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PROPELLER TRIMMING

DATE: 17/05/2023

IMO LEGISLATION

EEDI

EEXI

CII

EEDI - Energy Efficiency Design Index

IMPROVING THE TECHNICAL PERFORMANCE OF NEW BUILD SHIPS

- Ships which are designed and constructed today must be more efficient than the base-line (of the previous generations), thus reducing their carbon intensity.

- Performance targets are increasingly stringent over time, thus incentivizing innovation in ship design.

EEXI - Energy Efficiency eXisting ships Index
IMPROVING THE TECHNICAL PERFORMANCE OF EXISTING SHIPS

- The requirements for EEXI certification entered into force on 1 November 2022.
- All ships are required to calculate their attained energy efficiency.
- Targets design parameters.
- A review clause requires IMO to review the effectiveness of the implementation of the EEXI requirements, by 1 January 2026 at the latest, and, if necessary, develop and adopt further amendments.

CII - Carbon Intensity Indicator
IMPROVING THE OPERATIONAL PERFORMANCE OF EXISTING SHIPS

- A carbon intensity rating is assigned to the ship, from A to E.
- Aims to improve the carbon intensity of existing ships (ship speed optimization, etc.).
- Poorly rated ships have to implement a plan of corrective actions.
- Entered effect on 1 January 2023.

SHIP PROPULSION EFFICIENCY DEPENDS ON THREE FACTORS:

- $\boldsymbol{Hull\ Factor} = \eta_h = \frac{P_E}{P_D} = Hull\ Efficiency,$
- $\boldsymbol{Rotational\ Factor} = \eta_r = \frac{P_T}{P_T{}'} = Relative\ Rotative\ Efficiency,$
- $\boldsymbol{Propeller\ Factor} = \eta_o = \frac{P_T}{P_D} = Open\ Water\ Propeller\ Efficiency.$

$The\ Overall\ Propulsive\ Coefficient, \quad \eta_D = \eta_h \cdot \eta_r \cdot \eta_o$

$or, as\ earlier\ called\ Quasi - Propulsive\ Coefficient = QPC.$

HULL EFFICIENCY – η_h

The hull efficiency can readily be determined once the thrust deduction and mean wake fraction are known. However, because of the pronounced scale effect of the wake fraction there is a difference between the full-scale ship and model values. In general, because the ship wake fraction is smaller than the corresponding model value, due to Reynolds effects, the full-scale efficiency will also be smaller.

$$\eta_h = \frac{1-t}{1-w_t} = \frac{1 - Thrust\ Deduction\ Factor}{1 - Wake\ Fraction}$$

RELATIVE ROTATIVE EFFICIENCY – η_r

The behind-hull propeller characteristics, so far as powering is concerned, have been traditionally accounted for by use of the term relative rotative efficiency η_r. This term, which was introduced by Froude, accounted for the difference in power absorbed by the propeller when working in a uniform flow field at a given speed and that absorbed when working in a mixed wake field having the same mean velocity:

$$\eta_r = \frac{Power\ absorbed\ in\ open\ water\ of\ speed\ Va}{Power\ absorbed\ in\ mixed\ wake\ field\ of\ mean\ velocity\ Va}$$

Normally the correction defined by this efficiency parameter is very small and η_r is usually close to unity unless there is some particularly abnormal characteristic of the wake field. Typically, one would expect to find η_r in the range $0.96 < \eta_r < 1.04$.

OPEN WATER PROPELLER EFFICIENCY – η_o

The ratio of the thrust power to the power absorbed by the propeller operating without a hull attached:

$$\eta_o = \frac{Thrust\ Horsepower}{Delivered\ Horsepower} = \frac{J}{2\pi} \cdot \frac{K_T}{K_Q}$$

The K_Q, K_T versus J characteristic curves contain all of the information necessary to define the propeller performance at a particular operating condition.

OPEN WATER PROPELLER EFFICIENCY CURVE

$$\eta_o = \frac{Thrust\ Power}{Torque\ Power} = \frac{J}{2\pi} \cdot \frac{K_T}{K_Q}$$

$$J = \frac{V_a}{N \cdot D} = \frac{V_S \cdot (1 - \mathrm{w})}{N \cdot D}$$

Where,
$\eta_o = Open\ Water\ Efficiency,$
$J = Advance\ Coefficient,$
$K_T = Thrust\ Coefficient,$
$K_Q = Torque\ Coefficient,$
$V_a = Speed\ of\ Advance\ (= Ship\ speed - True\ Slip),$
$w = Wake\ Fraction,$
$N = Revolutions\ per\ Minute\ (rpm),$
$D = Propeller\ Diameter.$

$$Mean\ Moment\ Pitch(MMP) = \frac{\sum_1^n p(x_j) \cdot x_j}{\sum_1^n x_j}$$

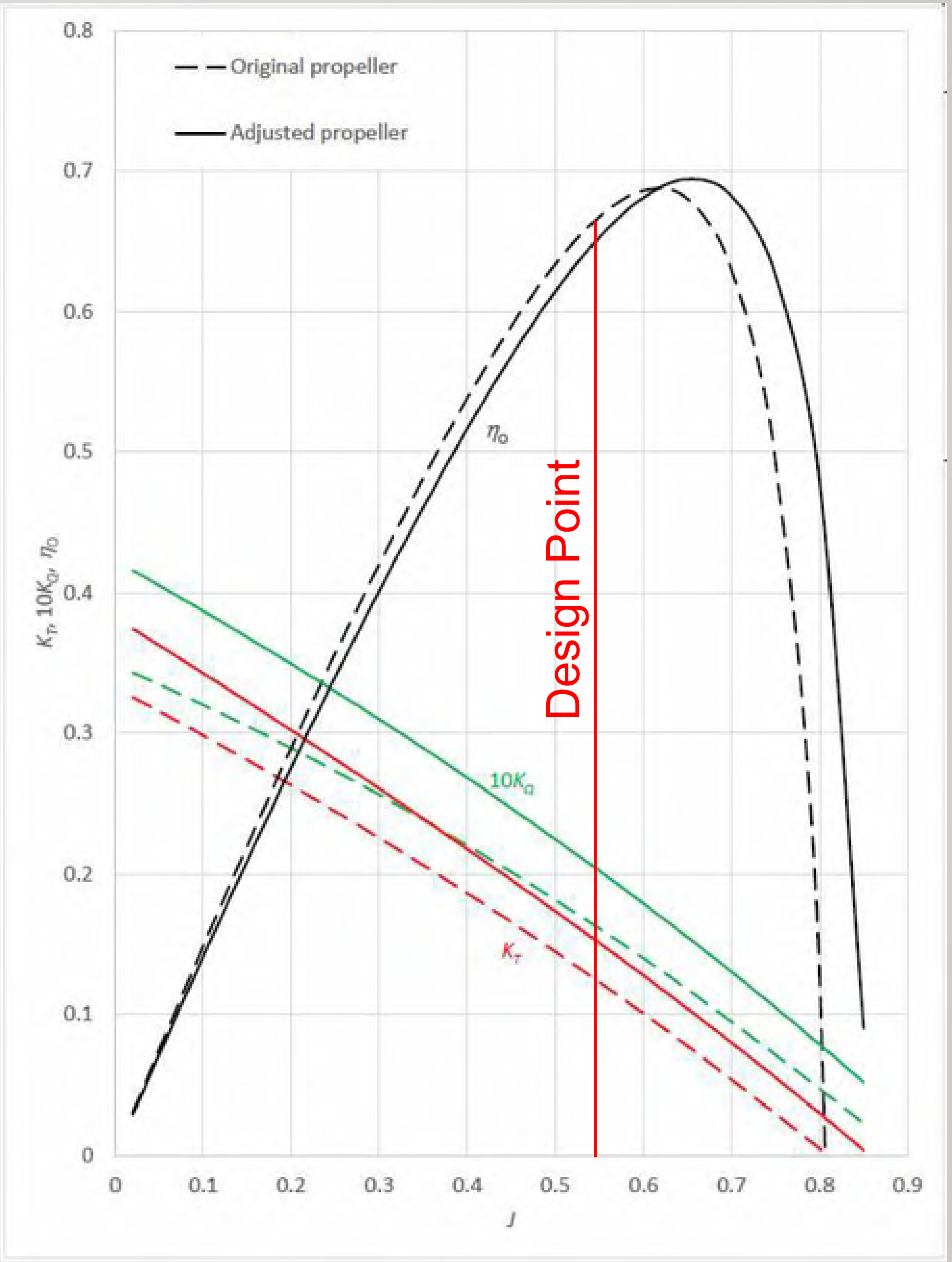
$-For\ varying\ pitch\ propellers.$
$-n = number\ of\ radial\ fractions\ were\ pitch\ is\ measured.$

