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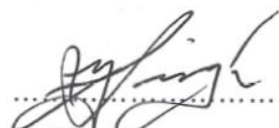
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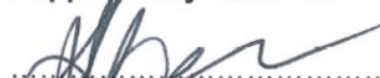
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## **EXECUTIVE SUMMARY**

This specification has been prepared for Eskom coal-fired power stations to define the requirements for primary light-up and combustion support fuel oils for pulverized coal firing. This specification covers the generic requirements of fuel oils derived from crude oil refining as well as synthetic fuels derived from the conversion of gas or coal. The specification has been updated to include limits on the blending of used lubricating oils into fuel oils supplied. Sulphur levels allowed have been adjusted based on available crude oils and refining technologies in South Africa. Suppliers must take note of the future requirement to reduce fuel oil sulphur levels in line with applicable environmental legislation and Eskom's emission licensing requirements.

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## 1. INTRODUCTION

This specification has been prepared for Eskom coal-fired power stations to define the requirements for primary light-up and combustion support fuel oils for pulverized coal firing. This specification covers the generic requirements of fuel oils derived from crude oil refining as well as synthetic fuels derived from the conversion of gas or coal. Fuels may either be distillates of gas, coal or crude refining methods, residual fuels or blends of different fuel types. This specification does not include fuels derived from waste product conversions, such as used lubricating oils, tyre pyrolysis or by-products of other chemical conversion processes. Since gas, coal and crude oil sources and refining techniques may differ significantly; this specification defines three generic fuel oil grades based on fuels historically used in Eskom. Alternative fuel types are beyond the scope of this specification.

## 2. SUPPORTING CLAUSES

### 2.1 SCOPE

This specification defines the generic fuel oil requirements for primary light-up and combustion support fuels used at Eskom coal fired power stations. The specification describes three grades and types of fuel oil and the laboratory testing requirements for these fuel oils.

#### 2.1.1 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

### 2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

#### 2.2.1 Normative

These documents are indispensable for the application of this document, i.e. documents to be used together with this document.

- [1] ASTM D86, Test Method for Distillation of Petroleum Products.
- [2] ASTM D93 (IP 34), Test Methods for Flash Point by Pensky-Martens Closed Cup Tester.
- [3] ASTM D95 (IP 74), Test Method for Water in Petroleum Products and Bituminous Materials by Distillation.
- [4] ASTM D97 (IP 5), Test Method for Pour Point of Petroleum Oils.
- [5] ASTM D129 (IP 61), Test Method for Sulphur in Petroleum Products (General Bomb Method).
- [6] ASTM D130, Standard Test Method for Detection of Copper Corrosion from Petroleum Products by Copper Strip Tarnish Test.
- [7] ASTM D189, Standard Test Method for Conradson Carbon Residue of Petroleum Products.
- [8] ASTM D240 (IP 12), Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter.
- [9] ASTM D445 (IP 71), Standard Test Method for Kinematic Viscosity of Transparent and Opaque liquids.
- [10] ASTM D473 (IP 53), Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method.
- [11] ASTM D482 (IP 4), Test Method for Ash from Petroleum Products.

