Practical Experience with ISO 19030 at Chevron Shipping - Part 2

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Abstract

This paper reviews AkzoNobel's practical experiences of applying ISO 19030 to vessel performance datasets provided by Chevron Shipping. It highlights benefits and limitations of noon report datasets and illustrates some of the challenges that are encountered when applying the ISO 19030 standard using data that does not meet the strict data-quality requirements of the standard. Consequently, data-analysts must use their judgement, make assumptions and apply ad hoc modifications to the methods prescribed by ISO 19030 in order to interpret these datasets and extract useful and meaningful vessel performance data to support decision making. Based on detailed discussions of practical adjustments to analysis method and the uncertainties in the results, it points out the need for sufficient data quality and quantity. The findings are valuable information and provide useful starting points for future improvements of ISO 19030.

1. Introduction

1.1. Background

This is the second in a short series of papers that will present the interim results of a multi-year technical project involving Chevron Shipping, AkzoNobel Marine and Protective Coatings and Jotun Paints relating to Chevron's experience of ISO 19030 on measurement of changes in hull and propeller performance, *ISO (2016a,b,c)*. *Eliasson (2018)* introduces the concept behind the collaborative project, its objectives and, in broad terms, some of the outcomes so far. This second paper of the series considers the practical aspects of applying the 3-part ISO 19030 standard to a series of vessel datasets provided by Chevron. *Abrahamsen (2018)* reviews the perceived limitations of ISO 19030 and discuss future potential changes to improve the practical applicability of the standard.

In common with many vessel operators, Chevron have a wealth of in-service performance data to-hand for the vessels in their fleet but may not always have the necessary in-house resource, expertise or available dedicated time to thoroughly interrogate and interpret the data. As a result, the impact of past investment decisions is often difficult to meaningfully assess, and the impact of potential future decisions difficult to reliably predict, especially when a range of vessel performance is seen across a fleet. Assembling a team of experts from various scientific disciplines may seem like an obvious solution, but historically individual fleet owners have often been very protective of their information on the operational efficiency of their vessels. In this project, Chevron have adopted a more collaborative approach to share data with two of its fouling control coatings suppliers in order to develop a better understanding of the connection between hull condition, fouling control coating selection and vessel operational efficiency.

The choice of fouling control coating is one of the key variables influencing the hull condition and ship efficiency for any particular vessel. ISO 19030 is intended to provide practical methods for measuring changes in ship-specific hull and propeller performance and defines a set of relevant performance indicators for hull and propeller maintenance, repair and retrofit activities. In principle, this enables vessel performance datasets to be reviewed in order to quantify the impact of past and future selections of energy saving solution options such as the choice of fouling control coating. This paper will review some of the practical experiences of AkzoNobel's vessel performance analysis team when applying ISO 19030 to vessel performance datasets provided by Chevron Shipping.

1.2 Project Overview

The overall aims of the project have been outlined in *Eliasson (2018)* and its general structure is schematically represented in Fig.1. It is acknowledged that the project objectives are ambitious and may not be fully realised in the short term and it is understood that it may take many years to generate and interrogate sufficient quantity and quality of data to fully deliver every aspect of the project.

