CIMAC
INTERNATIONAL COUNCIL
ON COMBUSTION ENGINES

09 | 2014

CIMAC Guideline

The Interpretation of Marine Fuel Oil Analysis Test Results with Particular Reference to Sulphur Content

By CIMAC WG7 ‘Fuels’

The first edition of this CIMAC Guideline was approved by the members of the CIMAC WG 7 ‘Fuels’ in July 2014.

Content

Appendices:

I Commercial Practice: Application of ISO 4259 to Fuel Oil Sulphur Limits

II Application of the MARPOL Annex VI Appendix VI Procedure

III CIMAC WG7 Fuels: Step-by-Step Guide to Fuel Oil Sulphur Test Results

IV CIMAC WG7 Fuels: Recommendations for Inspector verification of the MARPOL Sample and fuel in-use samples

V Bunker Delivery Note – Supplier's Declaration

1 Sulphur Appraisal Tables

The following 'Sulphur Appraisal Tables' provide a clear and concise approach to determining the acceptability of a fuel sulphur test result, obtained by using the ISO 8754: 2003 method, in a number of scenarios:

- Tables 1 and 2 reflect normal commercial practice in accordance with ISO 4259 (Section 6.2)
- Table 3 reflects current MARPOL practice (Section 8)
- Tables 4, 5 and 6 cover CIMAC WG7 Fuels recommended replacement approach for MARPOL (Section 10 & 11)

The background to, and implications of, these tables are detailed in the attached review.

1.1 Normal commercial practice in accordance with ISO 4259

Sulphur Appraisal Table 1			
Recipient – testing own "fuel oil as supplied" sample - Single test result 'A'			
V = Ordered limit	**W = V + 0.59R**	**A ≤ W**	**A > W**
3.50	3.67	The recipient cannot claim that the ordered limit has not been met and consequently has to accept that the fuel oil as supplied meets the ordered limit	The fuel oil as supplied fails to meet the ordered limit – supplier to test (see Table 2)
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

Sulphur Appraisal Table 2		
Supplier – testing supplier retained sample - Single test result 'B'		
V = Ordered limit	**B ≤ V**	**B > V**
3.50	Fuel oil as supplied meets the ordered limit	The supplier cannot claim that the ordered limit has been met with any level of confidence and therefore has to accept that the fuel oil as supplied fails to meet the ordered limit
1.50		
1.00		
0.50		
0.10		

1.2 Current MARPOL practice

Sulphur Appraisal Table 3				
Inspector – testing MARPOL Sample (MARPOL verification procedure) – Result 'C'				
X = Y – 0.59R	**Y = Reg. 14 limit**	**W = Y + 0.59R**	**C ≤ Y**	**C > Y**
3.33	3.50	3.67	Compliant	Not Compliant
1.42	1.50	1.58		
0.94	1.00	1.06		
0.47	0.50	0.53		
0.090	0.10	0.11		

Note: Any recipient or supplier measured value between and including X and W could be determined as not compliant in accordance with the MARPOL verification procedure (Section 8.3)

1.3 CIMAC WG7 Fuels recommended replacement for MARPOL verification

Sulphur Appraisal Table 4			
Inspector – testing MARPOL Sample - Single test result 'D'			
Y= Reg. 14 limit	**W = Y + 0.59R**	**D ≤ W**	**D > W**
3.50	3.67	Based on the inspection it cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil as supplied meets the regulation limit	Fuel oil as supplied fails to meet the regulation limit
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

1.4 CIMAC WG7 Fuels recommended approach to 'fuel in-use' samples

(Both Stage 1 and Stage 2 samples to be drawn during an inspection)

Sulphur Appraisal Table 5 – Stage 1			
Inspector – testing inspector drawn 'in-use' sample (From "in service system" but not outflow of service tank) - Single test result 'E'			
Y = Reg. 14 limit	**W = Y + 0.59R**	**E ≤ W**	**E > W**
3.50	3.67	Based on the inspectionit cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil in-use meets the regulation limit	Go to Stage 2 (Table 6)
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

Sulphur Appraisal Table 6 – Stage 2			
Inspector – testing inspector drawn 'in-use' sample (From outflow of service tank*) - Single test result 'F'			
Y = Reg.14 Limit	**W = Y + 0.59R**	**F ≤ W**	**F > W**
3.50	3.67	Based on the inspection it cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil in-use meets the regulation limit	Fuel oil in-use fails to meet the regulation limit
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

* This recommended approach applies where it is the fuel oil service system only which is common to the two sulphur grades of fuel oil (i.e. inside ECA-SOx and outside ECA-SOx grades) used on board. Hence the last point where the lower sulphur content fuel oil is still segregated is in the outflow pipe from the service tank containing that fuel.

Where that last segregated point is either earlier or later in the overall fuel oil system then the sampling point for the Stage 2 sample would need to be correspondingly positioned.

In the case where there is only a single sulphur grade of fuel oil on board then only Stage 1 applies.

2 Introduction

This review highlights the differences in the interpretation of fuel oil sulphur test results as set out in the international marine fuel specification ISO 8217 and MARPOL Annex VI. The issues between these different interpretations are identified and their impact and implications considered.

The difference between these interpretations has been further highlighted through the European Commission's current detailed review of the implementation of the EU Sulphur Directive, which enacts the MARPOL Annex VI legislation.

3 Executive Summary

With the introduction of MARPOL Annex VI, the sulphur content of a particular fuel oil is now often the primary factor in assessing whether or not that fuel oil is acceptable for intended use. However, at present, this issue is complicated by the fact that the Annex's approach to assessing compliance differs fundamentally from the commercial process under which the fuel oil is ordered and supplied.

Since all fuel oil testing is subject to inherent variations, the commercial assessment of fuel oils as supplied is governed by the provisions of ISO 4259. This requires that the supplier must not obtain a test result over the required specification limit value. In contrast, the recipient cannot consider a product out of specification unless the recipient's test result exceeds the specification limit value by more than the 95% confidence limit which, for a single test result, is given by the reproducibility of the test method multiplied by 0.59. This statistically based process defines how results shall be interpreted allowing for these inherent test variations.