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- [12] ASTM D524, Standard Test Method for Ramsbottom Carbon residue of Petroleum Products.
- [13] ASTM D664, Standard Test Method for Acid number of Petroleum Products by Potentiometric Titration.
- [14] ASTM D1266, Test Method for Sulphur in Petroleum Products (Lamp Method).
- [15] ASTM D1298 (IP 160), Standard Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
- [16] ASTM D2622, Test Method for Sulphur in Petroleum Products by X-Ray Spectrometry.
- [17] ASTM D4052, Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter.
- [18] ASTM D4057, Practice for Manual Sampling of Petroleum and Petroleum Products.
- [19] ASTM D4870, Petroleum products - Total sediment in residual fuel oils, Part 1: Determination by hot filtration.
- [20] ASTM D5185, Standard test method for determination of additive elements, wear metals and contaminants in used lubricating oils by inductively coupled plasma atomic emission spectrometry.
- [21] ASTM D5291 - 16 Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants.
- [22] ASTM D6560, Standard Test Method for Determination of Asphaltenes (Heptane Insolubles) in Crude Petroleum and Petroleum Products.
- [23] IP 285, Test Method for Vanadium.
- [24] IP 336, Test Method for determination of Sulphur.
- [25] IP 375, Test Method for Existent Dry Sludge. (equivalent to ASTM D4870 part 1 and ISO 10307-1).
- [26] IP 377, Test Method for Aluminium and Silicon.
- [27] IP 390, Test Method for Accelerated Dry Sludge. (equivalent to ISO 10307-2).
- [28] ISO test methods
- [29] ISO 2719; Petroleum products and lubricants – Determination of flash point – Pensky Martens closed cup method.
- [30] ISO 3016, Petroleum products and lubricants – Determination of pour point.
- [31] ISO 3104; Petroleum products – Transparent and opaque liquids – Determination of kinematic viscosity and calculation of dynamic viscosity.
- [32] ISO 3170, Petroleum liquids – manual sampling.
- [33] ISO 3171, Petroleum liquids – Automatic pipe sampling.
- [34] ISO 3405, Petroleum products – Determination of distillation characteristics.
- [35] ISO 3675, Crude petroleum and liquid petroleum products- Laboratory determination of density or relative density – Hydrometer method.
- [36] ISO 3733: Petroleum products including bitumen – determination of water – Distillation method.
- [37] ISO 3735, Crude petroleum and fuel oils – determination of sediment – Extraction method.
- [38] ISO 4262, Petroleum products – Determination of carbon residue – Ramsbottom method.
- [39] ISO 6245, Petroleum products – Determination of ash.

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- [40] ISO 8754, Petroleum products – Determination of sulphur content – Energy - dispersive X-ray fluorescence method.
- [41] ISO 10307-1, Petroleum products – Total sediment in residual fuel oils – Part 1: Determination by hot filtration.
- [42] ISO 10307-2, Petroleum products – Total sediment in residual fuel oils – Part 2: Determination using standard procedures for ageing.
- [43] ISO 10478, Petroleum products – Determination of aluminium and silicon in fuel oils – Inductively coupled plasma emission and atomic absorption spectroscopy methods.
- [44] ISO 14597: Petroleum products – determination of vanadium and nickel in liquid fuels – Wavelength-dispersive X-ray fluorescence method.
- [45] SABS ISO 9001:2008, Quality management systems requirements.

## 2.2.2 Informative

### 2.2.2.1 Related Specifications

The following specifications have been reviewed during the compilation of this standard.

- [46] ASTM D396, Standard Specification for Fuel Oils.
- [47] ISO 8217:2010, Petroleum products — Fuels (class F) — Specifications of marine fuels.
- [48] SABS/CKS 142: 1989, Specification for Heavy fuel oil.
- [49] SANS 1314, Industrial fuel oil for burner applications.
- [50] SANS 342, Automotive diesel fuel.

## 2.3 DEFINITIONS

Definition	Description
Distillate fuel	In crude oil refining, distillate fuels are products in the mid boiling range derived from the distillation of the crude oil in a distillation column.
Residual fuel	Fuel derived from the residue that collects at the bottom of a distillation column or pipe still. A fuel composed mainly of unevaporated materials after the atmospheric distillation of crude oil.

### 2.3.1 Disclosure Classification

**Controlled Disclosure:** Controlled Disclosure to external parties (either enforced by law, or discretionary).

## 2.4 ABBREVIATIONS

Abbreviation	Description
ASTM	American Society for Testing and Materials
cSt	Centistokes. Kinematic viscosity measured in mm <sup>2</sup> /s
IP	Institute of Petroleum in the United Kingdom.
COA	Certificate of Analysis.
ISO	International Standards Organisation
PEIC	Production Engineering Integration Coal.

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Abbreviation	Description
SABS	South African Bureau of Standards
SANS	South African National Standard
ULO	Used lubricating Oil

## 2.5 ROLES AND RESPONSIBILITIES

Personnel at Eskom coal fired power stations, and personnel involved in the supply of fuel oil to Eskom coal fired power stations, must ensure that the fuel oil is compliant with the provisions of this specification.