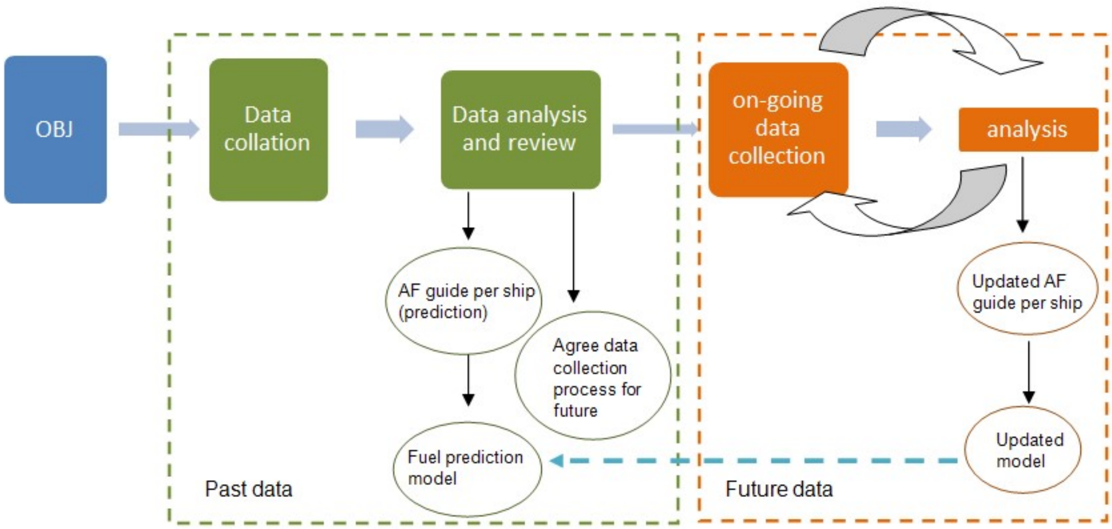

Fig.1: High-level project overview

2. Chevron Fleet In-Service Performance Datasets and Subsets

The applicability of ISO 19030 to the analysis of in-service performance datasets will be illustrated using a sub-set of data for 10 vessels from Chevron's tanker fleet. Table I gives summary information on the vessels and the relevant data-sets before and after a dry-docking (DD) event. Table II lists a selection of the parameters included within the noon reports for the sub-set of vessels from Chevron's fleet.

Table I: Summary information on the vessels reviewed in the project

Vessel Identifier	Vessel Type	DWT	Activity (%)[a]		Number of months in-service for the dataset		Data Points Available (before processing)		Data Points Available (after processing)	
			Before DD[b]	After DD	Before DD	After DD	Before DD	After DD	Before DD	After DD
A	VLCC	320,000	76	77	18	29	820	898	202	333
B	VLCC	321,000	70	76	28	22	840	736	202	285
C	VLCC	317,000	81	73	23	25	730	833	180	287
D	VLCC	321,000	80	84	36	17	1011	553	302	238
E	Shuttle	154,000	40	57	33	7	1046	393	153	59
F[c]	VLCC	319,000	-	76	-	32	-	1103	-	384
G[c]	VLCC	319,000	-	78	-	46	-	1741	-	468
H[d]	Aframax	105,000	-	39	-	48	-	1776	-	166
I[d]	Aframax	106,000	-	68	-	21	-	514	-	235
J[d]	Aframax	105,000	-	38	-	49	-	1789	-	210

[a] Activity (%) = total percentage of time the vessel operated with a speed over ground (SOG) > 3 knots during the relevant period; [b] DD = dry-docking event; [c] new-build vessels so there is no applicable pre-DD data; [d] no pre-DD data available.

Table II: List of selected parameters from Chevron's noon reports

Average speed through water from last report (knots)
Steaming distance from last report (NM)
Shaft power (kW)
Total fuel oil consumption (FOC) from last noon
Average RPM from last report
Wind speed (knots & Beaufort number) & direction
Wind sea height (m) & wind sea direction
Swell height (m) & direction
Loading conditions (ballast or laden)
Slip from last report (%)
Total hours reporting

The in-service vessel performance datasets from Chevron's fleet consist of noon reports that are derived from daily recordings of parameters such as the vessel speed and heading etc., as well as calculated averages of speed through water, fuel oil consumption (FOC) etc. since the previous noon report. The reported noon data is manually collected by the crew and inputted to an Excel spreadsheet which is then transferred to a central database. Typically, it takes the crew around 15 minutes per day to collect and transfer the noon report data.

3. Data Treatment

As the in-service vessel performance dataset from Chevron consisted of noon reports, it was not possible to analyse these datasets via the ISO 19030-Part 2 default method, *ISO (2016b)*, as the minimum data-quality requirements were not met. As such, the analysis was therefore conducted in a manner consistent with the general principles set out in ISO 19030-Part 3, *ISO (2016c)*, which outlines alternative methods. However, even here it should be noted that the Chevron in-service vessel performance noon report datasets are not fully consistent with the data-requirements of any of the four specific alternative methods that are outlined in Part 3. The method with the closest fit to the Chevron dataset is ISO 19030-Part 3 method 3-4, but without use of the water depth and speed over ground parameters as these data were not available.