$$Pitch\ x \frac{RPM}{60} = Max\ Speed$$

$$Speed\ of\ Advance\ - Wake\ Speed = True\ Slip$$

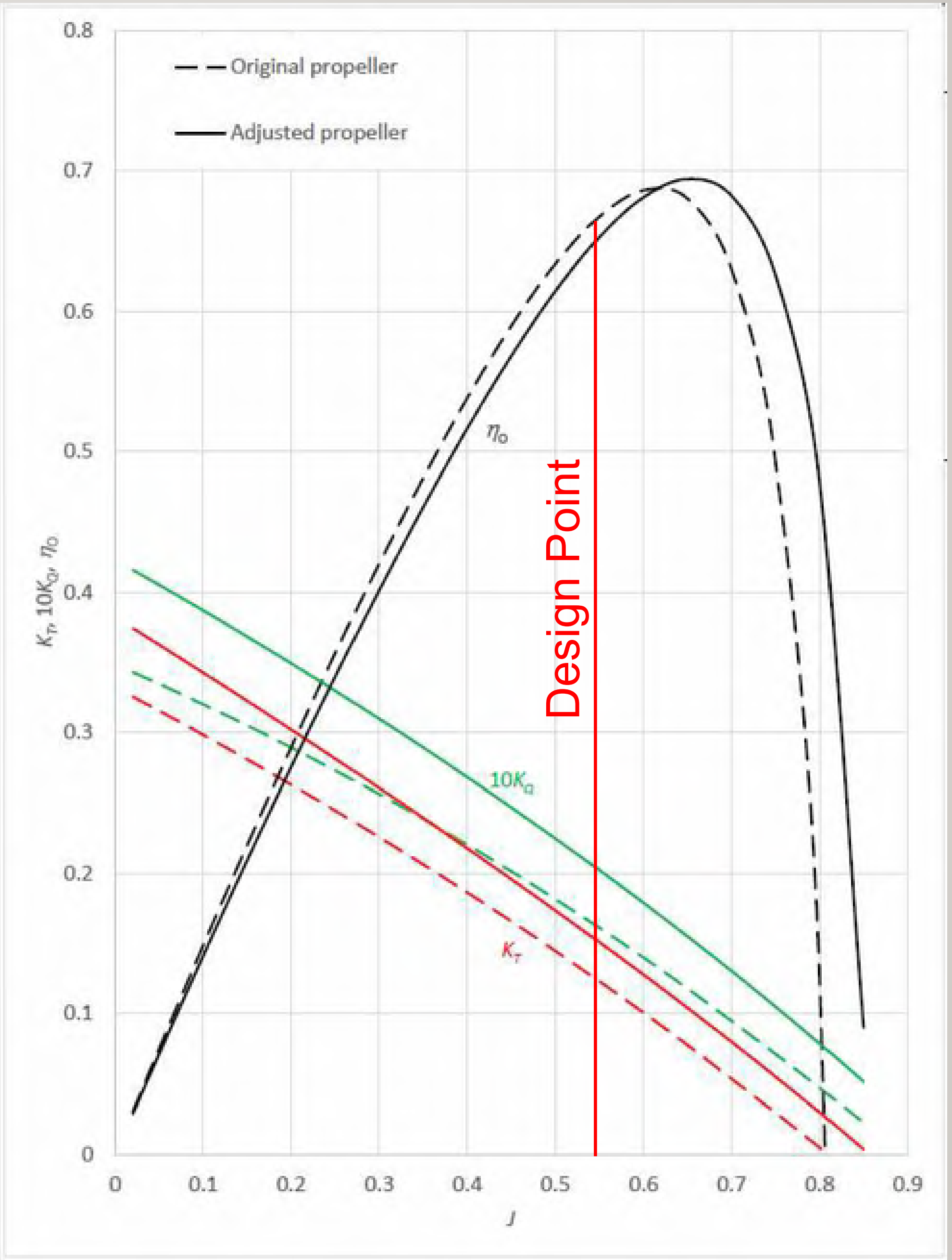
$$Pitch\ x \frac{RPM}{60} - Ship\ Speed = Apparent\ Slip$$

For propeller applications, ***True Slip*** *is used.*



OPEN WATER PROPELLER EFFICIENCY CURVE

- Propeller is designed to operate as demonstrated in the η_o-J diagramme.
- It is preferable to bring the η_o-J design line just before the peak, as small J changes may bring about large η_o reductions.
- Scope to match the new engine operational regime with a nearly optimum-sized propeller.



