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# IMO REGULATIONS COULD INCREASE CRUISE SHIP $CO_2$ EMISSIONS

*The way IMO has formulated its Carbon Intensity Index may have a counterproductive effect for cruise ship CO2 emissions, writes Markus Aarnio, Chief Naval Architect, Foreship*.*

While attention has been focusing on the International Maritime Organization's Energy Efficiency Index for Existing Ships (EEXI), a mandatory Carbon Intensity Indicator (CII) is also planned for all ships above 5,000 GT (subject to MEPC76 adoption in June 2021).

In CII, ships are given a rating of A to E based on their annual $CO_2$ emission and annual travelled distance. Ratings of A to C are considered acceptable but if the ship receives a rating of D or E a corrective action plan needs to be developed and approved so that at least a rating of Cis achieved. Today, the plan is for CII to be in force in 2023, although it should also be noted that rating thresholds are expected to get continually more stringent towards 2030.

The planned formula for CII for cruise ship's is as follows (for cargo ships the formula uses DWT instead of GT):

$$CII = \frac{Annual\ CO_2 emissions\ [g]}{Gross\ Tonnage\ x\ Annual\ distance\ traveled\ [nlm]}$$

For cargo ships, which need to transport cargo from point A to B, this formulation makes sense. However, for passenger cruise ships, the situation can be very different because cruise ships do not really need to do any transportation work. In a seeming paradox, in this case achieving a better CII rating can lead to increased fuel consumption and thus increased $CO_2$ emissions.

Figure 1 shows an example of planned CII rating curves for cruise ships, with example ratings for a 100,000 GT cruise ship.

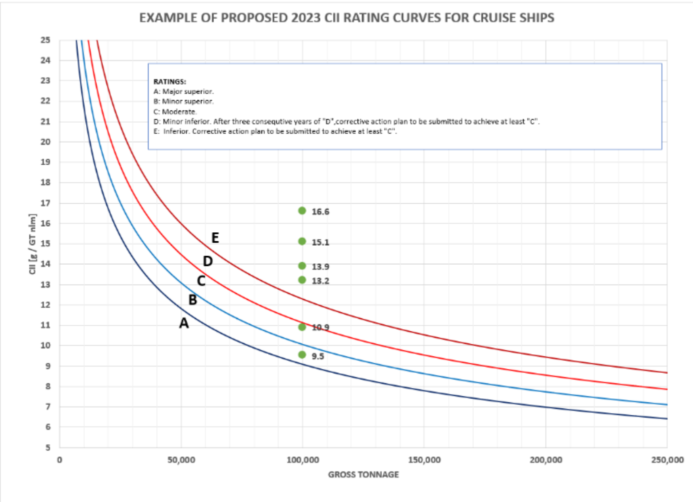


***Figure 1: Example of planned CII rating limits for a cruise ship in the year 2023.***


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Figure 2 shows the fuel consumption per nautical mile for a 100,000 GT cruise ship. Consumption per nautical mile is directly proportional to the CII. Due to the high portion of hotel load, cruise ships have a certain optimal speed where consumption per nautical mile is considered; this is typically around 12 knots. The higher the propulsion power demand required, the lower the optimum speed. Meanwhile, higher the hotel load, higher the optimum speed.

To achieve the best possible CII, this example cruise ship should always sail at 12 knots. Reducing the speed below 12 knots would result in a lower CII rating, even if $CO_2$ emissions reduced at the same time. Self-evidently, the lowest possible fuel consumption and $CO_2$ emissions would be achieved if the ship stayed continuously at anchor or in port, but the associated CII rating would be infinity, due to annual travelled distance being zero. In the same way, our ship would achieve the same CII rating whether cruising at 6 knots or at 21 knots, despite the huge difference in actual fuel consumption and $CO_2$ emissions per hour.