The principle outputs from ISO 19030 are a series of performance indicators (PIs) in relation to the dry-docking performance, in-service performance, maintenance trigger and maintenance effect. To calculate these PIs, however, the data-analyst more or less always has to apply their own interpretation regarding how to best apply ISO 19030 to individual datasets. Specifically, in the case of the datasets provided by Chevron, four key aspects of the data-analysis are discussed below.

1) Vessel performance datasets almost invariably exhibit large variation in the raw data. As a result, the large variations are carried through from the raw data to the PIs. This is the case even after outlier data-points have been identified and removed using standard tools such as application of Chauvenet's criterion or multiple standard deviation filters. The dispersity of the data leads to larger uncertainties than would be otherwise desired.
2) Section 6.3.2 of Part 3 of the standard, *ISO (2016c)*, recommends that reference curves are either provided or determined for all relevant draught conditions within which only a small range of draught variance is permissible. In order to have sufficient data points to construct reliable reference curves, a commonly adopted approach is to simply split the dataset into ballast and laden draught conditions corresponding to the loading condition of the vessel. This approach was utilised for the analysis of Chevron's tanker fleet dataset.
3) Given that ISO 19030 primarily focusses on changes in the power / speed relationship of a vessel over time, assessing the reliability of these measured parameters is of considerable importance. Following a review of the reported shaft power data for all vessels, it is clear that there were serious inconsistencies in the dataset. As a result, the shaft power data was not considered in this project. Instead, the focus within this project shifted to the relationship between FOC / speed, which

is often assumed as to be a proxy for the power/speed relationship. It should be noted that this represents a marked deviation from the normal practice of ISO 19030.

4) The reference best-fit regression curves for both the power speed or FOC / speed relationship for the processed data is very often found to exhibit a low level of fitness to the data. ISO 19030 recommends that "coefficient of determination (R^2-value) for the generated speed-power curves must be above 0.8". When the R^2-value is less than 0.8, as is the case for the example datasets illustrated in Fig.2, the cubic law was used to normalize the power or fuel to a specific speed.