The Power Station Manager shall be responsible for the implementation of this specification at his power station.

Technology Group (CoE) shall be responsible for the periodic review of this document. PEIC will support CoE in this process.

The supplier shall be responsible for supplying all information required in this specification.

The supplier shall state the nature and the source of supply for fuel oils supplied

## 2.6 PROCESS FOR MONITORING

Supply and monitoring of fuel oils for use at Eskom power stations ensure regular analysis is conducted to verify compliance of fuel oil qualities to this specification.

## 2.7 RELATED/SUPPORTING DOCUMENTS

This document replaces GGSS 0957 and GSP 36-731.

## 3. REQUIREMENTS

### 3.1 GENERAL REQUIREMENTS

#### 3.1.1 Fuel Oil Grades

Three fuel oil grades are described as follows:

##### 3.1.1.1 Grade 1

This is typically a light to medium distillate fuel. These fuels may be derived from gas, coal or crude oil and are intended for use in boiler fuel oil systems burning fuels such as diesel, without heating facilities. These fuels are used at Arnot, Kriel and Duvha Power Stations. Additional specific limits may be placed on fuel sulphur contents for boilers using fabric filter flue gas cleaning technologies. The typical performance and physical properties of the fuel are described in table 1.

##### 3.1.1.2 Grade 2

This is a typically a blend of medium to heavy distillate fuel (typically crude oil derived diesel) and residual fuel (typically crude oil derived). These fuels may be derived from gas, coal or crude oil and are intended for use in boiler fuel oil systems without heating facilities. Additional specific limits may be placed on fuel sulphur contents for boilers using fabric filter flue gas cleaning technologies. The typical performance and physical properties of the fuel are described in table 1.

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### 3.1.1.3 Grade 3

This is a typically a blend of medium to heavy distillate fuel (typically crude oil derived diesel) and residual fuel (typically crude oil derived bitumen's).is a typical natural crude oil derived residual fuel. The typical performance and physical properties of the fuel are described in table 1.

### 3.1.1.4 Composition

The grades of fuel oil specified in this document shall be homogenous hydrocarbon oils, free from inorganic acids and excessive amounts of foreign solid or fibrous matter.

All grades, including blends of residual and distillate fuels residual fuels and distillate fuels shall remain uniform during storage and not separate or stratify by gravity into light and heavy oil components outside the viscosity limits for the grade. All grades shall resist sedimentation and sludging during storage.

To reduce contaminants suppliers are encouraged to filter fuel oils using suitable cleaning technologies prior to delivery to Eskom.

### 3.1.2 Compatibility with other fuels

Fuel oils supplied to meet Eskom grades 1, 2 or 3 shall be fully compatible with existing fuel oils supplied to meet these requirements. Fully compatible means that no sludging, sedimentation or stratification of fuel oil components shall occur within the fuel oil storage, supply and circulation systems, when the new fuel oil is mixed in any proportion with fuel oils in use.

#### 3.1.2.1 Compatibility testing

Fuel oils supplied to meet the same grade and replace or top-up existing fuel oils shall be tested for compatibility by the supplier in accordance with an Eskom approved method prior to supply to Eskom.

The supplier shall indicate whether de-sludging or loosening of deposits in the fuel oil system can be expected with a change to the new fuel oil. ASTM D4740-95 shall be used to verify fuel oil compatibility for residual fuels and blended fuels containing residual fuels.

### 3.1.3 Atomisation

Eskom boilers are typically fitted with pressurised burners designed to atomise fuel oil with a viscosity in the range of 10 cSt to 20 cSt at the burner.

For stations using Grade 1 fuel, the viscosity at the burners needs to be between 3 cSt and 10 cSt.

For Grade 2 and Grade 3, the burner viscosity range is between 10 cSt and 15 cSt.

### 3.1.4 Sampling

The sampling of petroleum fuels for analysis, for purposes of this specification, shall be carried out in accordance with the procedures given in ISO 3170, ISO 3171, ASTM D4057 or an equivalent suitable sampling standard.

