الهيئة السعودية للمواصفات والمقاييس والجودة

Saudi Standards, Metrology and Quality Org (SASO)

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Specification of Fuel Additives Containing Oil Soluble Magnesium Sulphonate for Boilers and Gas Turbines of Power Plant

ICS: 75.160

Foreword

Saudi Standards, Metrology and Quality Organization (SASO) has updated the Saudi Standard No. (……../2020) “Specification of Fuel Additives Containing Oil Soluble Magnesium Sulphonate For Boilers and Gas Turbines of Power Plant" based on relevant ADMO, International and National foreign Standards and references.

Fuel Additives Containing Oil Soluble Magnesium Sulfonate

For Boilers and Gas Turbines of Power Plant

1. Scope and Field of Application:

1.1 This SASO Standard is concerned with the Fuel Additives (Oil Soluble Magnesium Sulphonate) to be injected to the Crude Oil and Heavy Fuel Oil for Gas Turbines and Generating Steam Boilers of Power Plant.

1.2 A main Component of Fuel Additives is Magnesium (Mg). Fuel Additives is being dozed to Heavy Fuel Oil/Crude Oil (used in Boilers& Gas Turbines), which contains high percentage of Sulfur, Vanadium & other Impurities to Control Corrosion.

2. Complementary References

2.1 ASTM D4860 “Standard Test Method for Free Water and Particulate Contamination in Middle Distillate Fuels (Clear and Bright Numerical Rating)”.

2.2 ASTM D4052 “Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter”.

2.3 SASO ASTM D445 “Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)”.

2.4 ASTM D97 “Standard Test Method for Pour Point of Petroleum Products”.

2.5 SASO ASTM D93 “Standard test methods for Flash Point of Petroleum Products by Pensky-Martens Closed Cup Tester”.

2.6 ASTM D7061 “Standard Test Method for Measuring n-Heptane Induced Phase Separation of Asphaltene-Containing Heavy Fuel Oils as Separability Number by an Optical Scanning Device”.

2.7 SASO ASTM D5185 “Standard Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)”.

2.8 ASTM D511 “Standard Test Methods for Calcium and Magnesium in Water”.

2.9 SASO ASTM D6595 “Standard Test Method for Determination of Wear Metals and Contaminants in Used Lubricating Oils or Used Hydraulic Fluids by Rotating Disc Electrode Atomic Emission Spectrometry”
Note: to determine Na, K, Ca, V, Pb, Ni, Zn, Al, Si Trace Metal Content.

2.10 SASO ISO 4406 “Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles”.

2.11 SASO ASTM D95 “Standard Test Method For Water in Petroleum Products and Bituminous Materials By Distillation”.

3.0 Classification:

3.1 Fuel Additives of Boilers and Gas Turbines with different Concentration shall be classified as Follows.

3.1.1 Gas Turbines and Boilers Fuel Additives Magnesium Sulfonate with Concentration of 11% Mg.

3.1.2 Boilers and Gas Turbines Fuel Additives Magnesium Sulfonate with Concentration of 20% Mg.

3.1.3 Boilers and Gas Turbines Fuel Additives Magnesium Sulfonate with Concentration of 28-30 % Mg.

4 Purpose of Injection of Fuel Additives to Heavy Fuel Oil or Crude Oil used in Boilers and Gas Turbines of Power Plant

4.1 To Protect Hot Section Components of the Gas Turbines and Boilers from Corrosion and Fouling Effect of the Fuel Impurities i-e Na, K, V, Pb, S, Ni, Zn etc. exists in Crude oil / Heavy Fuel Oil and ultimately Increase the Melting Points of Vanadium and Other Oxides and Protect Turbine Blades from Vanadic and Sulfurdization Corrosion.

4.2 Control of Hot and Cold End Corrosion due to Vanadium and Sulfur Attack (Gas Turbines and Boilers).

4.3 Control of SO3 Condensation in the Boilers.

4.4 Decrease of Acid Dew Point of Sulfuric Acid in the Boilers.

4.5 Maintain of PH of Fly Ash Produced during Combustion in the range of 3.5-4.0 and Acidity <1.0 at APH (Air Preheater) and ESP (Electro Static Precipitator) Outlet to avoid Sulphuric Acid Condensation at the Cold End Parts of the Boiler.