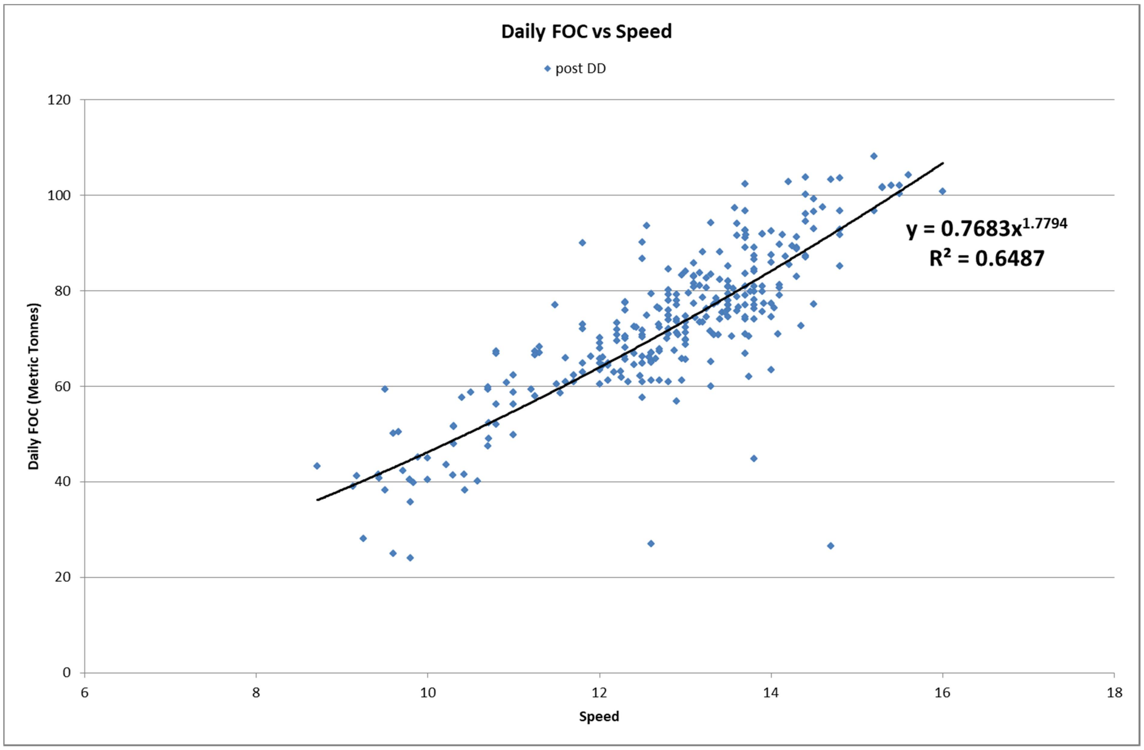

Fig.2: Example of a FOC / speed curves derived for vessel A in the laden condition post dry-docking

4. Results & Discussion

Using historical data and information regarding maintenance events such as dry-dockings, hull and propeller cleans, the ISO 19030 PIs associated with the dry-docking, in-service, and maintenance effect have been determined using the modifications to the ISO 19030-Part 3 procedure outlined above. As the purpose of this paper is to illustrate the process rather than to presents the detailed results, the majority of the examples provided below will focus on the PIs relevant to laden draught condition.

4.1. Dry-docking PI

ISO 19030-Part 2 stipulates that the reference and evaluation periods when calculating the dry-docking PI must be a minimum of 1 year. However, ISO 19030-Part 3 allows for shorter periods to be used where necessary or desirable. In this example, the dry-docking PI has been determined for reference and evaluation periods of 6-month pre- and post-dry-docking. Based on their experience, most ship owners would likely expect to observe an improvement in vessel performance as a result of a dry-docking, and as illustrated in Fig.3, this is the case here for the five vessels in the Chevron dataset with pre- and post-DD data.

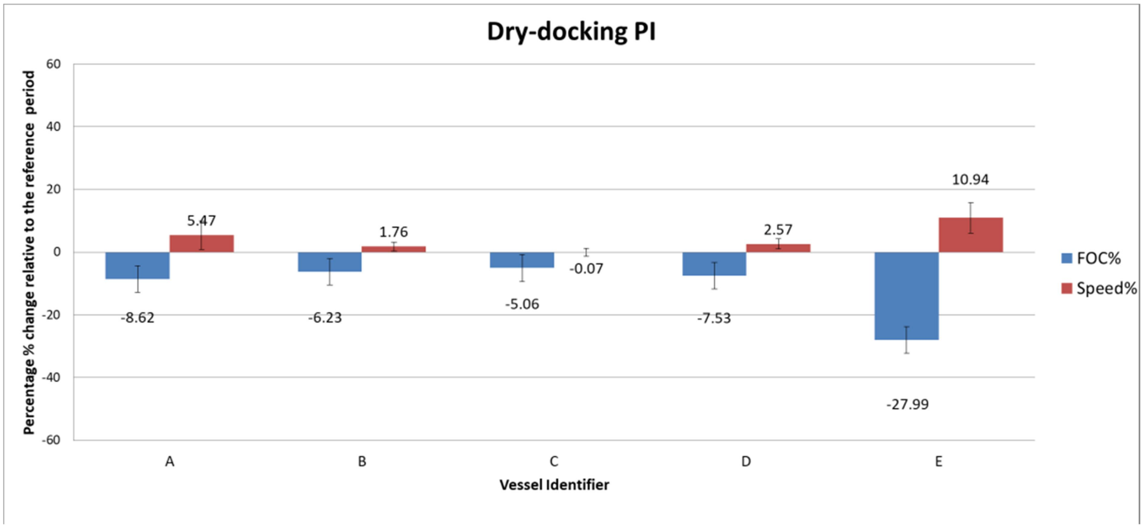

Fig.3: Examples of the dry-docking PI for selected vessels; error bands represent 95%CI. Note: FOC is being used as a proxy for the shaft power parameter specified by ISO 19030-Part 3.