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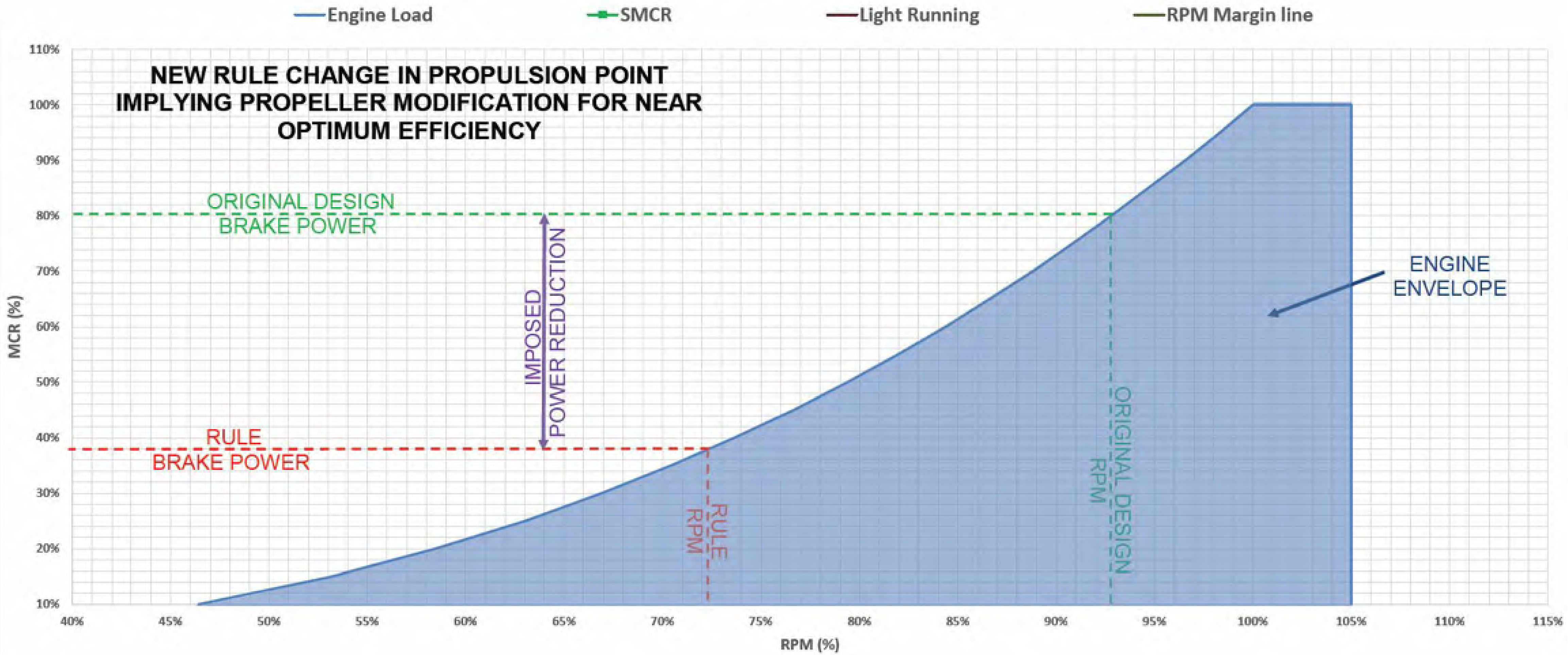
Main Engine Performance Data



PROPELLER TYPES

- ***Fixed-Pitch Propeller (FPP):***

A fixed-pitch propeller involves adjusting its diameter and pitch during the design process to optimize performance for specific operating conditions.

- ***Controllable-Pitch Propeller (CPP):***

A controllable-pitch propeller involves adjusting the blade angle during operation to optimize performance for varying speeds, loads, and operating conditions.

The blade angle can be adjusted to match the current operating condition, resulting in improved efficiency, reduced fuel consumption, and enhanced overall performance.

PROPELLER TRIMMING

Performance improvement

Lighter propeller inertial loads

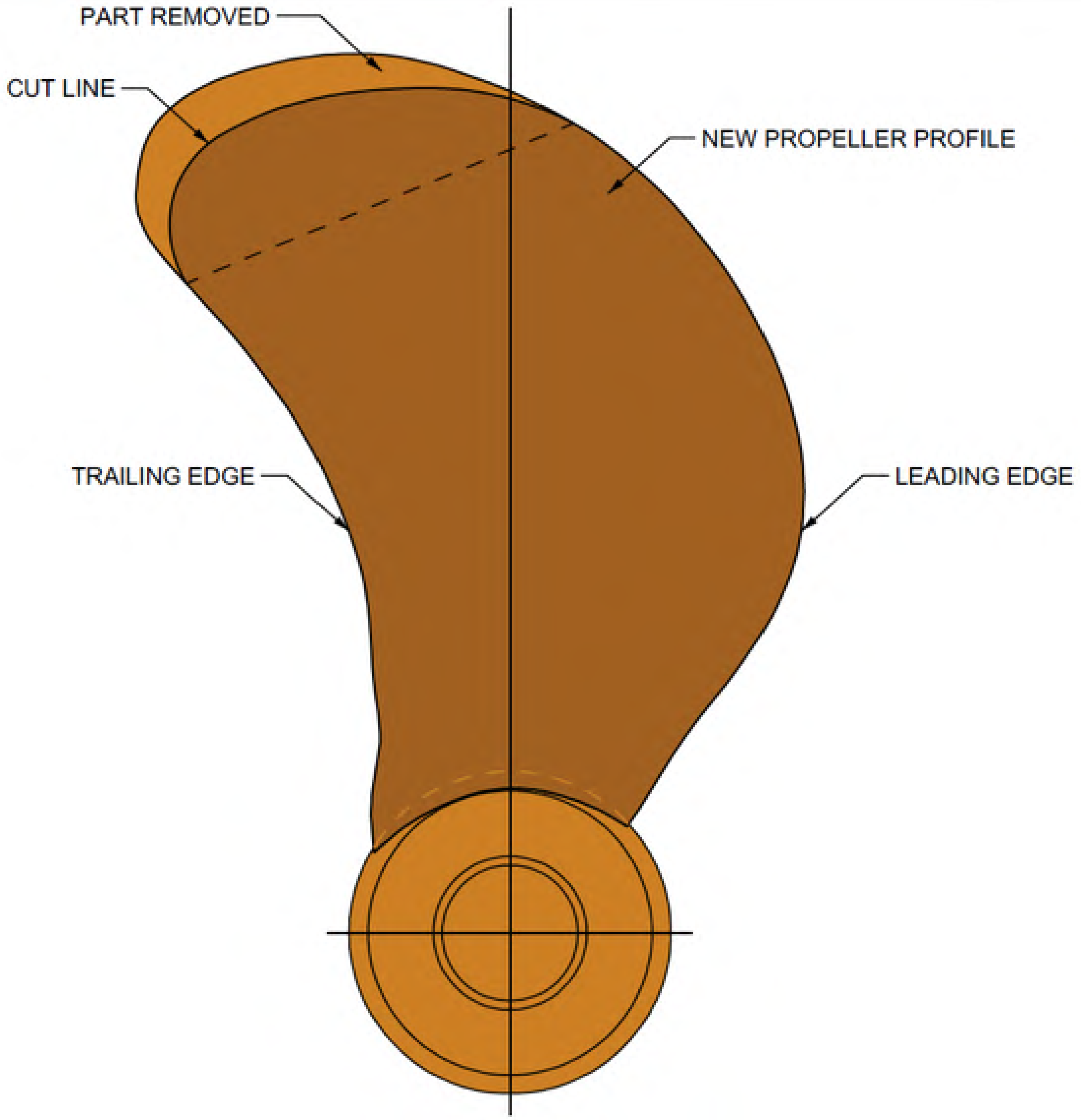
Enhancement of acceleration and fuel consumption