4.6 Reduces Fly Ash Acidity of Fuel used in Boiler.

4.7 Decrease of Adhesion of Ash at Heating Elements and keep Ash Friable in Boiler Internals.

4.8 Maintain APH (Air Pre-Heater) cleans during the Combustion of Heavy Fuel Oil and Crude Oil.

4.9 Reduce Cold End Corrosion of APH (Air-Preheater) Baskets, IDF (Induced Draft Fan) Corrosion, Flue Gas Ducting, ESP (Electrostatic Precipitator) and Chimney of the Boiler.

4.10 Control Gas Emission and Air Pollution (Gas Turbines and Boilers).

4.11 To Protect the Heat Transfer Surfaces of the Boilers, i-e, Generation Tubes, Super Heaters, Reheaters, Economizers, from Corrosive and Fouling Effect of the Impurities (Na, K, V, S etc.) Present in Heavy Fuel Oil & Untreated Crude by Maintaining of PH of Fly Ash Produced during Combustion in the range of 3.5-4.0 & Acidity < 1.0 % at Air Heater Outlet and Electrostatic Precipitator Outlet to avoid Sulfuric Acid Condensation at Cold End Parts without Impact on the other Operational Parameters of the Boiler.

4.12 Oil Soluble Magnesium Sulphonate Additives have good Performance for Protection the Internal Parts of the Boiler from Corrosion and in turn, will Increase the Lifetime of the Boiler. With the use of Proper Additive, Boiler remain Clean, Less Maintenance Cost.

5 Technical Discussion and Theory

5.1 **Corrosive Combustion By-Products and Low Melting Point Compounds** - When using Crude and Heavy Oils and Coal for the Firing of Boilers, Furnaces and Gas Turbines. Corrosive By-Products are formed by Decomposition of Lubrication Oils and by Combustion of Fuel in Internal Combustion Engines (e.g., Automotive).

5.2 Boilers are an Integral Part of Industrial Activity and are widely used as a means to Indirectly Heat or Vaporize Liquid Streams. The most Widespread Application is Power Generation where Boilers are used to Generate Steam that is used to drive Steam Turbines and Produce Electricity.

5.3 Gas Turbines are driven by Air instead of Steam and are used to Drive Electric Generators. The air is mixed with Fuel and Ignited Internally to Produce a High Temperature and Pressure Gas.

5.4 Fuel Oils also Contain Vanadium (V) and Sodium (Na). Upon Combustion these Impurities react to form Sodium Vanadates ($Na_2O \cdot xV_2O_5$), A Component of the Fuel Ash or Soot. These Vanadates are Low Melting Point Phases and at High Temperature Deposit and Stick onto the Equipment Internal Surfaces (Slag Formation). Being Potent Corrosives, they Cause Significant Damage to the Metal Surfaces. This type of Corrosion is usually called High-Temperature or Hot Corrosion (item 3.9.2).

5.5 Heavy Fuel Oil Temperature must be maintained 118-130 ºC to avoid Mg Sludge Formation at Burner Tips and Increase of Fuel Header Pressure of the Boiler.

5.6 As Crude Oil contains Na, K, Pb, V, S and other Trace Metals and can cause Vanadic and Sulfurdization Corrosion during Combustion in Combustion Chamber and Turbine Blades of Gas Turbines. To Control Slag Formation of Vanadium Oxides and Increase Melting Point (MP) of Pyro-Vanadate, Magnesium Sulfonates Additives are being injected in Crude oil / Heavy Fuel Oil with 1:3 (V: Mg - weight ratio)One Part of Vanadium against Three Parts of Magnesium to Control Vanadium and Sulfur attack at Internal Parts of Gas Turbine and Boilers.

5.7 Finally, in the Internal Combustion Engines the Gradual Decomposition of the Formation of Organic and Inorganic Acids that Corrode Critical Engine Parts and Surfaces.

5.8 Control of High Temperature Corrosion and Cold-End Corrosion by Fuel Additives (Magnesium Sulphonate)

5.9 There are Numerous Types but the Ones of Interest here are Magnesium Based Additives. The Basic Mechanism involves MgO Action and can be described as Follows:

5.9.3 For Cold-End Corrosion: Heavy Fuel Oil Contains Significant Amounts of Sulfur (S). Combustion of the Fuels Leads mainly to the Formation of SO_2 as well as Small Amounts of SO_3 in the Combustion Flame.SO_3 Quantity can be further Increased by the Catalytic Oxidation of SO_2. When the Combustion Gas Temperature is Lowered below its Dew Point (for example in Boilers this may happen inside the Air Heater), SO_3 will Convert to Sulfuric Acid (H_2SO_4) which damages Metal Surfaces. This Type of

Corrosion is usually called Cold or Low-Temperature or Cold-End Corrosion,

$$MgO + SO3 \rightarrow MgSO4$$

$$MgO + H2SO4 \rightarrow MgSO4 + H2O$$

These are basically acid Neutralization Reactions.