If there are no major retrofit works during the dry-docking that may significantly impact on the FOC of each vessel, it may be possible to link the degree of change between the pre- and post-underwater hull and propeller condition with the dry-docking PI. The magnitude of the improvement in the DD PI may then be dependent on several factors associated with the underwater hull and propeller condition, such as the hull and propeller condition pre-DD, extent of damage and repair, extent and nature of substrate preparation, the application of new coatings schemes, propeller cleaning and maintenance etc. As can be seen in Fig.3, the dry-docking PI varies from vessel to vessel and without a full knowledge of each vessel's history and its hull/propeller condition it would be very difficult to make sense of where the improvements originate. Future work will consider a review of the likely contributory factors to the dry-docking PI.

The magnitude of the error bar (uncertainty band) for each vessel PI reflects the degree of scatter within the dataset. Not surprisingly, large uncertainties are associated with most of PI values. The large uncertainty bands indicate that the apparent differences in the PI for some vessels, for example for vessels A and B, may not be statistically significant. Future work using standard statistical methods (e.g. ANOVA) will be used to look into this more closely. Reducing the uncertainty associated with this PI would be useful as it would allow greater discrimination between datasets. *Abrahamson (2018)* reviews how this can be achieved, in particular for noon datasets.

In light of the large uncertainty within an individual vessel's dry-docking PI, one useful approach is to generate an aggregated view and determine an average value for a range of similar vessels in a fleet, as illustrated in Fig.4.

Fig.4 shows the average DD PI determined for the five-vessel Chevron fleet sub-set. The average DD PI determined for these vessels, i.e. the difference between the pooled average FOC for the 6 months pre-DD period and the pooled average FOC 6 month post-DD period, is approximately 17%. This indicates that for this sub-set of vessels, an efficiency improvement of around 17% in FOC and with a corresponding reduction in GHG emissions is achieved as a result of the maintenance and repair conducted whilst the vessels were in dry-dock. However, it is not possible to use this data to determine the relative contribution to the overall improvement that arose from any retrofitting/engineering works that were undertaken from the contribution that arose from the application of fresh coating schemes or other general hull and propeller maintenance operations.