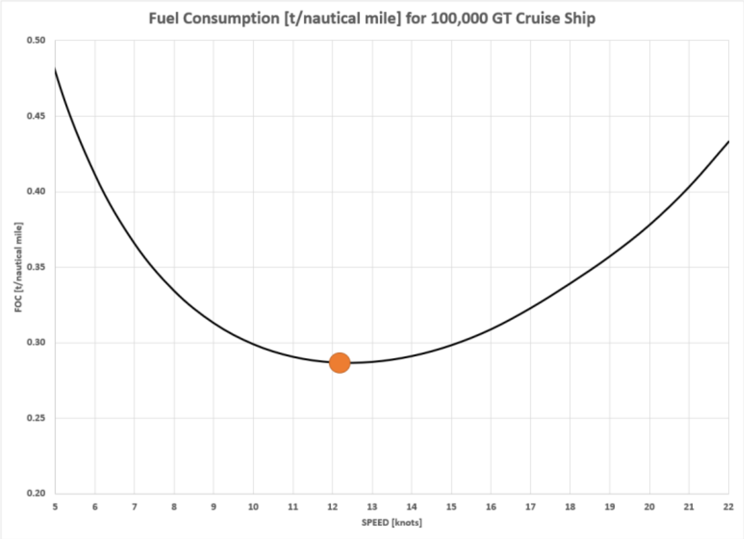


***Figure 2: Fuel consumption per nautical mile for a 100,000 GT cruise ship. Here the "CII optimum speed" is around 12 knots.***

The following four weekly itineraries (168 hours) has been devised to show what happens to CII when the shipowner tries to reduce fuel consumption and $CO_2$ emissions using different operating profiles in the example of a 100,000 GT ship running on Marine Gas Oil.


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**ITINERARY 1, OPTIMUM CII SPEED**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 50 | 0 | 0 | 7,000 | 7,179 | 1.51 | Distance traveled | 1,416 | nlm |
| Slow speed | 0 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 482 | t |
| Optimum speed | 118 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 1,544 | t |
| High speed | 0 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **10.9** | **g/GT nlm** |

**ITINERARY 2, OPTIMUM CII SPEED, LESS TIME IN PORT**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 10 | 0 | 0 | 7,000 | 7,179 | 1.51 | Distance traveled | 1,896 | nlm |
| Slow speed | 0 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 559 | t |
| Optimum speed | 158 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 1,792 | t |
| High speed | 0 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **9.5** | **g/GT nlm** |

**ITINERARY 3, OPTIMUM CII SPEED, MORE ITEM IN PORT**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 100 | 0 | 0 | 7,000 | 7,179 | 1.51 | Distance traveled | 816 | nlm |
| Slow speed | 0 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 385 | t |
| Optimum speed | 68 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 1,234 | t |
| High speed | 0 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **15.1** | **g/GT nlm** |

**ITINERARY 4, SLOW SPEED**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 50 | 0 | 0 | 7,000 | 7,179 | 1.51 | Distance traveled | 708 | nlm |
| Slow speed | 118 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 366 | t |
| Optimum speed | 0 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 1,175 | t |
| High speed | 0 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **16.6** | **g/GT nlm** |

**ITINERARY 5, SLOW SPEED + SHORE POWER**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 50 | 0 | 0 | 7,000 | 0 | 0.00 | Distance traveled | 708 | nlm |
| Slow speed | 118 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 291 | t |
| Optimum speed | 0 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 933 | t |
| High speed | 0 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **13.2** | **g/GT nlm** |

**ITINERARY 6, HIGH SPEED**

| Mode | Share [h/week] | Speed [knots] | Propulsion [kW] | Hotel [kW] | Engines [kW] | FOC [t/h] | | | |
|---|---|---|---|---|---|---|---|---|---|
| In port (or at anchor) | 50 | 0 | 0 | 7,000 | 7,179 | 1.51 | Distance traveled | 2,478 | nlm |
| Slow speed | 0 | 6 | 1,363 | 10,000 | 11,746 | 2.47 | Fuel consumed | 1,074 | t |
| Optimum speed | 0 | 12 | 5,616 | 10,000 | 16,394 | 3.44 | $CO_2$ emitted | 3,445 | t |
| High speed | 118 | 21 | 27,504 | 10,000 | 40,315 | 8.47 | **CII** | **13.9** | **g/GT nlm** |

