EEDI
Energy Efficiency Design Index
MAN Diesel & Turbo
Powering the world – responsibly

MAN Diesel & Turbo is the world’s leading provider of large-bore diesel engines and turbo-machinery. Our portfolio includes two-stroke and four-stroke engines for marine and stationary applications, turbochargers and propellers, as well as gas and steam turbines, compressors, and chemical reactors.

Our commitment to minimizing fuel consumption while meeting even the most advanced emissions regulations plays a vital role in safeguarding the environment for future generations.

We are seeing unprecedented climate change threaten our vital, yet fragile ecosystems. The knock-on effects of rising temperatures caused by greenhouse gas emissions such as carbon dioxide (CO₂) could have disastrous effects on global agriculture and trade. That’s why it has never been more important to limit the cause and effects for future generations.

**Shipping makes a difference**
Maritime transport will continue to expand with increasing globalization, and although shipping already counts as the most efficient form of bulk transportation, the industry has recognized that more can be done. Optimized engines and improved designs lay the foundations for positive change. Working with key stakeholders, the International Maritime Organization (IMO) has outlined new standards for greater efficiency throughout all stages of a ship’s lifecycle. One such measure, the Energy Efficiency Design Index (EEDI), is a perfect example of this ambitious goal.

**It pays to get on board**
With the international shipping industry so committed to ensuring positive change, it will be crucial for individual ship owners and operators to move with the tide. Market-based measures such as levies or emissions trading are foreseeable in the future, and this will only create further incentives to invest in efficient ships. Though final decisions have not yet been made in this respect, the IMO is certainly considering the possibility. So now is the time to act.
What is it?
The EEDI is used to calculate a vessel’s energy efficiency. This is based on a complex formula, taking the ship’s emissions, capacity, and speed into account. The lower a ship’s EEDI, the more energy-efficient it is and the lower its negative impact on the environment. IMO regulations stipulate that ships must meet a minimum energy efficiency requirement, so their EEDI must not exceed a given threshold.

Ships commissioned after January 1, 2013 and weighing 400 GT or more have to meet the requirements. Older vessels are only affected by the EEDI standards if they have undergone a major retrofit in recent years.

That said, ship owners and operators would be wise to consider that EEDI requirements will gradually be tightened: ships built in 2015, 2020 and 2025 will have to meet even higher standards.

Targeted requirements
At present, the EEDI only applies to the worst offenders when it comes to maritime pollution. In other words: the vessels responsible for the most emissions.

Extension of regulated ship types
Although there were a lot of exemptions in the beginning, the number of ship types to which the EEDI does apply is steadily increasing. According to the latest updates, RoRo, RoPax, Cruise Ships with diesel-electric propulsion and LNG carriers with diesel-mechanic or diesel-electric propulsion have to meet the limits of the required EEDI. However, based on the results observed in the first phase of the initiative, the IMO intends to expand the EEDI to include additional types of ships in the future. Here too, it will be invaluable for ship operators to keep abreast of the changes.

No EEDI for:
Gas turbine
Diesel-electric drive*
Hybrid propulsion
Offshore

* except for Cruise Passenger Ships and LNG Carriers
**EEDI Spells Efficiency**

**Definition and application**

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**Required EEDI**

The required EEDI is the limit for the attained EEDI of a ship and depends on its type and size. Starting with a baseline value in 2013, the limit will be reduced successively in three stages until 2025. The baseline for the required EEDI is a function of the EEDI for vessels built after the year 2000.

**Relevant energy consumption**

The EEDI assesses the energy consumption of a vessel under normal seafaring conditions, taking into account the energy required for propulsion and the hotel load for the crew. Energy consumed to maintain the cargo and for maneuvering or ballasting is not considered.