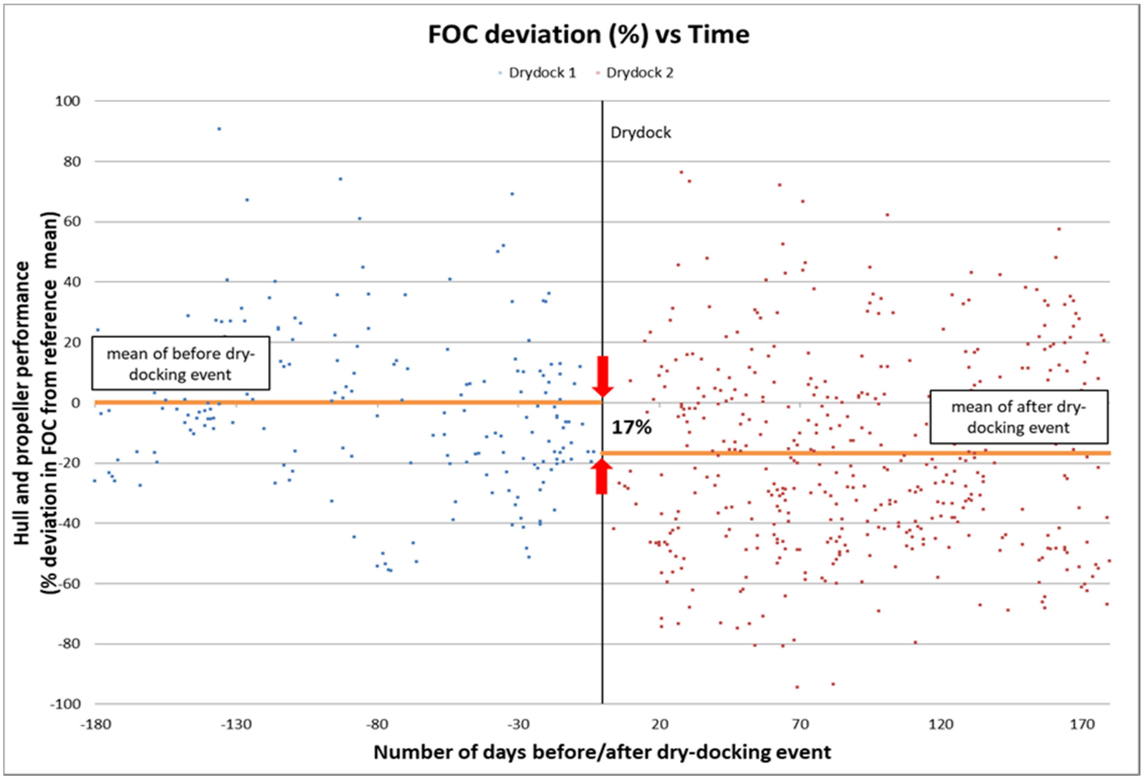

Fig.4: Overall average dry-docking PI for the Chevron fleet sub-set

4.2. In-service PI

As was the case for the dry-docking PI, ISO 19030-Part 3 allows for shorter post-DD reference and evaluation periods to be used for the in-service PI where necessary or desirable. In this example, the in-service PI has been determined for the nine vessels in the Chevron fleet which have suitable post-DD reference and evaluation periods of 6-months (vessel E is excluded as data is only available for 7 months in total). The in-service performance of each vessel will be dependent on many factors including but not limited to vessel type and size, its operational profile, effectiveness of the fouling control coatings etc. etc. That said, it might be expected that the accumulation of damage and wear and tear over time may lead to a slow but progressive loss of in-service performance. However, this does not appear to be true for most of the vessels within Chevron's sub-set of vessels illustrated in Fig.5. As before, it is not possible to use this data to determine the relative contribution of engineering factors from the contribution of the fouling control coating or other aspects of the hull and propeller condition.

Whether the indication of reduced FOC over time is valid or not is hard to determine without a more detailed inspection of the dataset. Again the degree of scatter or noisiness within the dataset and its impact on the statistical significance of each vessel's PI need to be carefully reviewed when attempting to compare the performance of vessels within a fleet.

As a further illustration of the in-service PI, Fig.6 provides an example where the in-service PI is calculated for an evaluation period ranging from the end of a 6-month reference period to the end of the 48-month overall dataset for vessel G in ballast and laden condition. The progression of the in-service PI over time can be clearly seen and there is a general trend of increasing FOC for the ballast condition, whereas there is a decreasing FOC trend for the laden condition.

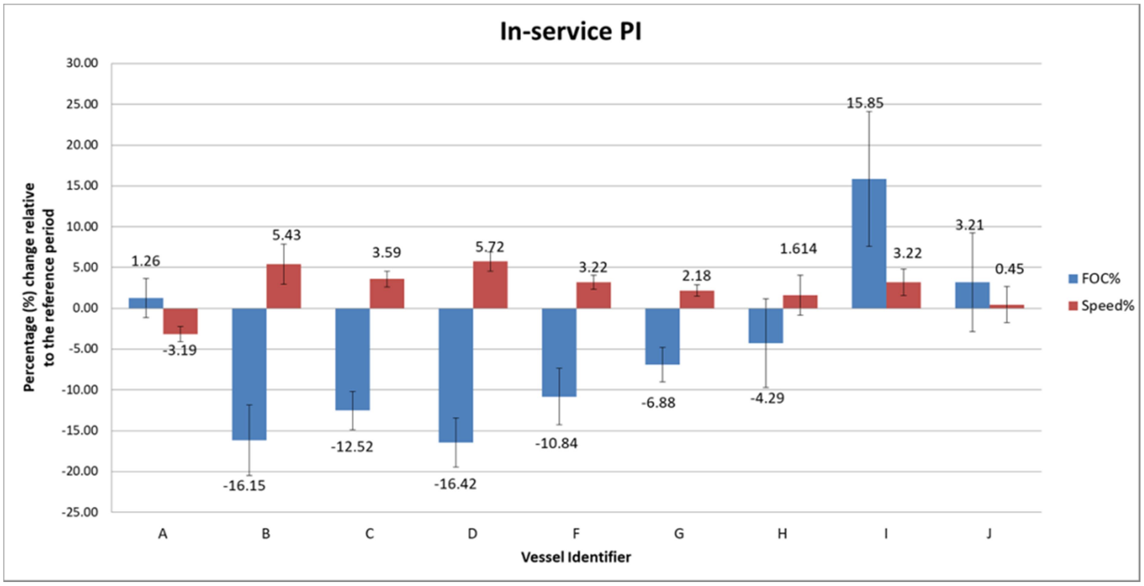

Fig.5: Examples of the in-service PI for selected vessels; error bands represent 95%CI.
Note: FOC is used as a proxy for the shaft power parameter specified by ISO 19030-Part 3.