***Table: Itineraries and CII calculation.***

1. "Optimal CII speed". Ship spends 50 hours in port (or at anchor) and cruises at sea mostly at 12 knots speeds. CII is 10.9, which would give rating "C" in 2023.
2. "Short harbour time". To improve the situation, ship reduces the harbour time from 50 hours to 10 hours. Now CII is 9.5 (corresponding to rating "B"), but fuel consumption and CO2 emissions has increased by 16%.
3. "Long harbour time". To reduce the fuel consumption, ship decides to stay more in port- 100 hours instead of 10 hours. Fuel consumption and CO2 emissions reduce by more than 30%, but CII will increase to 15.1, giving the worst rating "E".
4. "Slow Speed". Slowing down speed from original 12 knots to 6 knots would reduce emissions further, but CII would get worse, to 16.6.
5. "Slow Speed + Shore Power". Having slow speed of 6 knots, but using shore power in port, would reduce emissions by 40% from the original but CII would still be too high, at 13.2.
6. "High Speed". Instead of 6 or 12 knots, the ship now cruises at 21 knots. Fuel consumption would be more than twice the original, but CII is still not much higher than for the slow speed operation with shore power.


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Figure 3 summarises of the situation (with calculations for reference) in terms of a weekly $CO_2$ emissions vs. achieved CII value. As the above examples show, for cruise ships with freedom to choose itineraries the CII may not work at all but can lead to significantly higher fuel consumption in some cases. In general, a cruise ship would achieve a better CII by cruising in circles at optimum speed instead of staying at anchor.

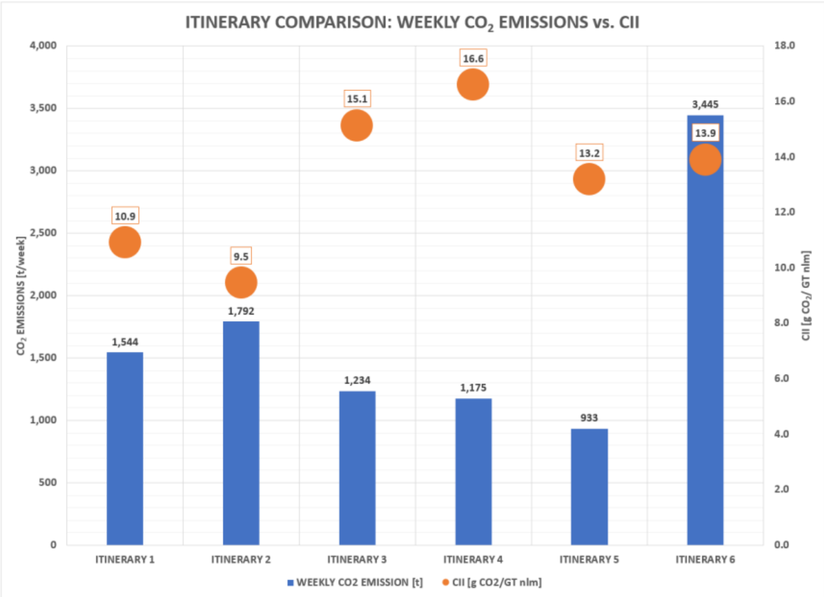


***Figure 3: Summary of weekly CO2 emission and CII calculation for the four itineraries.***

If the proposed CII remains unchanged, life will become very difficult for ships staying in port (without shore power) or at anchor for long periods. This includes residential ships and luxury ships, but also those vessels seeking to reduce fuel consumption by slowing down or staying more at anchor or at private islands. It could also force some ships to increase cruising speed and thus increase emissions.

Given the above, one option would be to rework the CII for cruise ships so the annual distance travelled should not be in the formula.

**ENDS**

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