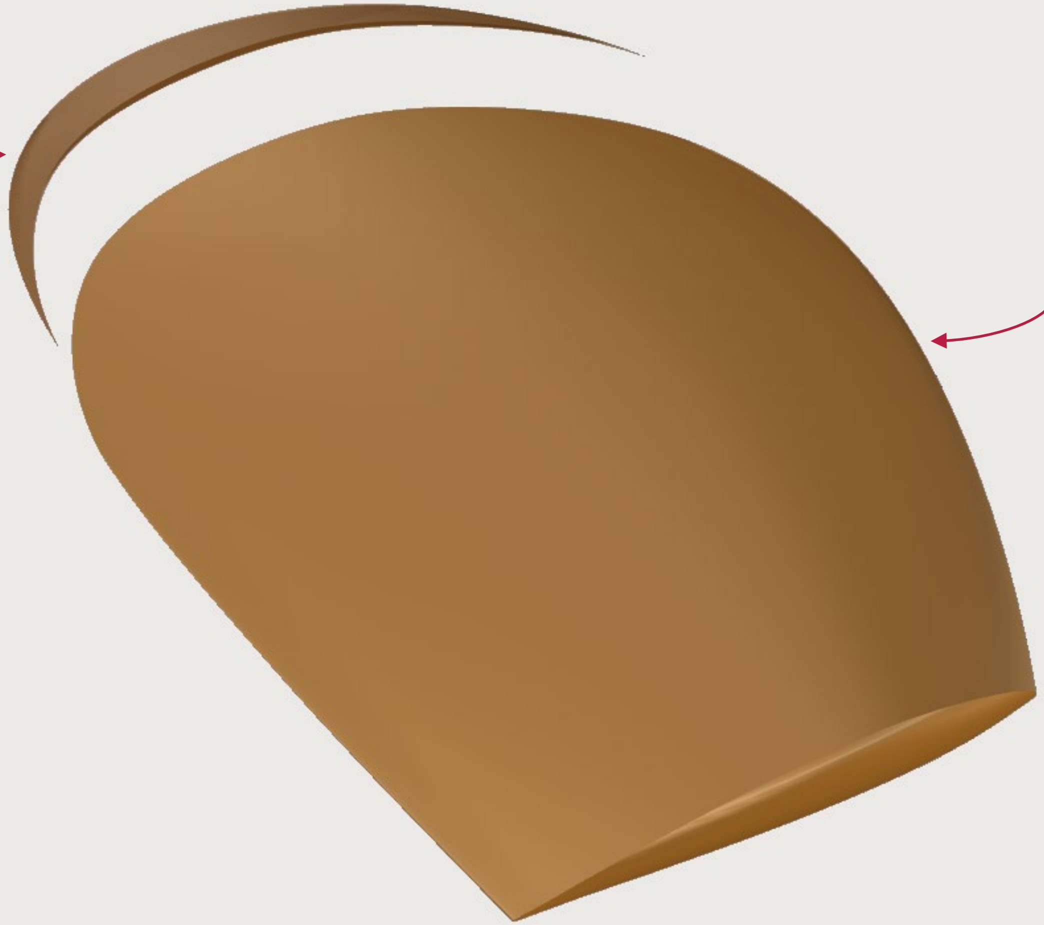
HOW LONG WILL IT TAKE TO TRIM THE PROPELLER?

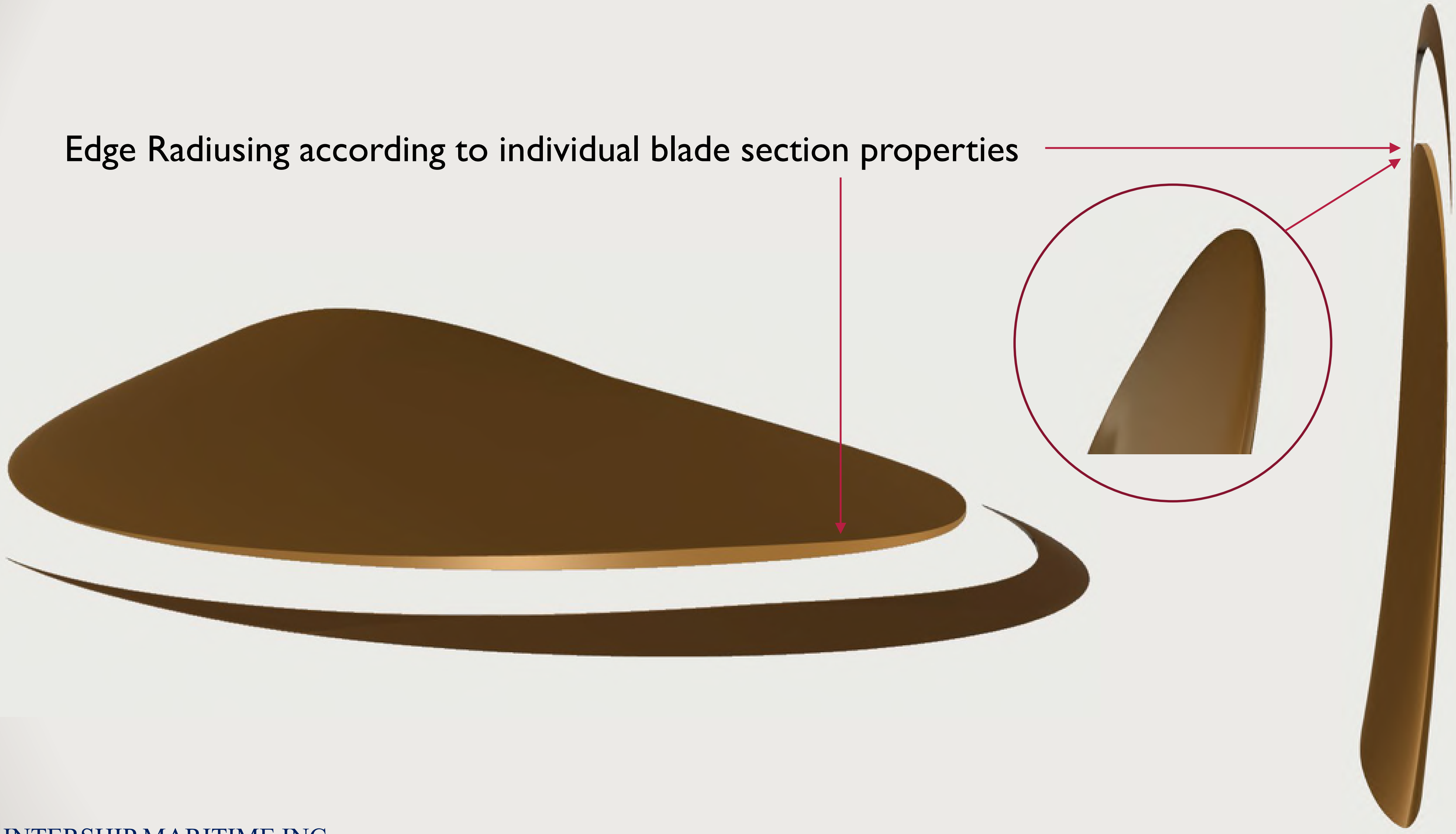
It depends on:

- Propeller size,
- Length and depth of cut, blade thickness along the section,
- Number of blades,
- Repair of damaged blades, if any.

Time taken within DD limits.