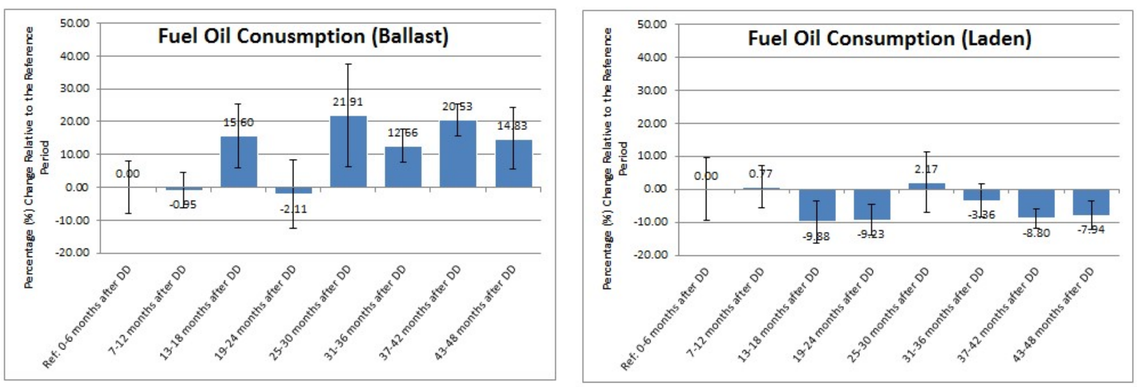

Fig.6: Time series evolution of in-service PIs for vessel G; error bands represent 95%CI. Note: FOC is being used as a proxy for the shaft power parameter specified by ISO 19030-Part 3.

The contrasting trends evident for the ballast and laden conditions are not uncommon and have been observed in noon datasets associated with vessels from different fleets. As the in-service PI is the measure used to indicate performance deviations and potentially trigger a maintenance event according to pre-defined maintenance trigger, the relative large uncertainty observed in the derived in-service PI suggests that other supporting information is required to validate and justify the need for a maintenance intervention. As such it is always recommended that a visual inspection be undertaken to validate the PI trends prior to commissioning hull and propeller cleaning.

4.3. Maintenance effect PI

For the purposes of ISO 19030 a maintenance event is a hull or propeller clean or other in-service maintenance activity that may impact on the performance of the vessel. ISO 19030-Parts 2 and 3 stipulate that the reference and evaluation periods in relation to the maintenance effect PI must be a minimum of 3 months. The maintenance PI is illustrated in Fig.7 for those vessels A, B, C, D, H and J that have been subject to a hull clean. Where vessels have been cleaned twice (i.e. vessels A and B) each clean is treated as a separate maintenance event.

