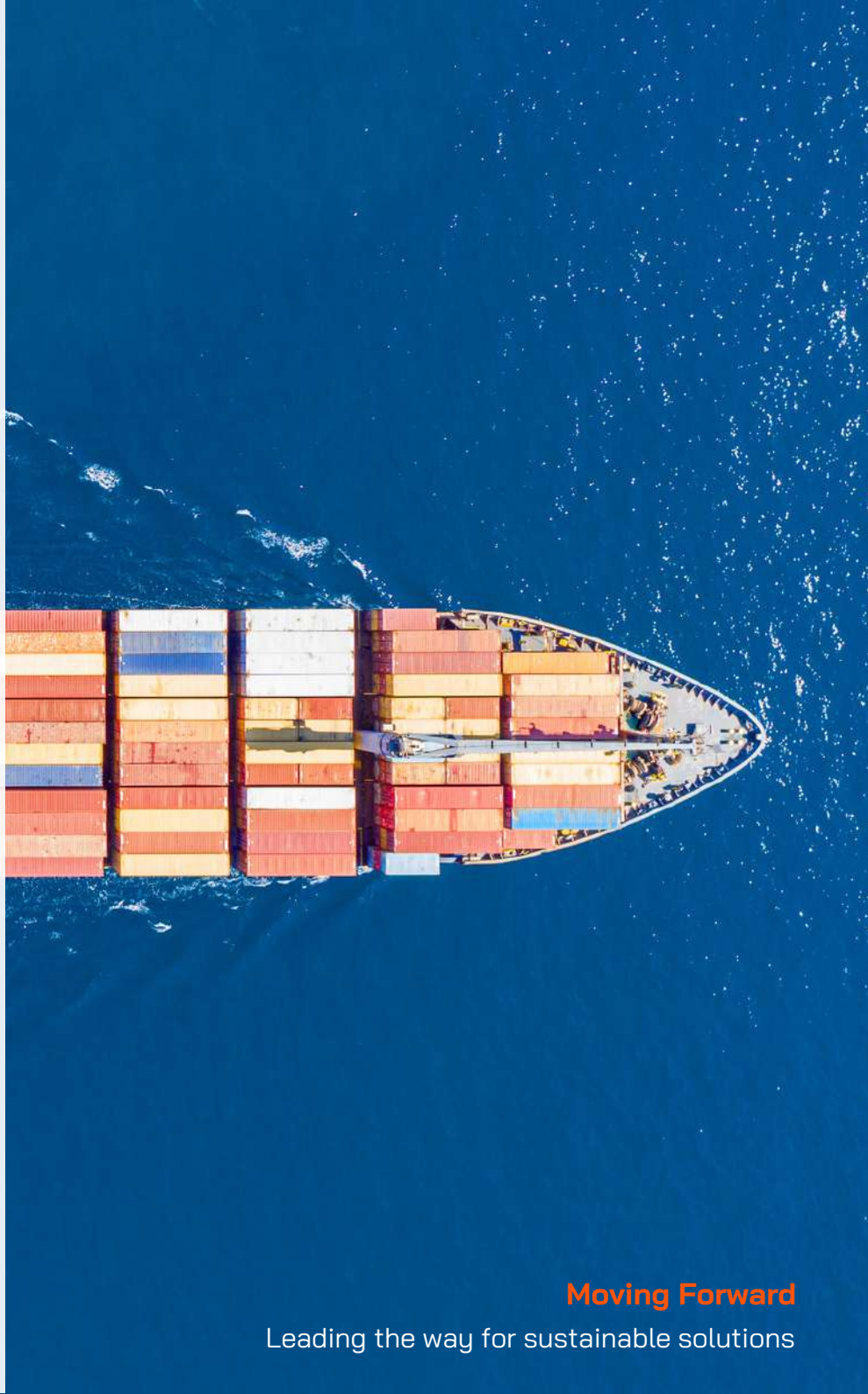
Introduction

Fuel ignition and combustion quality is an increasingly important parameter for safe and optimal consumption of marine fuels.

Due to the increasing types and range of marine fuels entering the maritime space, fuels vary greatly in their ignition and combustion properties. To reduce the risk of unstable engine performance and engine damage, understanding the ignition and combustion quality is vital to vessel owners and operators.