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**Not in accordance with IMO regulations**

**In accordance with IMO regulations**

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**Power included EEDI**

**Power excluded EEDI**

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**Auxiliary engines**

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**Switch board**

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**Main engine**

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**Shaft power**

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**Shaft motor**

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**Shaft generator**

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**Waste heat recovery, etc.**

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**Main engine pumps (2.5% P_{me})**

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**Accommodation (250 kWh)**

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**Boiler**

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**Cargo heat**

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**Thrusters**

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**Cargo pumps**

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**Cargo gear**

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**Ballast pumps**

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**Reefers**

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EEDI – An Overview
Formula and definitions

**Engine power (P)**
Individual engine power depending on application (e.g. PME = 75% Maximum continuous rating for diesel-mechanic propulsion)

- **P**<sub>main</sub> Main engine power reduction due to individual technologies for mechanical energy efficiency
- **P**<sub>aux</sub> Auxiliary engine power reduction due to individual technologies for electrical energy efficiency
- **P**<sub>pt</sub> Power of individual shaft motors divided by the efficiency of shaft generators
- **P**<sub>AE</sub> Combined installed power of auxiliary engines
- **P**<sub>ME</sub> Individual power of main engines

**CO<sub>2</sub> emissions (C)**
CO<sub>2</sub> emission factor based on type of fuel used by given engine

- **C**<sub>ME</sub> Main engine composite fuel factor
- **C**<sub>AE</sub> Auxiliary engine fuel factor
- **C**<sub>MEi</sub> Main engine individual fuel factors

**Ship design parameters**

- **V<sub>ref</sub>** Ship speed at reference conditions (see PME definition, etc.)
- **Capacity** Deadweight tonnage (DWT) rating for bulk ships and tankers; a percentage of DWT for container ships; DWT indicates how much can be loaded onto a ship; gross tonnage for passenger ships (cruise)

**Specific Fuel Consumption (SFC)**
Fuel use per unit of engine power

- **SFC**<sub>ME</sub> Main engine (composite)
- **SFC**<sub>AE</sub> Auxiliary engine
- **SFC**<sub>AEi</sub> Auxiliary engine (adjusted for shaft generators)
- **SFC**<sub>MEi</sub> Main engine (individual)

**Correction and adjustment factors (F)**
Non-dimensional factors that were added to the EEDI equation to account for specific existing or anticipated conditions that would otherwise skew the ratings of individual ships

- **f<sub>a</sub>** Availability factor of individual energy efficiency technologies (=1.0 if readily available)
- **f<sub>i</sub>** Correction factor for ship-specific design elements, e.g. ice-classed ships which require extra weight for thicker hulls
- **f<sub>W</sub>** Coefficient indicating the decrease in ship speed due to weather and environmental conditions
- **f<sub>C</sub>** Capacity adjustment factor for any technical/regulatory limitation on capacity (=1.0 if none)
- **f<sub>c</sub>** Cubic capacity correction factor (for chemical tankers, LNG carriers and RoPax)
- **f<sub>i</sub>** Correction factor to compensate deadweight losses through cargo-related equipment like cranes, RoRo ramps, etc.
Meeting the EEDI Requirements
Optimized engines, components, and engine systems

Only ships fitted with state-of-the-art technology will stand a chance of complying with the EEDI. This is where MAN Diesel & Turbo steps in as a competent partner to industry. Our comprehensive range of solutions – including engines, turbochargers and propellers – reflects the high standards that have made us a market leader across the seven seas.

Banking on efficiency
Burning liquefied natural gas (LNG) produces less CO₂ than other conventional sources, making it a powerful alternative in achieving a significantly reduced EEDI. MAN Diesel & Turbo has recently introduced a range of extremely efficient and versatile dual-fuel engines, suitable for almost any type of shipping. With these engine models, ship owners benefit from attractive gas prices and full fuel flexibility.

Due to reduced carbon factors, the use of LNG by the new MAN 35/44DF results in approx. 14% lower EEDI.