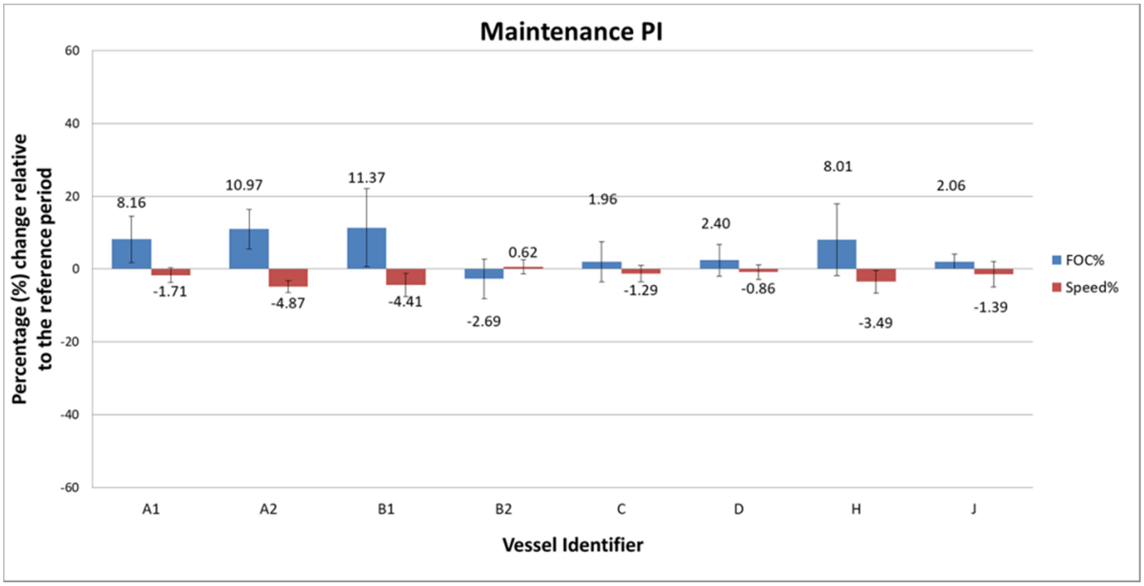

Fig.7: Examples of the maintenance effect PI for selected vessels; error bands represent 95%CI. Note: FOC is being used as a proxy for the shaft power parameter specified by ISO 19030-Part 3. 3-month periods are used before and after hull cleanings (HC) in the calculation, except A2 and B2 which use 3 months before HC and 1 month after HC due to the data availability.

As can be seen in Fig.7, the maintenance effect PI determined for these vessels suggests that the apparent differences in the impact of the hull cleaning event on the FOC change between different vessels again may not always be statistically significant. This may be in-part due to the relatively small size of the datasets available pre- and/or post- hull cleaning as well as the inherent high degree of scatter within such datasets.

A key missing element when reviewing the maintenance event PI when either a hull and/or propeller clean has taken place is often the absence of a visual record of the hull and propeller condition before and after the cleaning event. Such visual records would allow the apparent requirement for the clean to be undertaken in the first place, as well as aiding the understanding of the quality and extent of the cleaning work that was done.

Moreover, in the absence of suitable photographic and/or video records of each vessel's hull and propeller condition, it is not possible to validate any potential assumption that the apparent impact of the cleaning event as indicated by the maintenance effect PI is directly associated with a change in the hull and/or propeller condition.

5. Conclusion

The general applicability of the ISO 19030 standard for measuring changes in hull and propeller performance has been illustrated using noon report data for a sub-set of Chevron's tanker fleet. This has highlighted some of the challenges that are encountered when applying the ISO 19030 standard to such datasets. An overall aim of the standard is to provide a series of data requirements, analysis procedures and specified performance indicators that can be used by the industry in a consistent manner. However, it should be noted that in practice many noon report datasets, such as those collected by Chevron, do not meet the strict data-quality requirements of the ISO standard, including the four alternative methods set out in Part 3 of the standard. Particular issues include missing data parameters and the inability to generate appropriate reference curves. It is the authors' experience that very few noon report datasets from any ship owner fully align with the requirements of ISO 19030-Parts 2 or 3.

Consequently, the professional data-analyst must therefore use their judgement, make assumptions and apply ad hoc modifications to the methods prescribed by the ISO 19030 standard in order to interpret these datasets and extract useful and meaningful vessel performance data. In this way, as illustrated for example by the Chevron datasets, it is possible to understand the general trend of performance change for a particular vessel, although the resulting PIs are often associated with a degree of high statistical uncertainty, mainly due to the quality and quantity of data in the noon reports. To what extent the results are acceptable or considered valuable by an owner depends on their particular requirements and will likely vary case-by-case.

The technical project involving Chevron, AkzoNobel and Jotun is ongoing and will involve more comprehensive data-analysis as it progresses. This will lead to an enhanced understanding of ship performance in general but will specifically help identify the benefits and limitations in using ISO 19030 performance indicators to support future investment choices. Based on the learning, some possible improvements of ISO 19030 can be identified which should be addressed in the future development of the standard. This is discussed by *Abrahamsen (2018)* in more detail.

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