However, within the Annex, the assessment of sulphur compliance is undertaken by testing the mandatory MARPOL Sample, using the given verification procedure, to determine a value which is then compared to the relevant limit. This verification procedure does not take into consideration inherent variations in results obtained in one laboratory and normal bias between laboratories. Furthermore, this can result in a fuel oil being established as non-compliant, in accordance with the Annex, despite both the supplier's and recipient's test results meeting the recipient's specification limit, where that limit is the regulation 14 value.

To date, the members of the CIMAC Fuels Working Group, which spans oil suppliers, fuel testing services, ship owners and others, are aware that the Annex verification procedure is not being widely applied in practice. From discussions with some authorities, this is, at least in part, due to the conflict with the standard commercial practice. Furthermore, the Annex's verification procedure lacks the necessary robustness and certainty required for an authority to take action, as specified under regulation 18, against the supplier, in the case of the supply of non-compliant fuel oil.

This review concludes that IMO should be invited to re-consider the Annex verification procedure, taking into account the technical facts and the established commercial practice. If there is to be a robust and reliable enforcement of the sulphur limits, there needs to be a single universal unambiguous approach. The international standard for marine fuels (ISO 8217) applies the well-established, statistically based, ISO 4259 for the interpretation of test results and it is recommended that IMO should adopt the same approach for the enforcement of the Annex sulphur limits, since this would then provide uniformity and an unambiguous approach across the marine industry. Adoption by IMO would also align the marine industry with automotive and land based industries which are legislated to use the ISO 4259 approach.

4 Background and Assumptions

On a technical basis, in order to use a fuel oil on board a ship, it is first necessary to know its properties and where those lie in relation to the limitations of the system in which it is to be used. In addition, there can be a range of other considerations, such as environmental controls, which introduce further potential limitations as to what represents an acceptable fuel oil in a particular situation. Consequently, it is necessary to undertake a range of analytical tests on the fuel oil. Inevitably there will be some variability in the parameter test results obtained between different laboratories, even when testing identical samples.

There are a number of standard test methods for determining fuel oil sulphur content. For marine fuel oils, the ISO 8754:2003 test method is the reference method both for ISO 8217 and the Annex and therefore this review is written on that basis. Sulphur test results are given on a mass basis; the weight of sulphur in the sample divided by the weight of sample. The test result is expressed as % (m/m) or mass %; however, in this review values are shown simply as %. The ISO 8754 test method has an application range of 0.03% - 5.00% and therefore covers the range of sulphur values typically encountered in marine fuel oils; distillates through to heavy residuals.

This review takes the approach that each party has a single test result; albeit in practice there may have been subsequent duplicate tests undertaken to validate the initial finding. Multiple test results act to reduce inter-test variability, but do not eradicate the previously mentioned inherent differences.

Additionally, there is the assumption that the fuel oil supplied is homogeneous and that all samples drawn from a fuel oil supply are identical, although in reality testing may be carried out on samples drawn from different locations which, while it does not preclude them being ‘identical’, can introduce further uncertainties.

In this review, the term ‘recipient’ is generally used to describe either the shipowner or the ship operator, whoever is the responsible party for receiving the fuel on board.

5 The Measurement of Fuel Oil Parameters

Measurement is not an exact science - this applies equally to fuel oil testing as to any other measurement activity. Consequently, there are factors, and combinations of factors, which influence a particular test result. A test result may be the outcome of a single test or a series of tests, obtained in a single laboratory or from a number of different laboratories. Therefore, in order to provide a controlled framework within which fuel oil testing is undertaken, analysis should be performed using standard test methods in duly accredited laboratories. The accreditation of a laboratory within a national laboratory scheme covers its general competence, impartiality and performance capability. Typically, this assessment will be against the requirements of ISO 17025 and will cover the principal test methods performed by the laboratory in question.

Standard test methods have been developed for a wide range of fuel oil parameters and the majority of the test methods usually exist within both the ISO system and national equivalents. These methods cover aspects such as the test equipment, reference materials, consumables and procedures used, together with the relevant reporting convention.

As part of the development of a test method, repeatability and reproducibility values will normally be determined and both are defined in the test method.

Repeatability – expressed as 'r'

Is the closeness of agreement, usually found, between independent results obtained in the normal and correct operation of the same method on identical test material, in a short interval of time, and under the same test conditions (same operator, same apparatus, same calibration standard and same laboratory).

Reproducibility – expressed as 'R'

Is the closeness of agreement, usually found, between individual results obtained in the normal and correct operation of the same method on identical test material but under different test conditions (different operators, different apparatus, different calibration standards and different laboratories).

6 Test Result Assessment in Commercial Practice

Given that there will be variability between test results, even from identical samples tested in the same laboratory, this raises the issue of when does an individual test result indicate that a fuel oil has, or has not, met a particular specification requirement. In the case of marine fuel oils, these are typically ordered and supplied against the ISO 8217 "Petroleum Products – Specifications of Marine Fuels" which refers to ISO 4259 "Petroleum Products – Determination and Application of Precision Data in Relation to Methods of Test" for the interpretation of test results. A summary of the relevant requirements is given as Annex L in ISO 8217.

6.1 Test result confidence

If a fuel had a 'true value' that was equal to the specified limit then, due to the natural variability in testing, there would be as many test results above the specified limit as there were below that limit.

On the basis of the inherent level of test variability, establishing the 'true value' of a specification parameter is not achievable in practice. Instead the usual approach adopted is in terms of 95% confidence that a single test result either satisfies or does not satisfy a specification limit. For commercial marine fuel oil transactions, the 95% confidence testing margin is given by ISO 4259 as 0.59 times the reproducibility value (0.59R) where R is defined by the test method; R is not a constant value but is a function of the number of tests undertaken and the number of laboratories involved in the testing. An important distinction in the application of the testing margin is that there are different approaches for the supplier and for the recipient as to whether a specification limit has been met.