<table>
<thead>
<tr>
<th>Carbon factors (CF)</th>
<th>Diesel gas oil</th>
<th>Light fuel oil (LFO)</th>
<th>Heavy fuel oil (HFO)</th>
<th>Liquefied petroleum gas (LPG / propane)</th>
<th>Liquefied petroleum gas (LPG / butane)</th>
<th>Liquefied natural gas (LNG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF (t-CO₂ / t-Fuel)</td>
<td>3.205</td>
<td>3.151</td>
<td>3.114</td>
<td>3.000</td>
<td>3.030</td>
<td>2.750</td>
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</table>

-1.7%  -2.9%  -6.4%  -5.5%  -14.2%
Meeting the EEDI Requirements
Optimized engines, components, and engine systems

Various solutions on the market today – and how they can be combined

<table>
<thead>
<tr>
<th></th>
<th>Post swirl fins</th>
<th>Rudder bulb</th>
<th>Kappel</th>
<th>PBCF</th>
<th>AHT nozzle</th>
<th>Mewis duct</th>
<th>Pre swirl fins</th>
<th>Efficiency rudders</th>
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</thead>
<tbody>
<tr>
<td>Post swirl fins</td>
<td>2–3%</td>
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<td>2–4%</td>
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<td>Rudder bulb</td>
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<td>2–5%</td>
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<tr>
<td>Kappel</td>
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<td>3–5%</td>
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<td>PBCF</td>
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<td>2–5%</td>
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<td>AHT nozzle</td>
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<td>5–8%</td>
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<tr>
<td>Mewis duct</td>
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<td></td>
<td>3–8%</td>
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<tr>
<td>Pre swirl fins</td>
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<td>3–5%</td>
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<tr>
<td>Efficiency rudders</td>
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<td>2–4%</td>
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</table>

Can be combined       Can sometimes be partially combined Should not be combined

Clever in combination
Enhance your vessel with one or more of the many MAN Diesel & Turbo products designed to boost energy efficiency. Take, for example, our robust Kappel propellers: used in combination with a rudder bulb, they contribute to ultimate ship performance. Whether your engine is driven by liquid or gaseous fuels, you can increase engine efficiency by up to 10%.

Less input for greater output
Truly efficient engines have the capacity to derive more power from less fuel. At MAN Diesel & Turbo, we have channeled our expertise into adhering to a simple maxim: less is more. That’s why we let nothing go to waste, not even the excess heat produced by the combustion process. With our engine systems, this heat is recovered, providing up to ten percent more power. It can easily be used to run a steam turbine or generator, or can flow into heating for accommodation and cargo.

Typical energy/heat balance of a cruise ship
Efficiency in Action
Attained versus required EEDI

Container ship

DWT design draft 15,375 t
ME 11,200 kW (MAN B&W 8L58/64)
AE 4 x 1,720 kW (MAN 8L21/31)
Generator efficiency 93%
Speed 19 knots
Diesel/Gas Oil, ISO 8217, DMC – DMX

Requirement container ship

<table>
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<tr>
<th>IMO No.</th>
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<tr>
<td>Attained EEDI</td>
<td>25.49</td>
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<td>Phase 0:</td>
<td>1 Jan 2013 – 31 Dec 2014</td>
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<td>Required EEDI</td>
<td>26.96</td>
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<td>Compliance index</td>
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<td>Calculation ref.</td>
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Sensitivity
- Attained EEDI: 25.49
  (with MAN 12V51/60DF)
- Attained EEDI: 22.29
  (with engine MAN 9L51/60DF; 9,000 kW and 18 knots)
- Attained EEDI: 18.06
  (with engine MAN 7S50ME-B8, two-stroke)
- Attained EEDI: 24.28
  (with engine MAN 7S50ME-B8, two-stroke and LNG)
- Attained EEDI: 21.06
  (with engine MAN 7S50ME-B8, two-stroke and LNG)

Assumptions and considerations:
All variations are only achieved by changing the main engine characteristics.
**Efficiency in Action**

**Attained versus required EEDI**

**Requirement tanker (2008)**

DWT design draft 7,900 t  
ME 3,360 kW (MAN 6L32/44CR)  
AE 1 x 1,290 kW (MAN 6L21/31)  
Generator efficiency 93%  
Speed 13.3 knots  
Diesel/Gas Oil, ISO 8217, DMC – DMX

**Sensitivity**

- **Attained EEDI: 14.24**  
- **Attained EEDI: 13.84**  
  (with engine MAN 9L27/38; 3,060 kW and 185 g/kWh SFC*)  
- **Attained EEDI: 12.64**  
  (using MAN 6L35/44DF)  

* 85% MCR

**Assumptions and considerations:**

All variations are only achieved by changing the main engine characteristics.
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