Ignition quality is a measure of the relative ease by which a fuel will ignite. Any delay in fuel ignition or incomplete combustion can lead to following issues with marine engines:

- Starting difficulties
- Heavy knocking
- Increased post combustion deposits
- Sticking exhaust valves
- Blow-by, Collapse of piston rings
- Burned down piston crowns
- Worn and cracked cylinder liners
- Increased emissions. e.g. CO, NOx and particulate matter

In the worst-case scenario, poor ignition and combustion can render the engine inoperative and loss of propulsion posing a threat to the safety of the ship, crew and environment.
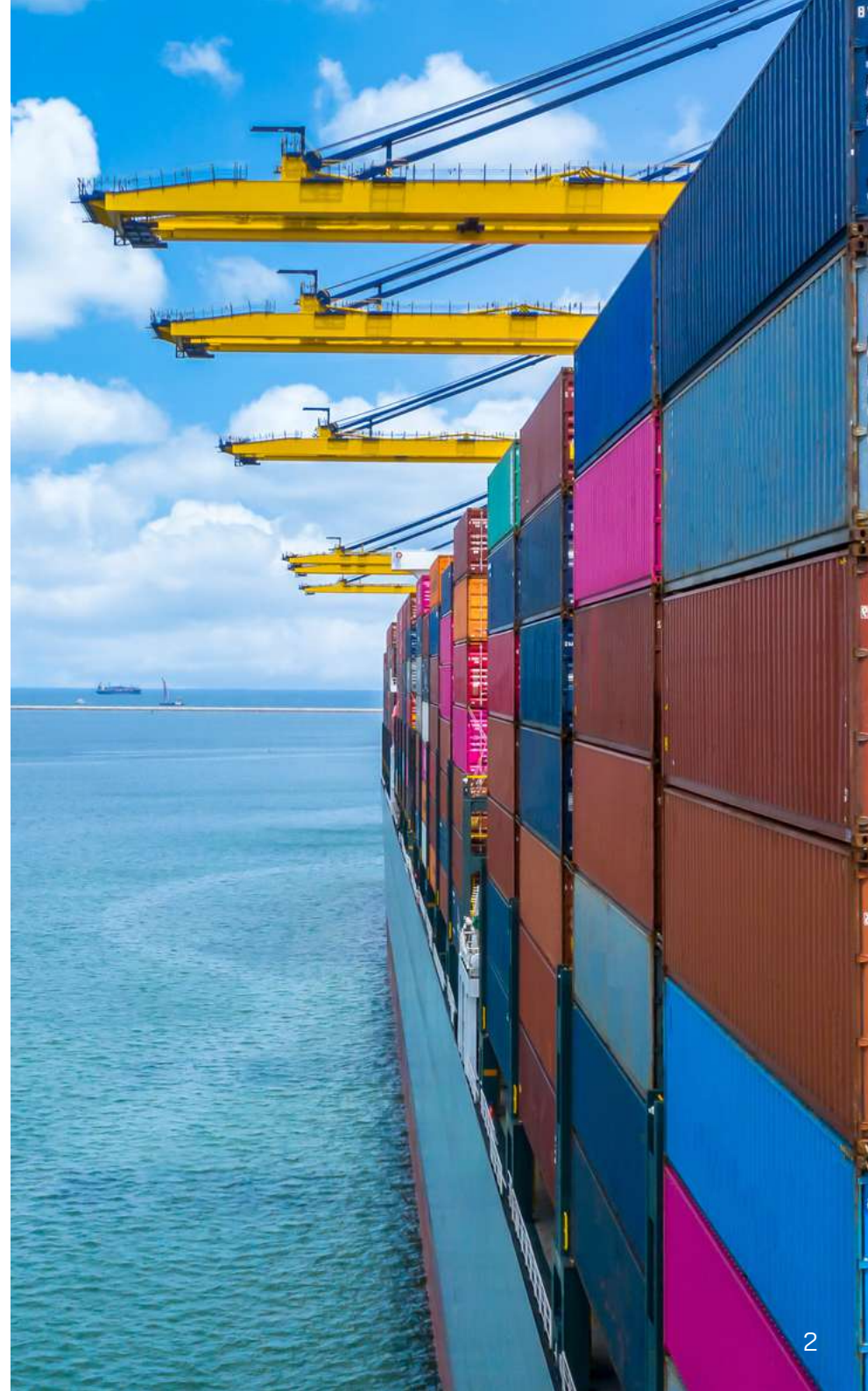
The CCAI (Calculated Carbon Aromaticity Index) developed in the 1980's is an empirical index calculated from the density and viscosity of a fuel.