6.2 Interpreting the test result in accordance to ISO 4259

For the supplier, with a single test result, the approach is:

> *In the case of a maximum specification limit, the specification limit has been met, with 95% confidence, if the test result is less than or equal to the specification limit minus 0.59R.*

However, it is further given that*, this is for the guidance of the supplier, not an obligation,* and that *a value between the specification limit and the limit minus 0.59R is not proof of non-compliance* (not proof that the specification has not been met)*.*

In contrast for the recipient, with a single test result, the approach is:

> *In the case of a maximum specification limit, the specification limit has not been met, with 95% confidence, if the test result is greater than the specification limit plus 0.59R.*

This means that the recipient with a single test result above the specification limit but below the 'limit plus 0.59R' cannot claim that the specification has not been met and consequently has to accept that the product has met the specification and there is no requirement to carry out additional testing.

Similar clauses apply in the case of minimum limits.

The application of the ISO 4259 process to fuel oil sulphur limits is illustrated in Appendix I.

6.3 The implications of ISO 4259

The implications of these clauses are that the supplier, intending to meet a particular maximum specified limit, should target a value at or below the specified limit.

Any test result obtained by the supplier which exceeds the specified limit indicates that the product has not met that specification limit, whereas the recipient can only consider that a maximum specified limit value has been exceeded if their test result exceeds the limit plus 0.59R.

A further point to note is that 95% confidence is a defined statistical process and is not 100% confidence – in fact, it is not possible to achieve a confidence level of 100%. Therefore, despite all the care taken in the application of the relevant test method, there remains a slight chance that the result variation will be outside this 0.59R margin. In such cases, the supplier has to accept the risk that a parameter, which from their initial testing was shown to not exceed the specified limit, on retesting does exceed that limit. Equally, from the recipient's side, there is the same chance that a result which indicated that the limit plus 0.59R had been exceeded is not supported by subsequent analysis. Such is the reality of fuel oil testing. However, this risk can be minimised by carrying out repeat checks in a laboratory (using the same sample and test method) before reporting the result.

7 Fuel Oil Sulphur Limits in Commercial Practice

The first three editions of the ISO 8217 specification (1987, 1996 & 2005) included sulphur limits for all fuel oil grades, on the basis that sulphur acts to reduce a fuel's specific energy value and can result in cold corrosion of susceptible components. Subsequent editions of ISO 8217 have, as explained in Annex C of the specifications, retained stated sulphur limits only for the distillate grades in order to avoid sulphur initiated corrosion in small high speed diesel engines.

The rational for this change of approach was the adoption of fuel oil sulphur limits in a wide variety of environmental protection regulations, such as MARPOL Annex VI, the European Union's Sulphur Directive, various local regulations, environmental award schemes, performance notations and other measures, each with their own particular application clauses. This would have resulted in a multitude of sulphur limits and hence grades.

In order to avoid a proliferation of grades, differing only in terms of sulphur content, the ISO 8217 specification from the fourth (2010) edition onwards, for all grades (both distillate and residual),

states that it is the responsibility of the purchaser to specify the maximum sulphur content of the fuel oil to be supplied. Even though sulphur is a purchaser defined specification limit, the precision and interpretation of test results are handled in the same way as other characteristics given in the ISO 8217 specification.

8 Fuel Oil Sulphur Limits in MARPOL Annex VI

8.1 Annex requirements

The implementation of the Annex has introduced new requirements, procedures and parties which were not previously engaged in the commercial fuel oil supply process.

Regulation 14 of the Annex controls the SOx and particulate matter emissions from all ship borne combustion equipment. This is achieved by defining the maximum sulphur limit of any fuel oils used on board a ship, either inside or outside areas designated as 'Emission Control Areas in respect of SOx and particulate matter emissions' (ECA-SOx). Although compliance may be achieved by other equivalent means, with the approval of the ship's flag State, virtually all ships currently seek to comply with the requirements of this regulation by purchasing fuel oil not exceeding the relevant sulphur limit.

Typically, fuel purchasers will order fuel oil in accordance with ISO 8217 with the maximum sulphur content specified at the limit defined in regulation 14. However, under the Annex, there is no obligation on the part of the shipowner to test the fuel oils as supplied in order to verify the Bunker Delivery Note (BDN) sulphur value.

8.2 Supplier's position

The purchaser's specified sulphur limit defines the maximum limit which has to be met by the supplier. Whilst the purchaser can specify a limit below the regulatory limit, defined in the Annex, typically the purchaser will specify fuel in accordance with ISO 8217 at the relevant regulatory limit, in order to minimise the cost of the fuel.

The supplier may either test the sulphur content of the fuel oil prior to delivery or calculate the content from the known values of the blend components to give the sulphur content documented on the BDN. The BDN sulphur content must not exceed the purchaser's specified limit.

Annex VI regulation 18 requires that the supplier provides:

- a BDN which, amongst other aspects, has to state the sulphur content of the fuel oil supplied, as measured by ISO 8754:2003, and
- a representative sample of that supply; usually referred to as the 'MARPOL Sample'.

As part of this review, it has been identified that the current wording of the fuel oil supplier declaration is inappropriate. This point is discussed in detail in Appendix V.

8.3 Shipowner's position

Despite adopting an ISO test method for the determination of sulphur, the Annex does not adhere to the ISO approach for the assessment of that test result. Instead, Appendix VI of the Annex provides its own, unique, fuel verification procedure for establishing the sulphur content of a MARPOL Sample. This verification procedure is examined in detail in Appendix II of this review. The verification procedure could, in some circumstances, result in a fuel oil supply being

established as being non-compliant, despite both the supplier's and recipient's test results meeting the specification limit.

In contrast, the industry standard approach is based on ISO 4259 and adopts the 95% confidence test margin, since it recognises the inevitability of variation between test results.

Consequently, the shipowner is presented with the situation that there is a fundamental difference between the Annex verification procedure and the ISO 4259 approach. The implications of this difference, and the resulting issues, are examined in detail in the following sections of this review.

8.4 The role of the Bunker Supplier Registration Scheme

Generally, the provisions of the Annex are enforced by the ship's flag State together with inspections by port State control (PSC). Additionally, the Annex also requires signatory Parties to set up Bunker Supplier Registration Schemes (BSRS) covering fuel oil suppliers within their jurisdiction. The key functions of the BSRS are:

a. the maintenance of a register of suppliers within their area;
b. to ensure fuel suppliers have provided and completed the BDN in accordance with the Annex requirements;
c. to ensure fuel suppliers have drawn and supplied the MARPOL Sample (see Section 8.5); and
d. where necessary take appropriate action against the fuel suppliers.