PART REMOVED
CUT LINE
NEW PROPELLER PROFILE
TRAILING EDGE
LEADING EDGE

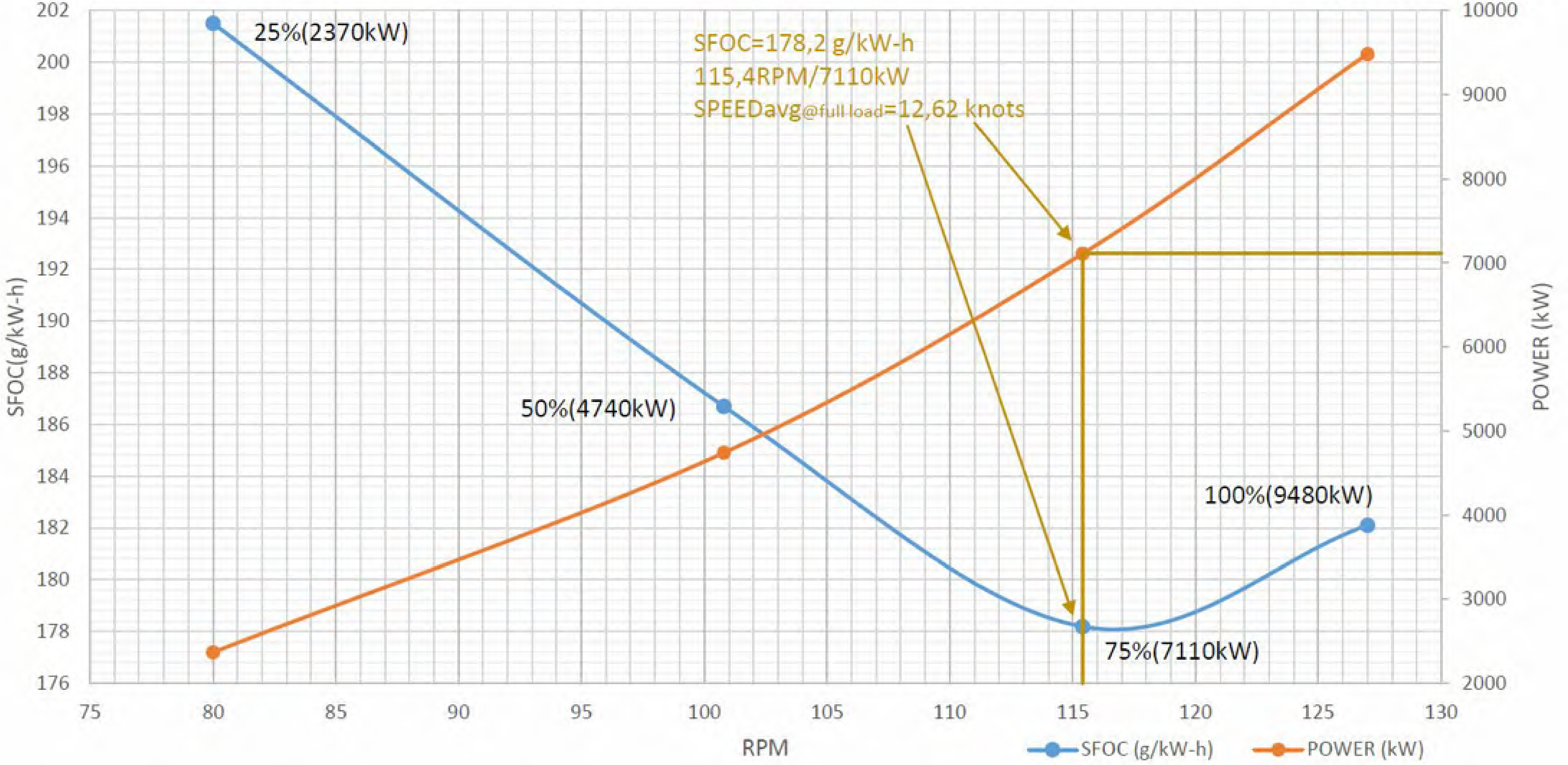

Part Removed
New Propeller Blade


Edge Radiusing according to individual blade section properties

CASE 1

Case 1

Project No.: 230388



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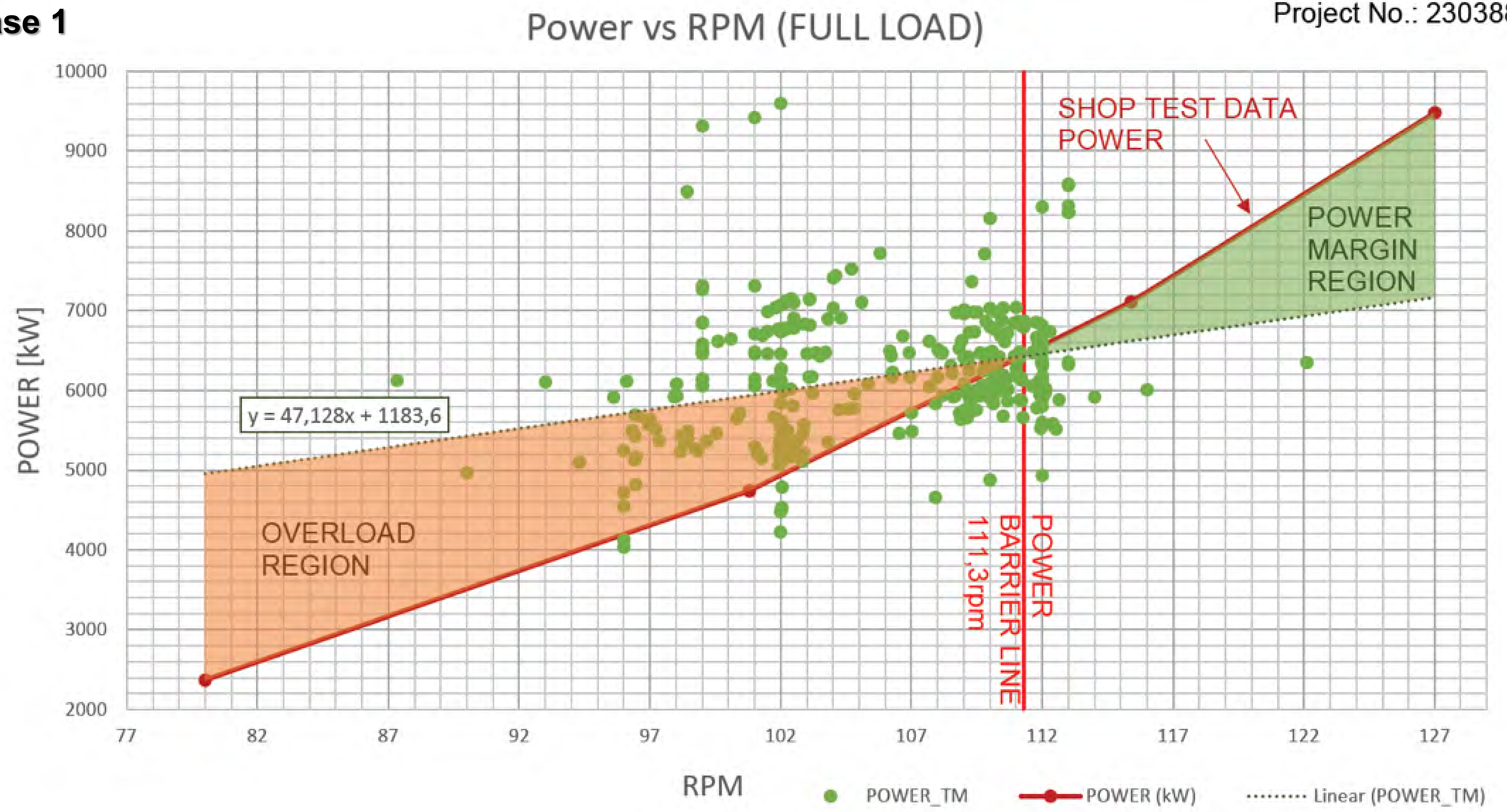