The CCAI was a good ignition quality indicator for straight run fuels made by atmospheric distillation at that time. However it does not correlate well with today's fuels which are mostly the blended end products of complex refining process such as vacuum distillation, thermal cracking, catalytic cracking.

For this reason, while the CCAI provides a readily available indication of the possible ignition performance of a fuel, the fuels having similar densities, viscosities and CCAI values can in fact have significantly different ignition characteristics.

Also, it is important to note the CCAI value is merely an ignition indicator and does not address the combustion characteristics of a fuel.
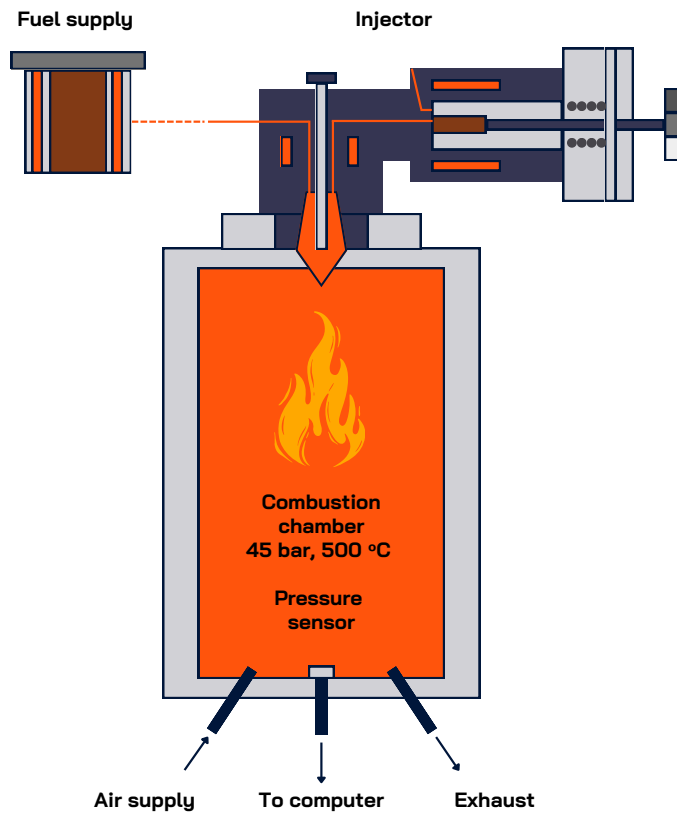
Therefore, to assess both the ignition and combustion characteristics of a fuel, a standard test method IP 541/06 was developed where a fuel sample is injected into a pressurized constant volume combustion chamber at elevated temperature and pressure. The pressure and temperature sensors data are then software processed.

The industry approved test method IP 541/06 for determination of fuel ignition and combustion characteristics (FCA) is a proven superior alternative over the CCAI.

Fuel Combustion Analyser | FIA-100 FCA

The FIA-100 Fuel Combustion Analyzer (FCA) instrument operated according to test method IP541/06 evaluates the ignition, combustion and after-burning characteristics of the fuel when burning in a constant volume combustion chamber.

The Estimated Cetane Number (ECN) is calculated from the ignition parameters Main Combustion Delay (MCD); high ECN given by a short MCD (favourable), low ECN given by a relatively longer MCD (less favourable).