8.5 The MARPOL Sample

Under the Annex, the MARPOL Sample, provided by the supplier, is the physical representation of the delivery. MEPC, as the IMO committee responsible for the MARPOL Convention, has established Guidelines directed to BSRS, covering how this sample should be drawn and handled (MEPC.182(59)). However, it is for individual BSRS to approve the particular arrangements, thereby allowing for local variations.

The MARPOL Sample is not to be used by the supplier, recipient (i.e.shipowner) or others involved in any commercial dispute; even where the dispute is in respect of the sulphur content of the fuel oil supplied. Only the relevant authorities, in accordance with the Annex verification procedure, can analyse and establish the sulphur content of the MARPOL Sample.

8.6 Correctness of the Bunker Delivery Note

The Annex requires that the supplier shall document the sulphur content and density of the fuel oil on the BDN. These values will be the direct outcome of the supplier's own testing of that fuel consignment or derived by calculation from blend component analytical values.

Since there is an inherent level of variability in test results, this will mean that the test results of the recipient's sample may differ slightly from the values documented on the BDN. Where samples have been taken from the same location and source, the results will rarely differ by more than the relevant test reproducibility (R) – see Section 6.3.

9 Differences in Commercial and MARPOL Approaches to Assessing the Sulphur Content of the Fuel Oil as Supplied

When comparing the legal responsibilities of the supplier under the bunker contract and those of the shipowner under MARPOL, most shipowners are not aware that they are faced with two different verification criteria:

I. Commercial
The fuel oil has been ordered and delivered within the commercial framework, in which the assessment of whether or not the specified sulphur limit has been met is undertaken in accordance with the provisions of ISO 4259.

II. MARPOL Annex VI
In contrast, the Annex verification procedure is to be used by the relevant authorities to assess if the fuel oil sulphur content is in agreement with the relevant regulation 14 limit. The application of this procedure is outlined in Appendix II of this review.

9.1 The shipowner has a commercial case for raising a dispute

A shipowner, having specified a limit for the sulphur content of the fuel oil (for example, corresponding to the relevant regulation 14 limit) in the purchase request, can find their tested sample result is above that limit.

When that single result is above the 'limit plus 0.59R' then, in accordance with ISO 4259, there is a case for raising a dispute with the supplier. This would then proceed through the usual stages, as with any other commercial dispute, with the supplier testing their retained sample relating to the delivery. If the supplier's test result exceeds the limit, the claim is substantiated. If under this circumstance the relevant authority arranges for the analysis of the MARPOL Sample, in accordance with the Annex verification procedure, then it is highly probable that the result would also exceed the limit.

Generally, the relevant authorities have not indicated the action to be taken where it has been agreed by both parties that the sulphur content has exceeded the relevant limit. However, the US Coast Guard (USCG) in their February 2014 'frequently asked questions' www.homeport.uscg.mil states:

> '*We understand that when these* [shipowner] *results indicate sulphur content that exceeds the established limit (1.00% m/m) and that which is recorded on the BDN it is recommended that the owner/operator file a 'Notice of Protest' (NoP)*[to the supplier]*, Although there are no statutory requirements for the vessel to submit this NoP, the US Government believes that it is an appropriate means to document the disparities between the BDN and the third party analysis results…….The results of an independent third party fuel sample analysis will not, by itself, form the basis of an enforcement action by the U.S. Government against a fuel supplier. However, the analysis may trigger a further investigation. Additionally, while the filing of a notice of protest by a vessel does not render the fuel compliant, all actions taken by a vessel owner/operator to address the unknowing bunkering of compliant fuel (including issuance of a NoP and the use of the lowest sulphur fuel available) are relevant to the determination of penalties, or whether to take an enforcement action against the vessel'.*

9.2 The shipowner has no commercial case for raising a dispute but has a predicament

A shipowner may be faced with the situation of having a single test result which

- is above the regulatory limit, but does not exceed the 'limit plus 0.59R'
- is at or below the specified limit, where that is the regulatory limit, but is not less than the 'limit minus 0.59R'

In these instances:

- there are no grounds for raising a commercial dispute. Application of the ISO 4259 process means that the fuel oil supplied has not, from the recipient's perspective, exceeded the limit and therefore has to accept that the product has met the limit. There is no necessity for any additional testing
- consequently there is no requirement to notify the relevant authorities

However, the predicament faced by the shipowner is that if the MARPOL Sample is checked, in accordance with the Annex verification procedure, it may, or may not, be found to exceed both the BDN value and the relevant regulation 14 limit.

A number of scenarios resulting from the application of the Annex verification procedure are given in Appendix II of this review.

10 Sulphur Compliance in Practice

10.1 Ships operating only inside an ECA-SOx or outside an ECA-SOx

Regulation 14 requires that the fuel oil as used shall not exceed specified limits. Therefore ships which either operate only inside or are operating outside the various ECA-SOx, having ordered a fuel and received a BDN that does not exceed those limits, should have no concern regarding the fuel's compliance as there is no means on board to increase the sulphur content of the fuel oil beyond the relevant limit.

However, unless the fuel has been delivered with sulphur content below the regulation 14 limit minus 0.59R, either as specified by the shipowner or by the supplier's operational constraints, the risk still remains that the fuel oil could be found to be non-compliant if tested by an authority in accordance with the Annex VI verification procedure.