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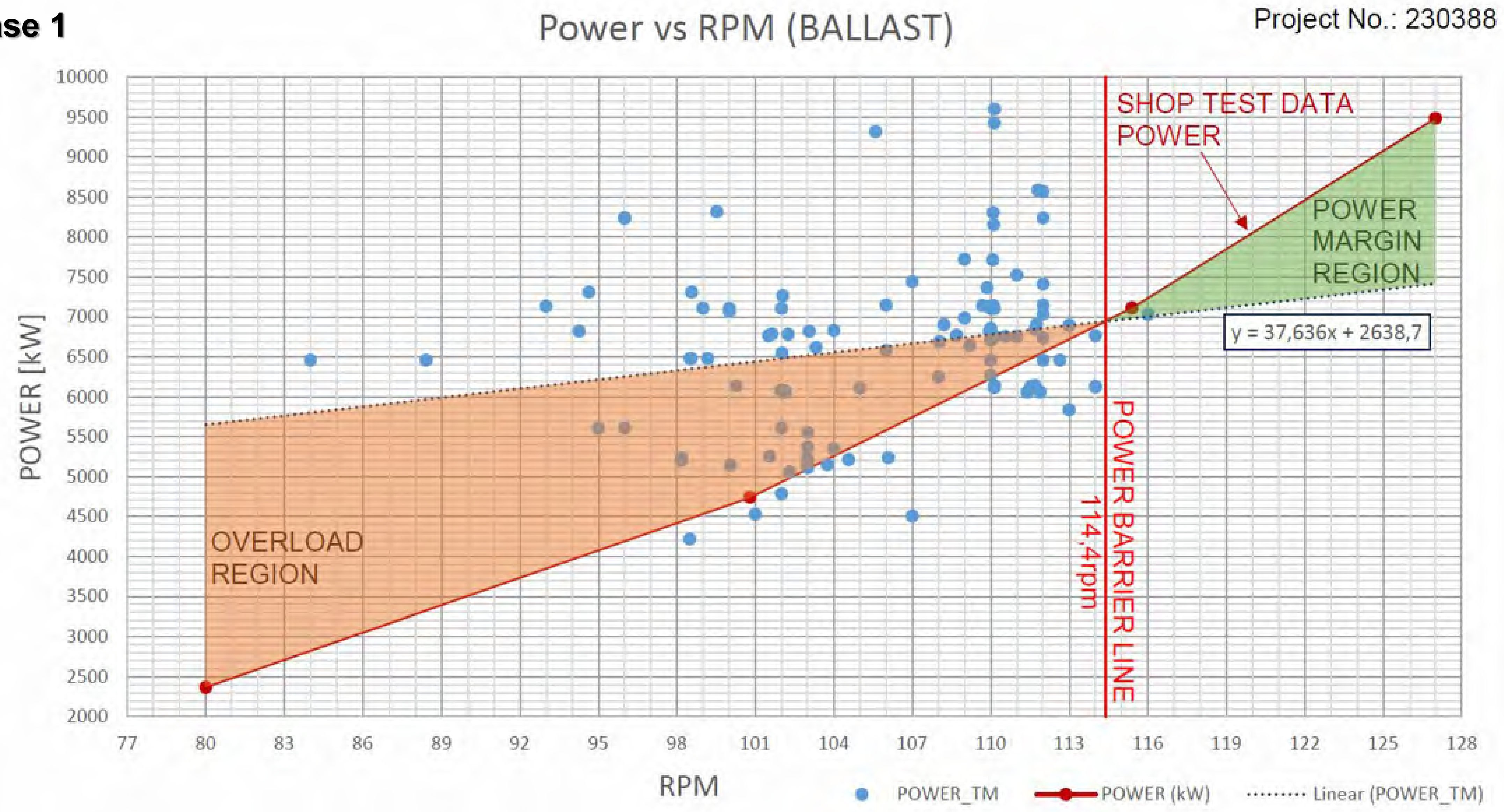

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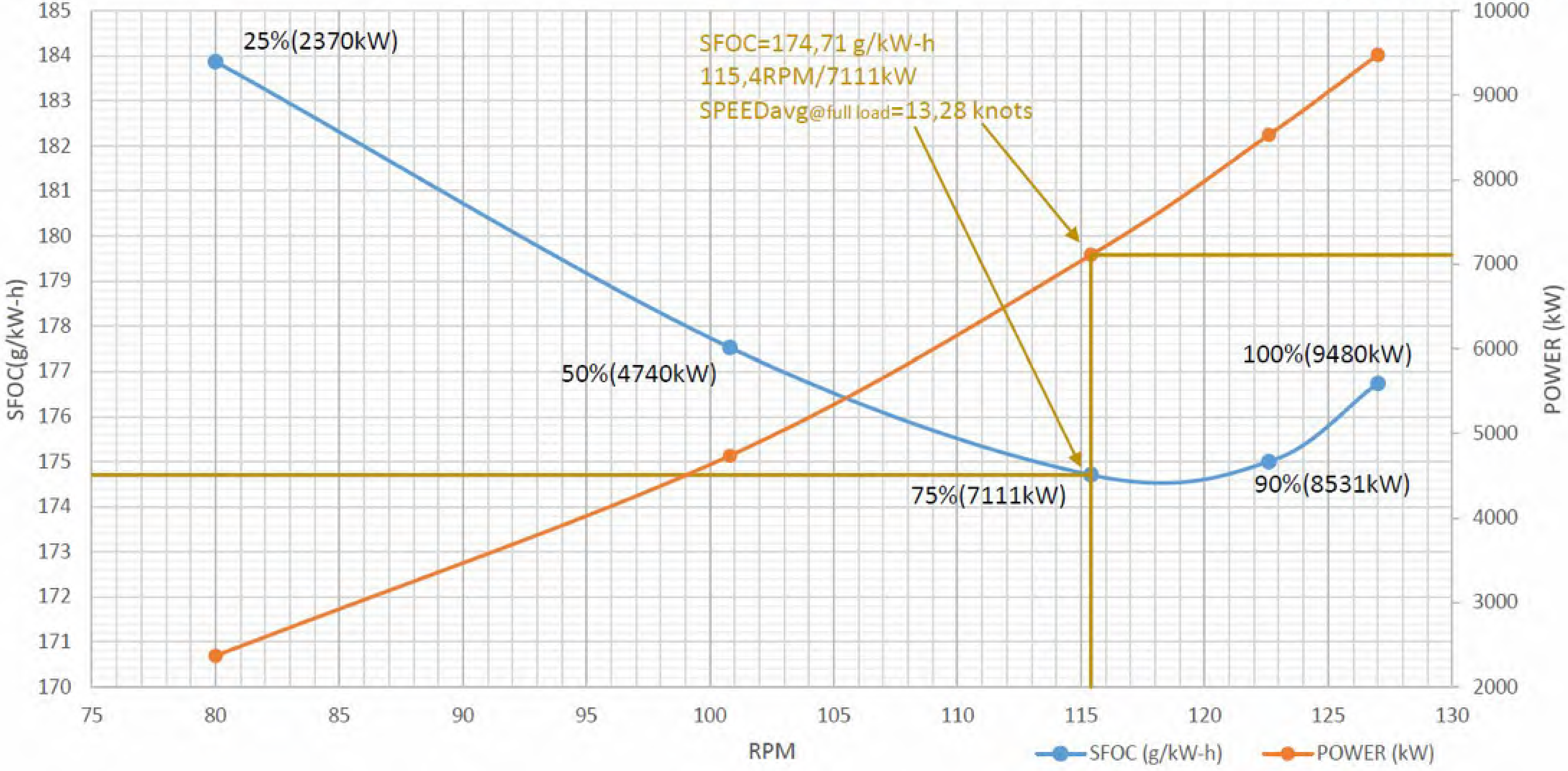
CASE 2