Fuel supply   Injector

Combustion
chamber
45 bar, 500 ºC

Pressure
sensor

Air supply   To computer   Exhaust

Combustion parameters and implications

On the right is a brief description of the combustion properties as described in method IP541/06 & the technical implications from the CIMAC guidelines.
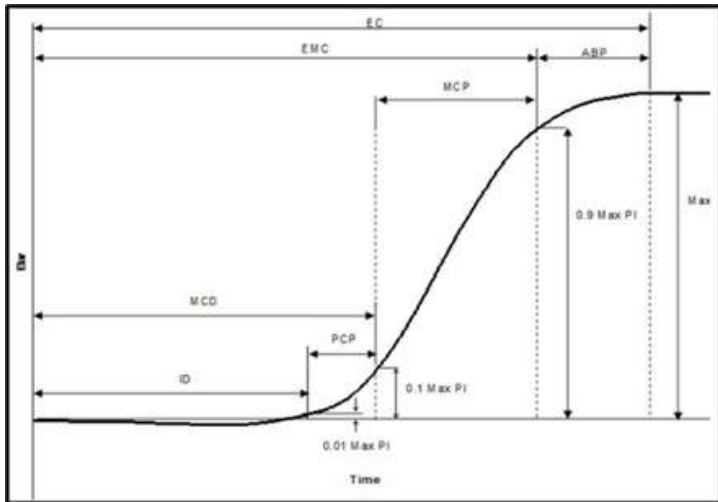
ID - Ignition Delay
That point in time where the pressure increase, relative to the starting pressure reaches 1% of the maximum pressure recorded at end of combustion.

MCD - Main Combustion Delay
That point in time where the pressure increase, relative to the starting pressure reaches 10% of the maximum pressure recorded upon combustion completion. This is interpreted as the time where the main combustion process starts.

Max ROHR - Max Rate of Heat Release level
A high value of the Max ROHR with a late PMR (Position of Maximum ROHR) could be prejudicial for the engine reliability. In addition, the piston rings could also be submitted to unusual conditions. For low Max ROHR, the Combustion Period (CP) is generally longer, meaning a potential trend to late burning inside the cylinder. This could lead to increased smoke and particulate matter (PM) emissions. Combined with a late PMR, the low Max ROHR will cause lower temperatures by the cylinder expansion, with increased soot and PM emissions.

EC - End Combustion and CP - Combustion Period
A long Combustion Period means that some heavy fractions of the HFO might take time to burn in the cylinder, leading to:
- Increased soot and PM
- Increased risk of turbocharger problems
- Increased turbocharger speed and increased exhaust temperature before turbine if the turbine cleaning period is too long.

ABP - After Burning Period
Significant long ABP will mainly lead to:
- Increased probability of soot and PM emissions
- Increased probability of deposits and clogging of the exhaust gas system.

When using fuels with a long ABP for a longer period, interval between the exhaust turbine cleaning should be reduced in order to keep the exhaust system in good operating conditions.

Technical superiority with VPS

Although the FIA-100 instrument provides a reliable means to assess fuel ignition & combustion characteristics, the interpretation of test data however requires experience and a high degree of technical knowledge.

VPS Fuel Combustion Analysis (FCA) service is supported by comprehensive research on fuel ignition characteristics in relation to engine type & make.

VPS fuel experts have the capability to go beyond a general recommendation solely based on the ECN derived number.

By working closely with ship operators, VPS customizes its Fuel Combustion Analysis reporting to:

- Help clients determine an acceptable ignition and combustion quality of the fuel they use on ships engines by considering the engine type and make.