5.9.4 For Hot Corrosion: The Mechanism to Solve Vanadium Corrosion, the Melting Point of the Vanadium must be raised above the Gas Turbine Temperature. This can be done by Adding Mg Additives and in turn Vanadium Orthovanadate (Solid state) is formed instead of Vanadium Pentoxide.

$$MgO + V2O5 \rightarrow 3MgO{\cdot}V2O5(Mg_3V_2O_8)$$

5.10 Magnesium Orthovanadate Melts above 1200 ºC and This Temperature is above Typical Gas Turbine Temperature when the System of Gas Turbine is Lower Than the Melting Point of Mg Orthovanadate which is not Molted, it is a Solid. Vanadium Pentoxide is only Corrosive while it is Molten. Thus, by Adding 3 Parts of Mg to one Part of V, the System will be Protected from Corrosion.

6.0 Protocol for Selection of Fuel Additives (Magnesium Sulfonate) specification as per International General Electric (GEK 28150 F) OEM (Original Equipment Manufacturer).

The Specifications of Fuel Additive shall Meet the Following Items:

6.1.1 Adequate Mg Concentration 8-35 %.

6.1.2 Freedom from Contaminants Which Could Cause Hot Corrosion in the Gas Turbine or Corrosion or Fouling in the System.

6.1.3 Shelf life Max. One Year.

6.1.4 Kinematic Viscosity Max 130-150 cSt at 100 ºF to be Free to Flow and Suitable to Injection Pump.

6.1.5 Pour Point Max 0 ºF (<-18 ºC).

Note: A Max. Viscosity of 130-150 cSt @100 ºF and a Max. Pour Point 0 ºF will avoid Heating of the Additive for Pumping in most Locations. For higher Viscosity Additives ,Heating Equipment may be required to maintain Additive Viscosities in the above range (130-150 cSt @100 ºF).

6.1. 6 Flash Point Min. 150 ºF (51ºC).

6.1.7 Full Miscible with Fuel Oil /Crude Oil (which can be checked byadding1200ppm conc. additive and check there is no sludge)

6.1.8 Particle Size < 2 micron

6.1.9 Hydrolytic Stability: No Sludge Formation, Plugging of Fuel Filters, Wearing of Fuel Pumps, Flow Dividers, Check Valves and Fuel Nozzles during Operation.

6.1.10 Confirm the Reliability of the Material, Field Trial Test shall be Performed and Prove the Efficiency of Fuel additives for Both Boilers and Gas Turbines.

7.0 Properties

7.1 The Physical and Chemical Properties of the Different types and Classes of Fuel Additives shall conform to the Requirements Specified in (Table 1,2,3).

Table-1
Specification of Fuel Oil Additive for Gas Turbines/Steam Boilers
Operating on Crude Oil / Heavy Fuel Oil
Conc. 11% Mg

No.	Test Parameters	Measuring unit	Guaranteed values	ASTM Test Method
1	Magnesium base compound	n.a	Magnesium Sulfonate	n.a
2	Color	n.a	Grey or Brown liquid or TBR	n.a
3	Miscibility	n.a	Miscible	Pass
4	Magnesium (Mg)	%	11 Min.	D6595/4951/5185 AES-ICP or EDTA Titration
5	Density @ 15.5 °C	g/cm3	1.3 Max. or to be agreed between the seller and buyer	D4052
6	Kinematic Viscosity @ 40 °c	cSt	50 Max. or to be agreed between the seller and buyer	D445
7	Pour Point	°C	<-18	D97
8	Flash Point	°C	70 Min	D93
9	Water contents	% Vol.	2 Max	by centrifuge / D95
10	Hydrolytic Stability	Unit. No.	Pass	D7061/GEK 28150 F
11	FTIR Curve	cm-1	Test should show that the material is Sulfonate Base	E-1252
12	Sodium + Potassium (Na+K)	ppm	90 Max.	D6595/4951/5185 AES-ICP
13	Calcium (Ca)	ppm	1100 Max.	D6595/4951/5185 AES-ICP
14	Vanadium+ Lead (V+Pb)	ppm	50 Max.	D6595/4951/5185 AES-ICP
15	Particle size D-99.9	µ	2 Max.	INHOUSE