### 3.1.5 Used lubricating oils

Residual fuel may be blended with a maximum of 5% of used lubricating oil (ULO), provided that the ULO has been processed and/or cleaned prior to blending to remove any harmful contaminants. The maximum concentration of all contaminants from ULO shall not exceed 30 ppm.

### 3.1.6 Transportation

The supplier shall ensure that the fuel oil is transported in a manner that complies with local safety and environmental regulations and maintains the quality of the fuel oil. The supplier shall ensure that tankers

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are kept clean to prevent contamination of the fuel oil. The transportation of two dissimilar fuel oils on consecutive loads shall require cleaning between loads.

All Grade 3 fuel must be delivered at a minimum off-loading temperature of 45°C or higher if requested by the specific power station. Specifically for Majuba Power Station a minimum off-loading temperature of 50°C is required.

### **3.1.7 Technical and safety data**

The supplier must supply detailed technical data sheets showing all results for properties listed in Table 1. The supplier must test the fuel for all properties listed in table 1 every 3 months at an independent accredited fuel oil testing laboratory and submit the results to Eskom.

The supplier must submit a detailed certificate of analysis for each fuel delivery to Eskom. The certificate must include the batch number and the related batch certificate from the refinery including the following tests:

- Viscosity at 40°C (Grade 1 fuel)
- Viscosity at 50°C (Grades 2 & 3 fuel)
- Density of fuel.
- Calorific Value.
- Sulphur content.

The supplier will keep all batch data and COA data for all fuel delivered in an electronic database and provide such data to Eskom on a monthly basis as a minimum. Such data will be uploaded into Eskom's database and is required for Quality Management and Environmental Management. The data must be captured in .csv format for easy uploading into Eskom's databases.

### **3.1.8 Asphaltene content of fuels.**

The supplier must measure and report the asphaltene content of all grade 2 and grade 3 fuels to Eskom on a batch by batch basis. This data must indicate to which power station the fuel has been delivered.

### **3.1.9 Alternative fuels**

Fuel oils that are derived from sources other than those described above may be submitted for consideration to the Eskom Group Technology Department. New fuels will be subjected to full compliance testing, including compatibility testing with existing fuel oils.

### **3.1.10 Fuel oil preparation and processing**

Suppliers are requested to dose the fuel oil with a suitable fuel additive or stabiliser to reduce settlement of sludges in fuel oil tanks. The details of fuel treatment must be supplied to Eskom.

## 3.2 FUEL TESTING REQUIREMENTS

### 3.2.1 Table 1: Fuel Oil Specifications

Property	Test Method	Test Method	Test Method	Grade 1	Grade 2	Grade 3
Description	ASTM	IP	ISO	Light to heavy distillate	Blended fuel or medium to heavy distillate	Residual
Ash, % mass, max	ASTM D 482		ISO 6245	0.1	0.1	0.1
Asphaltene content, max	ASTM D 6560	IP 143		0	3	6
Calorific Value (Gross) MJ/kg, min.	ASTM D240	IP 12		41	41	41
Carbon Hydrogen Nitrogen (CHN) ratio.	ASTM D5291				report	report
Conradson carbon residue, % mass, max <sup>1</sup>	ASTM D 189		ISO 10370			report
Calcium and Phosphorus (mg/kg), max. <sup>3</sup>	ASTM D5185	IP 377	ISO 10478	30	30	30
Calcium and Zinc, mg/kg, max. <sup>3</sup>	ASTM D5185	IP 377	ISO 10478	30	30	30
Sediment, % (v/v), max.	ASTM D473	IP 375		0.1	0.1	0.2
Silicon, mg/kg, max.	ASTM D5185	IP 377	ISO 10478		report	report
Water, % (v/v), max.	ASTM D95	IP 74	ISO 3733	0.5	0.5	0.5
Aluminium and silicon, mg/kg, max.	ASTM D5185	IP 377	ISO 10478		25	80
Aluminium, mg/kg, max.	ASTM D5185	IP 377	ISO 10478		6	30
Copper strip corrosion rating, max, 3 h at 100°C	ASTM D 130			1b	report	report
Density at 20°C, kg/m <sup>3</sup> , max	ASTM D 1298 / D 4052		ISO 3675	920	980	report
Flash Point (PMCC), °C, min.	ASTM D 93	IP 34	ISO 2719	55	55	60
Pour point (winter) °C, max	ASTM D 97	IP 5	ISO 3016	-6	0	9
Ramsbottom carbon residue on 10% distillation residue % mass, max.	ASTM D 524 / D4530		ISO 4262	report	report	
Sulphur, % mass, max <sup>4</sup>	ASTM D 129 / D2622	IP 61/IP 336	ISO 8754	3.0	3.0	3.5
Vanadium, mg/kg, max <sup>2</sup> .	ASTM D5185	IP 285	ISO 14597		report	report
Viscosity at 100°C, max.	ASTM D 445	IP 71	ISO 3104			20
Viscosity at 25°C.	ASTM D 445	IP 71	ISO 3104		report	report
Viscosity at 40°C, max.	ASTM D 445	IP 71	ISO 3104	12	report	report
Viscosity at 40°C, min.	ASTM D 445	IP 71	ISO 3104	3		
Viscosity at 50°C, max.	ASTM D 445	IP 71	ISO 3104		10	150
Viscosity at 50°C, min.	ASTM D 445	IP 71	ISO 3104		3	90