Case 2

Project No.: 230311



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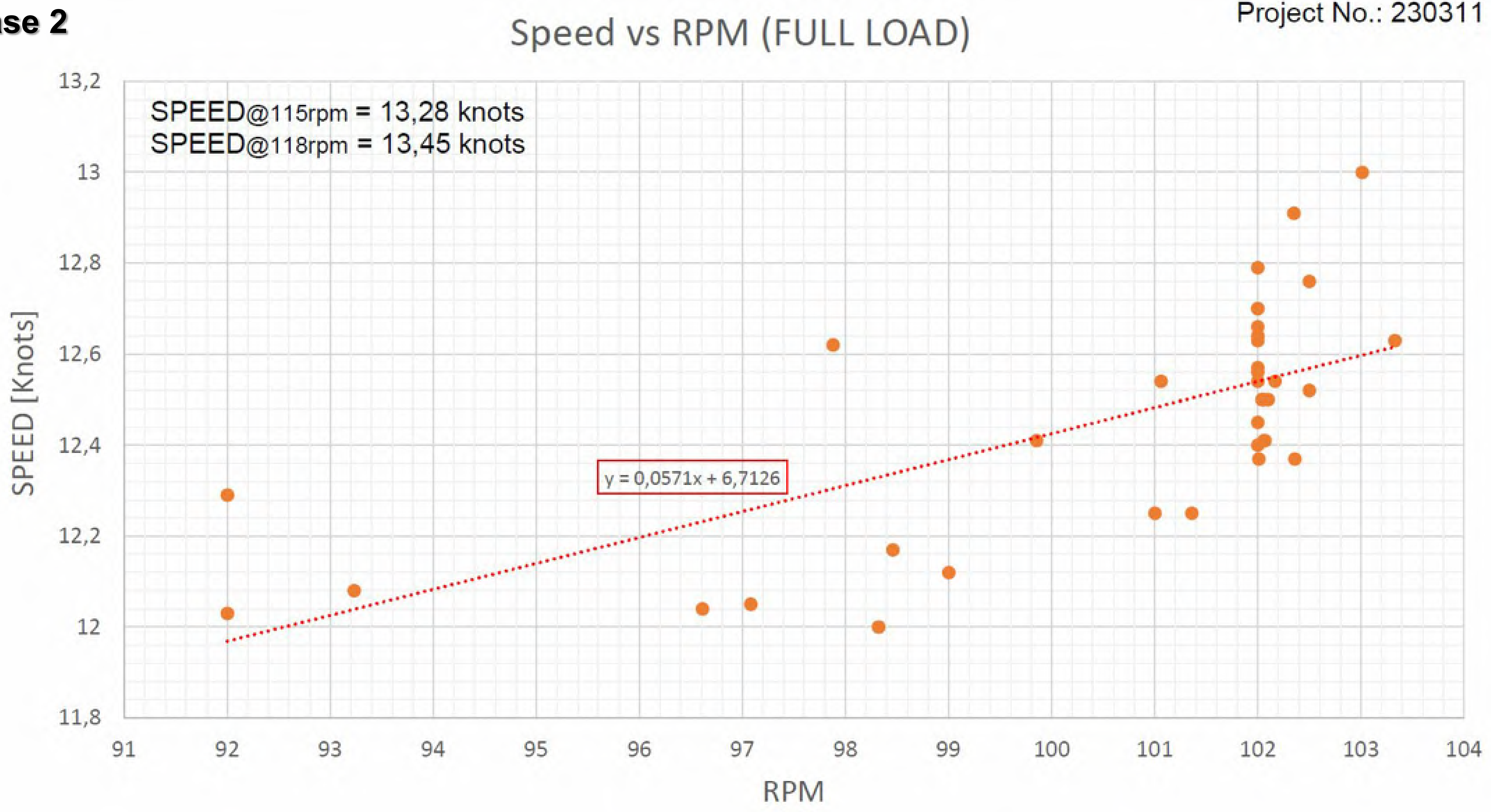

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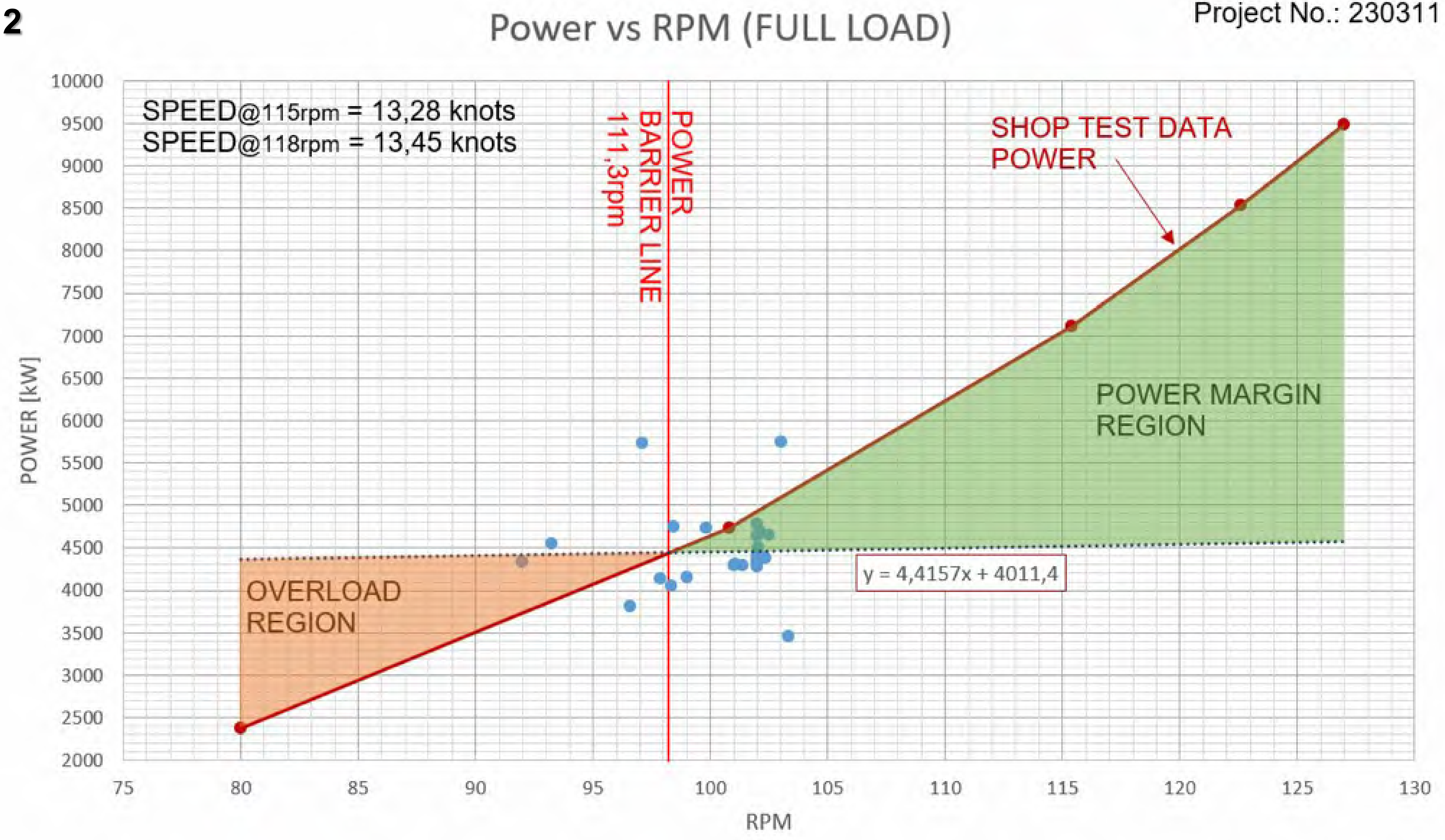
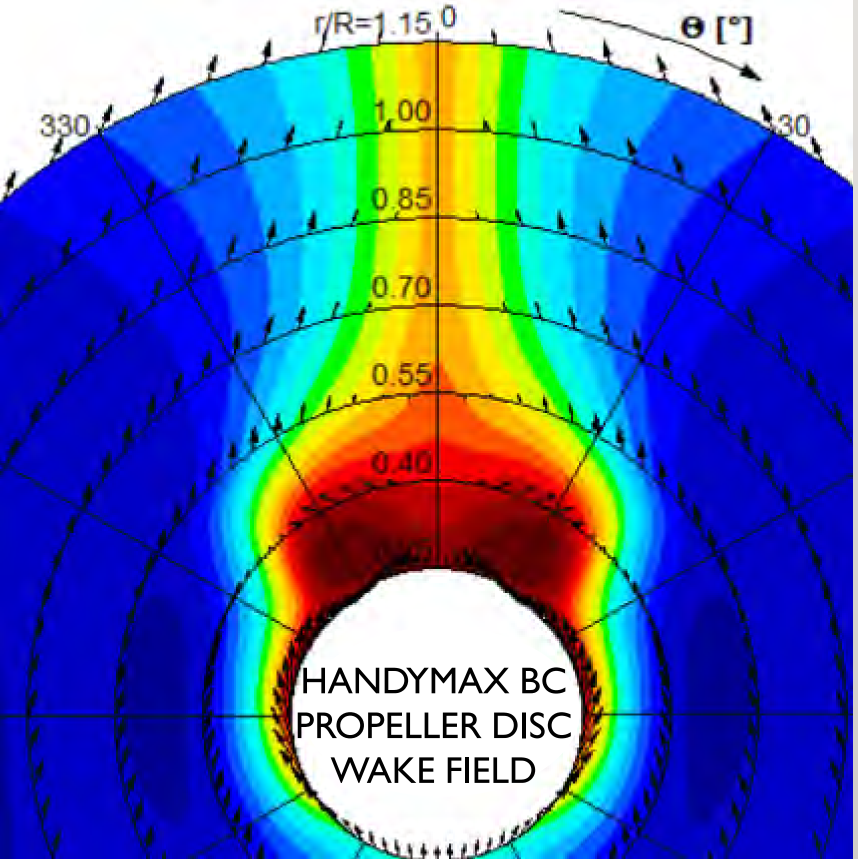