10.2 Ships which operate both inside and outside ECA-SOx

For ships which operate both inside and outside the ECA-SOx, there will tend to be two sulphur grades of fuel oil on board in order to meet the relevant requirements. In these instances there is the particular need to ensure that:

- the lower sulphur grade, ECA-SOx, fuel oil is not commingled with higher sulphur grade fuel oil in storage, transfer or use
- the change-over to the lower sulphur grade fuel oil is fully completed prior to entry into an ECA-SOx and duly recorded. In this it must be recognised that if the lower sulphur grade fuel oil is at the regulation 14 limit, then the change-over time, for a recirculating system, would be infinite, since the previously used fuel oil would never be diluted down to the regulation 14 limit. The larger the difference between the low sulphur grade fuel and the

regulation 14 limit, the shorter the change-over time and consequently, prior to entry into the ECA-SOx, less of the low sulphur grade fuel would be used during the change-over period

10.3 Compliance requirements

From the above, compliance with the regulation 14 limits divides into two issues:

1. Fuel oil supplied. This applies to all ships
2. Fuel oil in-use. This only applies inside ECA-SOx in those instances where there are higher sulphur grade fuel oils also on board

10.3.1 Issue 1 - Fuel oil supplied

Ideally the BSRS would function as intended and shipowners would have full confidence that the sulphur content of any fuel oil supplied would be correctly documented on the BDN and therefore have the confidence that their specified sulphur limit had been met. Furthermore, in those instances where it is subsequently determined by PSC that the sulphur content of the fuel oil, as supplied, exceeds the regulation 14 limit then, this is not the ship's fault; it would be solely a matter between the PSC and the BSRS in the port where that fuel oil was supplied. Despite the Annex having been in force since 2005, it is widely recognised that the BSRS mechanisms are generally not functioning as originally intended.

Even if the BSRS mechanisms were functioning as intended, the Annex verification procedure could still result in instances where a fuel oil, ordered against the regulation 14 limit and delivered meeting that limit, is found, on subsequent inspection by the PSC, to be non-compliant, as shown in Appendix II of this review.

10.3.2 Issue 2 - Fuel oil in-use

When the fuel oil supplied meets the regulation 14 limit, then compliance in respect of the fuel oil in-use relies on avoiding on board comingling of the lower sulphur grade fuel oil with higher sulphur grade fuel oil. In addition, prior to entering ECA-SOx, change-overs need to be carried out in a timely manner in accordance with the ship's procedures.

Whilst IMO has considered the issue of determining compliance in terms of the fuel oil in-use, to date no guidance for assessment has been issued. However, the European Commission has initiated detailed discussions to provide guidance to European Member States.

10.3.2.1 In-use fuel oil sampling

The objective of in-use fuel sampling is to obtain a representative sample, which can be a spot sample, of the fuel oil being used. Typically samples of the fuel oil in-use have been drawn at a position part way through the fuel oil service system, prior to the booster pumps and fuel oil heaters. This position is part of the fuel oil circulating system and therefore samples drawn from that position are potentially contaminated by previously used fuel oils and oily residues washed from the piping system walls. Whether a ship performs fuel oil change-over every other day, monthly or even annually, will have a major effect on the rate and degree of system clean-up being achieved. Consequently, samples drawn from part way through the fuel oil service system, whilst reflecting the fuel oil in-use, can be heavily affected by the totally unpredictable aspect of fuel oil system clean-up rates. Therefore, consideration should be given to sampling the fuel oil being supplied into the fuel oil service system, for example from the rundown line from the in-use service/day tank.

Furthermore, the provision of clear guidance by IMO, in conjunction with defining and clear labelling of the sampling point on board, will ensure that the sample will be representative of the fuel oil in-use and will not be drawn from an isolated dead leg of pipework or contaminated due to inadequate pre-flushing prior to drawing the sample.

The sulphur verification procedure, as given in Appendix VI of MARPOL Annex VI, is specifically applicable to the MARPOL Sample. Nevertheless, if this verification procedure is also applied to a sample drawn by PSC from a ship's fuel oil service system, the same concerns as given in section 10.3.1 equally apply.

10.3.2.2 Repositioning the point of change-over

At present, where the fuel type used both inside and outside ECA-SOx has been a residual grade product, having the change-over point adjacent to the service tanks has avoided the need to have a separate, dedicated, ECA-SOx service system (consisting of supply pumps, mixing tube, boost pumps, heaters, high temperature filters and a viscosity control system).

However, from 1 January 2015, the ECA-SOx limit of 0.10% will, in most cases, necessitate the use of distillate grade fuel oils in order to achieve compliance. Consequently, the distillate system with its own pumps and filters, which does not require heaters, should be segregated from the residual fuel oil service system, with the change-over positioned directly before the engine or boiler. Shipowners should now be considering whether this is a suitable modification for their ships since minimising mixing on change-over will both reduce operating costs and ensure that the system line clean-up concerns are avoided. However, the arrangements for the transition from heated residual fuel oil to the ECA-SOx distillate fuel would also need to be considered.

11 Recommendations to IMO

This review has highlighted a number of significant points which CIMAC WG7 Fuels recommends that the Parties to the Annex should bring to the attention to IMO. These need to be addressed in order to bring consistency and uniformity across the industry.

1. MARPOL Sample testing for compliance. The existing Appendix VI procedure should be replaced by the ISO 4259 approach
2. Guidelines covering in-use fuel sampling need to be developed to cover where and how representative 'in-use' samples should be drawn, together with their handling, distribution and analysis
3. The ISO 4259 approach should be adopted when comparing the sulphur result obtained from fuel samples drawn from 'in-use' with the relevant regulation 14 limits
4. Whilst not covered in detail in this report, consideration should be given to amending the fuel oil supplier's bunker declaration as outlined in Appendix V of this review

12 Concluding Comments

The MARPOL Annex VI fuel oil sulphur limits represent real reductions, and in the case of the 0.50% and 0.10% limits substantial reductions, in sulphur and particulate emissions from shipping, compared to what otherwise would have been the case.

It is important to recognise that adopting the ISO 4259 approach to assess compliance will not represent any lessening of the reduction in the emissions of SOx and associated particulate matter achieved by IMO. ISO 4259 is the established normal practice within the global marine fuel oil supply chain and other regulatory systems providing a proven means of dealing with the question of test variability.

Furthermore, putting in place robust and reliable assessment criteria will reduce uncertainty and promote a higher level of oversight and workable enforcement – to the advantage of Administrations, shipowners, fuel oil suppliers and the industry as a whole.