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**Notes:**

1. A carbon residue value of less than 20 is mandatory.
2. A vanadium level of less than 400mg/kg is mandatory for Grade 3 fuels. For grade 2 this must be below 100 mg/kg. There should be no Vanadium in distillate fuels of Grade 1.
3. Used lubricating oils (ULO): Calcium and Zinc; or Calcium and Phosphorus (mg/kg). The fuel be considered to exceed the maximum ULO content when either one of the following conditions is met: Calcium > 30 and zinc > 15; or Calcium > 30 and phosphorus > 15.
4. Power Stations must calculate total sulphur emissions as per environmental requirements. The amount of sulphur in fuel oil is usually well below the allowable limits but stations are advised to monitor these levels on an ongoing basis.
5. For Grade 3 fuels, the fuel oil density must be less than 1.1 kg/m<sup>3</sup>.
6. In order to comply with environmental emissions requirements, sulphur levels must be reduced in all fuel oil grades from year 2020 to below 3.0%. The new proposed limit will be 2.5 % maximum for all fuel oils.
7. Asphaltene content of residual fuels and fuels containing residual components shall not exceed 6%. The supplier shall consider using dispersant and stabiliser additives to prevent settling of heavy fuel oil components during transportation and storage.
8. All fuel oils should be filtered using a suitable filtration technology prior to loading.
9. For Majuba Power Station the minimum viscosity of Grade 3 fuel shall be 120 cSt at 50°C.

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#### 4. AUTHORISATION

This document has been seen and accepted by:

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#### 5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2014	0.1	L.F. Barker	Revision of previous Eskom fuel oil specifications and conversion of document to new format. Sulphur levels increased in line with new crude oil requirements.
November 2014	0.2	L.F. Barker	Draft Document for Comments Review
March 2015	1	L.F. Barker	Final Document for Authorisation and Publication
November 2017	1.3	L.F.Barker	Draft Document for Comments Review
May 2018	2	L.F.Barker	Final Rev 2 Document for Authorisation and Publication
May 2018	2.1	L.F.Barker	Small Updates to clarify Sulphur, Flashpoint and offloading Temp for Majuba
May 2018	3	L.F.Barker	Final Rev 3 Document for Authorisation and Publication

#### 6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- LF Barker - Chief Engineering Advisor.
- J Sproule - Senior Engineer.

#### 7. ACKNOWLEDGEMENTS

- None.