ALTERNATIVES

The replacement of the existing propeller with a new unit, designed to suit new IMO performance requirements may be the best option, if present significantly higher purchase and transport prices can be met with.



ENERGY SAVING DEVICES (ESD)

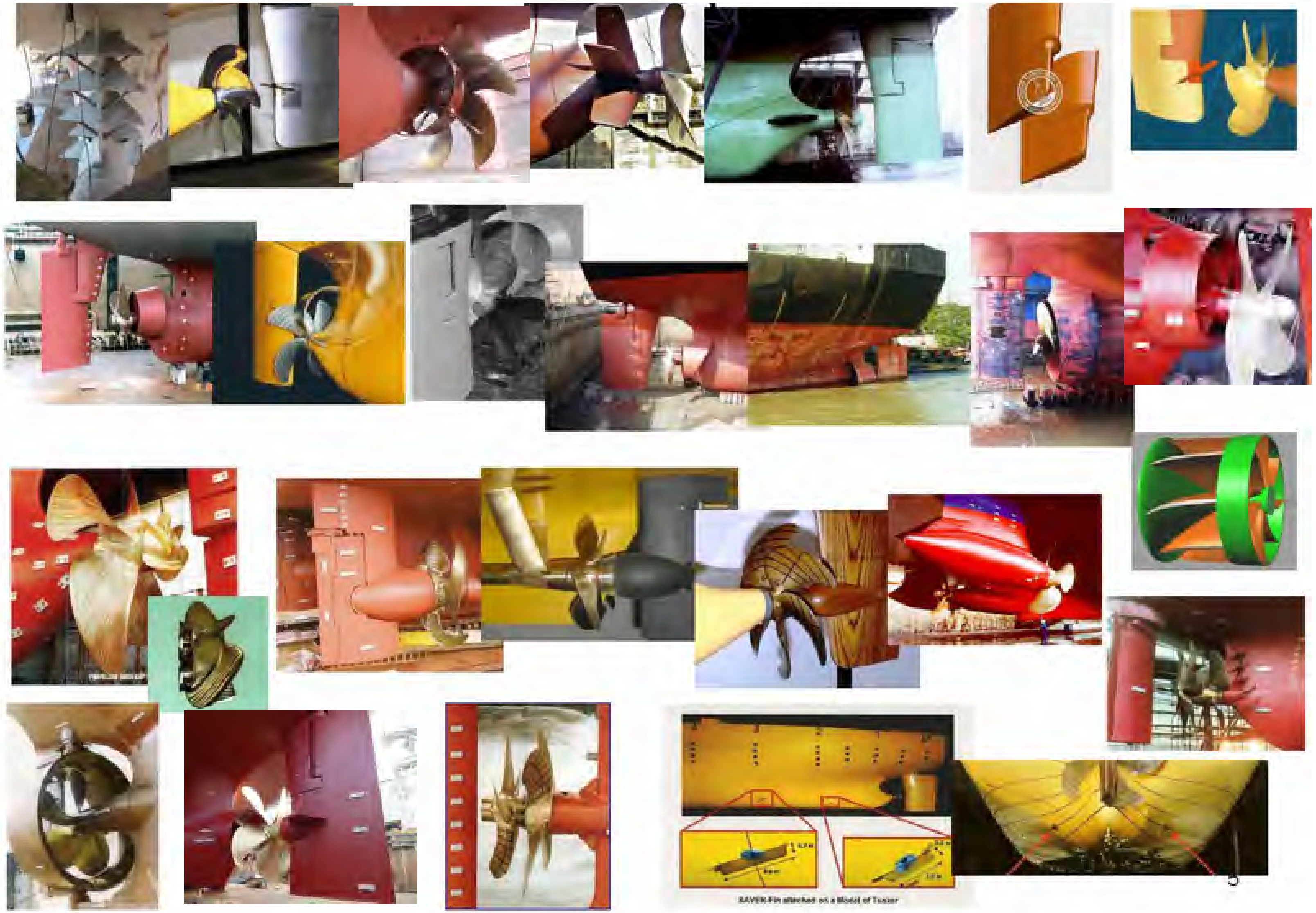
Made to reduce losses created mainly by the aft part of the ship. Cb (Block Coefficient) is also important into how big these losses are, as it effects the wake fraction.

Ducts are wake equalizers, i.e. they make the wakefield more uniform, thus reducing power loss due to wakefield strength.

A further reduction of rotational losses is possible if fins are fitted prior to the propeller flow (or even after).

If duct and fins are combined as in Finned Duct, then the best possible result is achieved, to the Author's twenty-year experience on ESD.

Energy Saving Devices



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ANY QUESTIONS ?