- Trouble shoot-whenever damage incident related to ignition and combustion quality of the fuel are observed, examining the fuel in question with the Fuel Combustion Analyzer & provide information & assistance to identify the root cause (s).
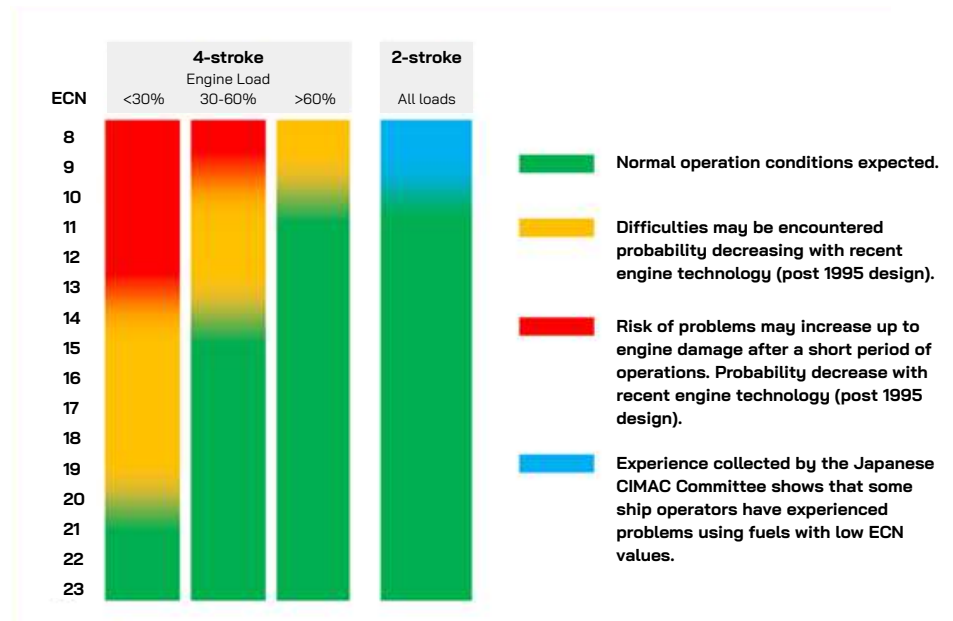

Figure 1: CIMAC recommendations on ECN

Contributing to Global Sustainability Development Goals

VPS Fuel Combustion Analysis service provides the opportunity for ship owners & managers to ensure that their vessel's burn the fuel efficiently for optimal propulsion thus minimising GHG emissions. Burning fuels more efficiently will also lead to clearer coastal air and ultimately save lives. We are delivering four key UN SDGs by working to improve the quality of the air we breathe, helping create sustainable energy, lessening the effect of climate change, and improving the way we treat our oceans. For forty years we have made a positive difference to how we grow sustainably — and we're committed to delivering even greater change in the future.

3 GOOD HEALTH AND WELL-BEING

ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES

- Our services are essential for compliance with the IMO's 0.5% S Cap to help give us all cleaner coastal air.
- Our services are vital for compliance with the Stockholm Convention reducing Persistent Organic Pollutants.

7 AFFORDABLE AND CLEAN ENERGY

ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

- We work with a number of partners on R&D projects to support the development of green marine fuels.
- Our services help ensure a reliable and consistent supply of electricity to industrial and domestic consumers.

13 CLIMATE ACTION

TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS

- Our services ensure fuel is burnt efficiently in vessels' engines for optimal propulsion, minimising GHG emissions.
- We support the renewables sector, servicing wind farms, solar energy and bioenergy.

14 LIFE BELOW WATER

CONSERVE AND SUSTAINABLY USE THE OCEANS, SEA AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

- Our services are critical to reducing ocean acidification by minimising CO_2, NO_x, SO_x emissions into the atmosphere.
- Our services are vital to reducing marine pollution by preventing leakage of fuel into the ocean during bunkering.

Conclusion

The maritime industry is current working to reduce emissions to meet the IMO target of net-zero on or around 2050. There have been lots of measures adopted over the last few years to improve fuel efficiency and reduce emissions. This has included slow steaming, vessel design, air lubrication etc. However, all of these methods still involve the use of fossil fuels. So, the next step is to start using alternative fuels with significantly reduced or even zero carbon footprints. This has started with many new builds and some retrofits on vessel with dual fuel engines allowing the use of alternative fuels such as methanol.

In the future we will also start to see other fuels being used, such as methanol and hydrogen, and there is a lot of current research ongoing around the use of ammonia as a zero-carbon fuel and also some consideration around the use of nuclear energy to power vessels.

Join us on this journey

Join us in the journey towards a greener, more sustainable maritime industry. At VPS, we are committed to accelerating the shift towards a low-carbon future, and we invite you to be part of this transformative change.

Are you a vessel owner or a stakeholder in the maritime industry? Let's collaborate to reduce your carbon footprint and make your operations more eco-friendly. With VPS, you will gain access to data-driven solutions, expert advice, and digital tools that guide you along the path to sustainability. Together, we can create a more environmentally responsible and economically efficient maritime sector.

Contact us today and let's pave the way to a cleaner, greener future for the maritime industry.

Contact

marketing@vpsveritas.com

vpsveritas.com

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