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## APPENDIX A: SIGNIFICANCE OF TEST METHODS

The significance of properties of fuel oils on which limitations are placed by this standard is as follows:

- a) **Flash Point:** The flash point of the fuel gives an indication of the maximum storage and handling temperature of the fuel without causing a serious fire hazard.
- b) **Pour Point:** The pour point gives an indication of the lowest temperature at which a fuel oil can be stored and still be capable of flowing under minimum pressures. Higher pour point fuels are permitted for fuel oil systems equipped with tank and /or line heating facilities. An increase in pour point can occur when residual fuel oils are subject to cyclic temperature variations that may occur in the course of storage or when the fuel is pre-heated and returned to the tank.
- c) **Water and sediment:** Appreciable amounts of water and sediment in a fuel oil may cause fouling and give trouble in burner mechanisms. Sediment may accumulate in storage tanks, on filter screens or burner parts, resulting in obstruction of oil flows within the fuel oil system. Water can also promote bacterial growth in storage tanks. Water in distillate fuels may cause tank and equipment corrosion or the formation of emulsions in residual fuels. Sediment for the purposes of this specification is defined as material insoluble in toluene.
- d) **Carbon Residue:** This is a measure of the carbonaceous material left after all the volatile components are vaporised in the absence of air. It gives a rough approximation of the tendency of a fuel to form deposits. To obtain measurable values in lighter distillate fuel oils it is necessary in the Ramsbottom test method to distil the oil to remove 90% of the fuel and then determine the carbon residue in the remaining 10% bottoms.
- e) **Ash:** The amount of ash measured represents the quantity of non-combustible material in the fuel oil. High ash contents may indicate the presence of materials that can cause wear to pumps and valves, and contribute to deposits on mainly heater surfaces.
- f) **Viscosity:** The viscosity is a measure of the fuel's resistance to flow. It indicates both the ease at which the oil can be pumped and the ability of the oil to atomise. For heavier grades, such as with residual fuels, heating facilities may be required for pumping and to achieve the correct viscosity for burner atomisation. For screw pumps, low viscosity, below the minimum required for safe pump operation, may increase pump wear rates.
- g) **Density:** Density alone is of little significance as an indication of the burning characteristics of the fuel oil. It is however of value when calculating the specific energy of a fuel oil in mass-volume relationships.
- h) **Corrosion:** The copper strip corrosion test indicates the effect of the fuel on copper, brass and bronze components in the fuel oil system and is only specified for distillate fuels.
- i) **Sulphur:** Limits may be placed on sulphur content for environmental considerations and in cases such as boilers using bag filter dust extraction technologies to extend bag life. Sulphur components in the fuel are converted to Sulphur oxides during combustion. These can be corrosive in exhaust gases if the temperature drops below the sulphuric acid dew point.
- j) **Vanadium and Nickel:** Vanadium occurs as an oil-soluble organometallic compound in crude oils, varying in concentration from less than 1 mg/kg to over 400 mg/kg depending on the origin of the crude oil or fuel source. During refining, the vanadium tends to concentrate in the residual oil with distillates effectively being vanadium free. Vanadium cannot be economically removed from crude oils or residual fuels to produce vanadium free oils.

During combustion, vanadium is converted to vanadium pentoxide, melting at 675°C. If sodium is present in the fuel with vanadium, sodium vanadates with melting points as low as 535°C can form.

The melting point of ash can be raised by adding magnesium compounds to the fuel. This is however counteracted by high sodium contents, therefore, to improve the response of magnesium; lower sodium

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contents are required. Silicon compounds reduce the corrosive action of sodium vanadates by means of a physical dilution effect.

- k) **Aluminium and Silicon (catalyst fines):** The main source of potentially abrasive particulates in residual fuels is catalyst fines. There are significant variations from refinery to refinery in the proportions of the aluminium and silicon compounds that comprise catalyst fines. The combined limiting value for residual fuels or blends of 80 mg/kg for aluminium plus silicon typically equates on average to an aluminium value of 30 mg/kg. Refineries producing high white product yields and making extensive use of aluminium catalysts may produce residual fuels with values exceeding these limits.
- l) **Asphaltene content of fuel oil:** Asphaltene content varies in fuel oil batches based on the degree of refining and the degree of distillate added to the final blend. Asphaltene content in fuel oil below 5% by mass is preferred to prevent sludge formation and blockages in the fuel oil system. Suppliers are encouraged to make use of fuel oil homogenisers as well as dispersant and stabiliser additives to keep fuel oil blends homogeneous and to prevent sludge settling in road tanker and fuel oil tanks.

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