13 References

MARPOL Annex VI, IMO Resolution MEPC.176(58) - as amended

MEPC.182(59) 2009 Guidelines for the sampling of fuel oil for determination of compliance with the revised MARPOL Annex VI

ISO 4259: Petroleum products — Determination and application of precision data in relation to methods of test

ISO 8217: Petroleum products — Fuels (class F) — Specifications of marine fuels

ISO 8754: Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry

ISO 17025: General requirements for the competence of testing and calibration laboratories

14 CIMAC WG7 Fuels Working Group Membership

A.P. Moller Maersk
Alfa Laval
ANP
Bollfilter
BP Marine
Caterpillar Motoren
CEPSA
Chevron
Chevron Oronite
CMA-CGM
E.R. Schiffahrt
Exxon Mobil
GEA
Germanischer Lloyd
IMarEST
Infineum
Innospec Fuel Specialties
Intertek Lintec Shipcare Service
Lehmann & Michels
Lloyd's Register FOBAS
Maersk Maritime Technology
MAN Diesel and Turbo
Mitsubishi Machinery & Engine Group
Mitsui O.S.K. Lines
Nippon Yuka Kogyo
Petrobras
Shell Marine Products
Total, France
TransMontaigne
US Biodiesel Board
US Navy
VISWA Lab
VPS
Wartsila
World Fuel Services

Appendix I

Commercial Practice: Application of ISO 4259 to Fuel Oil Sulphur Limits

Tables 1 and 2 define how to interpret a single sulphur test result when the sulphur has been determined using ISO 8754:2003

Sulphur Appraisal Table 1			
Recipient – testing own "fuel oil as supplied" sample -Single test result 'A'			
V = Ordered limit	**W = V + 0.59R**	**A ≤ W**	**A > W**
3.50	3.67	The recipient cannot claim that the ordered limit has not been met and consequently has to accept that the fuel oil as supplied meets the ordered limit	Fuel oil as supplied fails to meet the ordered limit – supplier to test (see Table 2)
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

Sulphur Appraisal Table 2		
Supplier – testing supplier retained sample - Single test result 'B'		
V = Ordered limit	**B ≤ V**	**B > V**
3.50	Fuel oil as supplied meets the ordered limit.	The supplier cannot claim that the ordered limit has been met with any level of confidence and therefore the fuel oil as supplied fails to meet the ordered limit
1.50		
1.00		
0.50		
0.10		

Note: In accordance with the ISO 8754 reporting protocol a test value result in the range 0.10 % to 5.00 % is reported to 2 decimal places and in the range 0.030-0.099 % to 3 decimal places.

Appendix II

Application of the MARPOL Annex VI Appendix VI Procedure

The core elements of this procedure are as follows:

An authority, such as PSC, requiring the MARPOL Sample to be tested for sulphur content, manages the whole process and engages either their own laboratory or an outside laboratory to undertake the first round of testing.

That laboratory is to be accredited to ISO 17025, or equivalent, for the performance of the given sulphur content test, ISO 8754:2003.

That laboratory undertakes two tests on the sample, results A and B which are to be within the relevant repeatability (r) margin. The average of A and B is compared to the relevant regulation 14 limit value;

- if that average value is less than or equal to the relevant limit value, the fuel oil is compliant
- if that average value exceeds the relevant limit value by more than 0.59R, the fuel oil is non-compliant
- if that average value exceeds the relevant limit value but by no more than 0.59R, then a second stage of testing is to be undertaken at another laboratory

The second laboratory is also to be accredited to ISO 17025, or equivalent, for the performance of the given sulphur content test, ISO 8754:2003.

This second laboratory undertakes an additional two tests on the sample, results C and D, which are to be within the relevant repeatability (r) margin.

Results A, B, C & D are to be within the reproducibility (R) limit.

The average of A, B, C & D is compared to the relevant limit value;

- if that average value is less than or equal to the relevant limit value, the fuel oil is compliant
- if that average value exceeds the relevant limit value, the fuel oil is non-compliant

The outcome from this procedure is final.

MARPOL Annex VI - Appendix VI verification procedure illustrated

To illustrate the application of this process in numbers, the following 4 scenarios are based on the 1.00% ECA-SOx fuel oil sulphur limit. At this sulphur level, for a single test result:

r = 0.02
R = 0.09
0.59R = 0.06

Shipowner orders 1.00% maximum sulphur content fuel oil for use in an ECA-SOx.

Bunker Delivery Note states the sulphur content is 1.00% based on the supplier's own test. Both parties are therefore entitled to consider that a compliant fuel oil has been supplied / received.

PSC decide to examine the MARPOL Sample in accordance with the MARPOL verification procedure:

Scenario 1

Result A 0.98%
Result B 1.00%
Results within (r)
Average 0.99%
Conclusion: Average not in excess of 1.00% - fuel oil compliant

Scenario 2

Result A 1.06%
Result B 1.08%
Results within (r)
Average 1.07%
Conclusion: Average in excess of 'limit + 0.59R' – fuel oil not compliant, no further testing required

Scenario 3

Result A 1.02%
Result B 1.04%
Results A and B within (r)
Average 1.03%
Outcome of first round: Average in excess of 1.00 % but not in excess of 'limit + 0.59R' – second round of testing in another laboratory required

Result C 1.03%
Result D 1.04%
Results C & D within (r)
Results A, B, C & D within (R)
Average A, B, C & D 1.03%
Conclusion: Average in excess of 1.00 % – fuel oil not compliant

Scenario 4

Result A 1.02%
Result B 1.04%
Results within (r)
Average 1.03%
Outcome of first round: Average in excess of 1.00% but not in excess of 'limit + 0.59R' – second round of testing in another laboratory required

Result C 0.98%
Result D 1.00%
Results C & D within (r)
Results A, B, C & D within (R)
Average A, B, C & D 1.01%
Conclusion: Average in excess of 1.00 % – fuel oil not compliant

In all the above scenarios the results obtained under the PSC testing process, apart from Scenario 2 Result B, were within R of the Bunker Delivery Note value.

In Scenario 2, only the Result B is outside 'limit + 0.59R'.

In Scenarios 3 and 4, none of the results obtained were outside 'limit + 0.59R' yet the fuel oil would be deemed non-compliant, due to the normal differences between laboratories carrying out the test.

In Scenario 4, the Results C & D are the same as Results A & B in Scenario 1 yet the opposite outcome is obtained; in Scenario 1 the fuel oil was deemed compliant but in Scenario 4 it was deemed not compliant. The non-compliance is purely due to the normal differences between laboratories carrying out the test.

Overall, therefore, it can be seen that there is a fundamental issue in the Appendix VI procedure. The result outcome can be purely a function of test variability. A fuel oil tested by the supplier as being within specification (and this could be the same finding as obtained by the shipowner on testing their own sample) can, by Appendix VI procedure, be determined as not compliant.

In contrast, had the ISO 4259 approach been applied to the single result A values, all scenarios would have given the same outcome – the fuel oil was compliant.

Appendix III

CIMAC WG7 Fuels: Step-by-Step Guide to Fuel Oil Sulphur Test Results

The following represents the current situation as outlined in this review whereby fuel oils are ordered and supplied within the usual commercial framework and statutory compliance is assessed on the basis of Appendix VI of MARPOL Annex VI, i.e. fuels are ordered against ISO 8217 and the purchaser specifies the sulphur content in accordance with the statutory limits given by regulation 14 of Annex VI. Therefore in this case the purchaser, given the user's requirements, sets an ordered limit which equals the relevant statutory limit.

1) **User reviews bunker requisition form** (i.e. before loading bunkers):
    a. Stated sulphur content at or below ordered limit
        i. Fuel oil to be supplied will meet the user's requirements *(go to 2)*
    b. Stated sulphur content above ordered limit
        i. Fuel oil not loaded as unacceptable for intended use.

2) **User reviews bunker delivery note** (i.e. on completion of bunkering):
    a. Stated sulphur content at or below ordered limit
        i. Fuel oil as supplied meets the user's requirements* *(go to 3)*
    b. Stated sulphur content above ordered limit
        i. Fuel oil as loaded not acceptable for use as intended. Claim process against supplier initiated - supplier has no defence *(see Section 9.1, potentially go to 5)*

3) **User chooses to analyse their own sample and assesses test result** in accordance with commercial practice - see Sections 6.2, 9.1 and 9.2.

Recipient – testing own "fuel oil as supplied" sample - Single test result 'A'			
V = Ordered limit	**W = V + 0.59R**	**A ≤ W**	**A > W**
3.50	3.67	The recipient cannot claim that the ordered limit has not been met and consequently has to accept that the fuel oil as supplied meets the ordered limit	Fuel oil as supplied fails the ordered limit – supplier to test their sample
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

    a. Test result is below 'ordered limit – 0.59R'
        i. The fuel oil as supplied has met the user's requirements and is suitable for use in the area of intended operation
    b. Test result is between 'ordered limit - 0.59R' and ordered limit
        i. The fuel oil as supplied has met the user's requirements and is suitable for use in the area of intended operation*
    c. Test result does not exceed the ordered limit by more than 0.59R
        i. The fuel oil as supplied must be accepted as having met the ordered limit and on the basis of the single test result the fuel is suitable for use in the area of intended operation*

d. Test result is above 'ordered limit + 0.59R'
    i. The fuel oil as supplied has not met the ordered limit - notify supplier *(go to 4)*. Furthermore at this stage the fuel oil cannot be considered as suitable for use in the area of intended operation

** However by the application of the MARPOL verification procedure 5) the fuel could be found to be non-compliant (see Appendix II scenarios).*

4) **Supplier verifies from their retained sample** in accordance with commercial practice – see Section 6.2

Supplier – testing supplier retained sample - Single test result 'B'		
V = Ordered limit	**B ≤ V**	**B > V**
3.50	Fuel oil as supplied meets the ordered limit	The supplier cannot claim that the ordered limit has been met with any level of confidence and therefore the fuel oil as supplied fails to meet the ordered limit
1.50		
1.00		
0.50		
0.10		

a. Test result is above the ordered limit
    i. Commercial settlement required. Additionally the fuel oil is not suitable for use in the intended area of operation *(see Section 9.1, potential for the relevant authorities to go to 5)*
b. Test result is at or below the ordered limit
    i. Claim is not substantiated. Further investigation may be carried out. There are two outcomes:
        a) If both parties agree that the result is not above the ordered limit - no further commercial action and the fuel oil may now, on the basis of the further testing undertaken, be considered suitable for use in the area of intended operation*
        b) If parties do not agree – dispute resolution**

*** It is out of the scope of this review to define the process of dispute resolution*

5) **Statutory action** which may follow from routine PSC inspection or from a pre-alert 4). Alternatively, it could result from PSC investigation of fuel in-use which has been found as non-compliant and is not related to a ship operational issue. As a result the MARPOL Sample is analysed in accordance with the Appendix VI procedure.

Inspector – testing MARPOL Sample (MARPOL verification procedure) – Result 'C'				
X = Y - 0.59R	**Y = Reg. 14 limit**	**W = Y + 0.59R**	**C ≤ Y**	**C > Y**
3.33	3.50	3.67	Compliant	Not compliant
1.42	1.50	1.58		
0.94	1.00	1.06		
0.47	0.50	0.53		
0.090	0.10	0.11		

Note: Any recipient or supplier measured value between and including X and W could be determined as not compliant in accordance with the MARPOL verification procedure (Section 8.3)

a. Fuel oil is compliant
    i. No further action
b. Fuel oil is not compliant
    i. Ship required to take corrective action
    ii. Investigating party to inform relevant BSRS authority with a view to their taking action against supplier

Appendix IV

CIMAC WG7 Fuels: Recommendations for Inspector verification of the MARPOL Sample and fuel in-use samples

CIMAC WG7 Fuels: Recommended replacement for MARPOL Sample verification

Inspector – testing MARPOL Sample - Single test result 'D'			
Y= Reg 14 limit	**W = Y + 0.59R**	**D ≤ W**	**D > W**
3.50	3.67	Based on the inspection it cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil as supplied meets the regulation limit	Fuel oil as supplied fails to meet the regulation limit
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

CIMAC WG7 Fuels: Recommended approach to 'in-use' fuel oil samples (both Stage 1 and Stage 2 samples drawn during inspection)

Stage 1, Inspector – testing inspector drawn 'in-use' sample (Drawn from 'in service system' but not outflow of service tank) - Single test result 'E'			
Y = Reg 14 limit	**W = Y + 0.59R**	**E ≤ W**	**E > W**
3.50	3.67	Based on the inspection it cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil in-use meets the regulation limit	Go to Stage 2
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

Stage 2, Inspector – testing inspector drawn 'in-use' sample (Outflow of Service Tank)* - Single test result 'F'			
Y = Reg 14 Limit	**W = Y + 0.59R**	**F ≤ W**	**F > W**
3.50	3.67	Based on the inspection it cannot be claimed that the regulation limit has not been met and consequently it has to be accepted that the fuel oil in-use meets the regulation limit	Fuel oil in-use fails to meet the regulation limit
1.50	1.58		
1.00	1.06		
0.50	0.53		
0.10	0.11		

* This recommended approach applies where it is the fuel oil service system only which is common to the two sulphur grades of fuel oil (i.e. inside ECA-SOx and outside ECA-SOx grades) used on board. Hence the last point where the lower sulphur content fuel oil is still segregated is in the outflow pipe from the service tank containing that fuel.

Where that last segregated point is either earlier or later in the overall fuel oil system then the sampling point for the Stage 2 sample would need to be correspondingly positioned.

In the case where there is only a single sulphur grade of fuel oil on board then only Stage 1 applies.

Appendix V

Bunker Delivery Note – Supplier's Declaration

During the course of this review CIMAC WG7 Fuels has identified that there is an inherent problem in the supplier's declaration text required to be stated on the Bunker Delivery Note.

Appendix V of MARPOL Annex VI gives the information to be included on the bunker delivery note as required by regulation 18.5. Included in this is the text of declaration to be signed and certified by the supplier's representative that '… *the fuel oil supplied is in conformity with the applicable paragraph of regulation 14.1 or 14.4 and regulation 18.3 of this Annex*'.

In reviewing this declaration, it is evident that as it stands, the reference to regulation 14.1 or 14.4 is inappropriate for two reasons:

1. As provided for by regulation 4 of the Annex, alternative equivalent means to comply with the requirements of regulation 14.1 and / or 14.4 may be approved by the ship's Administration. Exhaust gas cleaning systems (EGCS) as covered by the relevant Guidelines (MEPC.184(59)) are one such means. In this case the sulphur content of the fuel oil supplied to the ship is not limited by regulation 14.1 or 14.4 but by the capabilities of the EGCS to reduce the SOx component in the post treatment exhaust gas stream to levels no higher than those given in the Guidelines, being equivalent to the values as given by those regulations. Therefore, in those instances, it must be recognised that it is fully acceptable that the sulphur content of the fuel oil as supplied is higher than that as given by regulation 14.1 or 14.4. At present the use of EGCS tends to be confined to ECA-SOx areas and therefore it may well be that the fuel oil as bunkered in such instances does not exceed 3.50%, the limit given by regulation 14.1.2 but that is only applicable to fuel oils used outside ECA-SOx. Furthermore, this point becomes particularly relevant after the start date of regulation 14.1.3 which reduces the maximum sulphur content to 0.50% outside ECA-SOx in which case EGCS would be expected to be used to achieve compliance both inside and outside ECA-SOx. Consequently the references to regulations 14.1 or 14.4 need to be removed from the declaration as given in respect of fuel oils to be used in combustion systems fitted with EGCS.

2. Regulations 14.1 and 14.2 specifically refer to the '… fuel oil used on board ships..' not to the fuel oil supplied to ships. Hence reference to regulations 14.1 and 14.4 in the declaration is not only inappropriate in the case of fuel oils to ships fitted with EGCS but in all instances, since the supplier has no control on how the fuel oils are used on board.

Consequently, the supplier is in no position to make the declaration as currently required since the supplier cannot know, or be expected to know if:

a. the fuel oil as used will be a mix of the fuel oil being supplied with other fuel oils on board which causes the sulphur content of the fuel oil as consumed to exceed the applicable limit for the area in which the ship is operating
b. fuel oil supplied for use outside an ECA-SOx is actually being used inside an ECA-SOx
c. the change-over from outside ECA-SOx to ECA-SOx fuel has been undertaken as required
d. fuel oil is being used which was compliant with a previous limit now superseded by the next level of control, i.e. post 1.1.2015 when the ECA-SOx requirement changes from regulation 14.4.2 to 14.4.3

e. a ship is fitted with EGCS and if so to what extent those units are actually in operation and functioning as required

To reflect the reality of the situations, CIMAC WG7 Fuels would recommend that the text of the bunker delivery note declaration should be amended to read:

'A declaration signed and certified by the fuel oil supplier's representative that the sulphur content of the fuel oil supplied is in accordance with the value stated on this Bunker Delivery Note and the fuel is in conformity with regulation 18.3 of MARPOL Annex VI'.

In addition, due to the application of regulation 4, regulations 18.9, 18.11 and the first paragraph of Appendix VI, of the Annex, would also all require corresponding amendment.

Imprint

CIMAC Central Secretariat
c/o VDMA e. V.
Lyoner Strasse 18
60528 Frankfurt, Germany
Phone +49 69 6603-1355
Fax +49 69 6603-2355
E-mail: info@cimac.com

President: Christoph Teetz
Secretary General: Peter Müller-Baum

Copyright

CIMAC is the International Council on Combustion Engines, a worldwide non-profit association consisting of National and Corporate Members in 25 countries in America, Asia and Europe. The organisation was founded in 1951 to promote technical and scientific knowledge in the field of large internal combustion engines (piston engines and gas turbines) for ship propulsion, power generation and rail traction. This is achieved by the organisation of Congresses, CIMAC Circles, and other (including local) CIMAC events, and by Working Group activities including the publication of CIMAC Recommendations and other documents. CIMAC is supported by engine manufacturers, engine users, technical universities, research institutes, component suppliers, fuel and lubricating oil suppliers, classification societies, and several other interested parties.
For further information about our organisation please visit our website at http://www.cimac.com.