Table-2

Specification of Fuel Oil Additive for Steam Boilers/Gas Turbines Operating on Heavy Fuel Oil/Crude Oil

Conc. 20% Mg

No.	Test Parameters	Measuring unit	Guaranteed values	ASTM Test Method
1	Magnesium base compound	n.a	Magnesium Sulfonate	n.a
2	Color	n.a	Grey /Brown Liquid or TBR	n.a
3	Miscibility	n.a	Miscible	Pass
4	Magnesium (Mg)	%	20.0 Min.	D6595/4951/5185 AES-ICP or EDTA Titration
5	Density @ 15.5°C	g/cm3	1.5 Max. or to be agreed between the seller and buyer	D4052
6	Kinematic Viscosity @ 40 °C	cSt	30-100 or (suitable for injection pump)	D445
7	Pour Point	°C	<-18	D97
8	Flash Point	°C	70 Min.	D93
9	Water contents	% Vol.	2 Max	by centrifuge / D95
10	Hydrolytic Stability	Unit. No.	Pass	D7061 or GEK 28150 F
11	FTIR Curve	cm-1	Test should show that the material is Sulfonate Base	E1252
12	Sodium + Potassium (Na+K)	ppm	1500 Max.	D6595/4951/5185 AES-ICP
13	Calcium (Ca)	ppm	7500 Max.	D6595/4951/5185 AES-ICP
14	Vanadium+ Lead (V+Pb)	ppm	50 Max.	D6595/4951/5185 AES-ICP
15	Nickle (Ni)	ppm	1000 Max.	D6595/4951/5185 AES-ICP
16	Aluminum (Al)	ppm	10000 Max.	D6595/4951/5185 AES-ICP
17	Silicon (Si)	%	1 Max.	D6595/4951/5185 AES-ICP
18	Particle size D-99.9	µ	<2	INHOUSE

Table-٣

Specification of Fuel Oil Additive for Steam Boilers/Gas Turbines Operating on Heavy Fuel Oil/Crude Oil Conc. (28- 30%) Mg

No.	Test Parameters	Measuring unit	Guaranteed values	ASTM Test Method
1	Magnesium base compound	n.a	Magnesium Sulfonate	n.a
2	Color (Visual)	n.a	Grey/Brown Liquid or TBR	n.a
3	Miscibility	n.a	Miscible	Pass
4	Magnesium (Mg)	%	28-30	D6595/4951/5185 AES-ICP or EDTA Titration
5	Density @ 15.5 °C	g/cm3	1.7 Max or to be agreed between the seller and buyer	D4052
6	Dynamic Viscosity @ 40 °C	CP	1300 max. (suitable for injection pump)	D445
7	Pour Point	°C	<-18	D97
8	Flash Point	°C	70 Min.	D93
9	Water contents	% Vol.	2 Max.	by centrifuge / D95
10	Hydrolytic Stability	Unit. No.	Pass	D7061-06 or GEK 28150 F
11	FTIR Curve	cm-1	Test should show that the material is Sulfonate Base	E-1252
12	Sodium + Potassium (Na+K)	ppm	<2000 Max.	D595/4951/5185 AES-ICP
13	Calcium (Ca)	ppm	10,000 Max.	D6595/4951/5185 AES-ICP
14	Vanadium+ Lead (V+Pb)	ppm	50 Max	D6595/4951/5185 AES-ICP
15	Nickle (Ni)	ppm	1000 Max.	D6595/4951/5185 AES-ICP
16	Aluminum (Al)	ppm	10,000 Max.	D6595/4951/5185 AES-ICP
17	Silicon (Si)	%	1 Max.	D6595/4951/5185 AES-ICP
18	Particle size D-99.9	µ	<2	INHOUSE

8.0 Sampling

8.1 Samples shall be drawn according to ASTM D 4057 Procedure.

9.0 Test Methods

9.1 The Properties enumerated in this Specification shall be Determined in accordance with the following SASO or ASTM Test Methods:

9.1.1 **Particulate Matter Test**- ASTM D4860.

9.1.2 **Density Test** - ASTM D4052: The Customer must take Density Into the consideration in Evaluating the Cost of the Product. Lower Density indicates that the Customer receives Less Weight Of Mg in a Volume of Product.

9.1.3 **Kinematic Viscosity Test** - ASTM D445- Viscosity is very critical to handling the product. Low Viscosity can result in Low Lubricity and Abrasion of Additive Injection Pump. High Viscosity can lead to Cavitation on the Suction Side at Low Ambient Temperature with Failure to Treat the Fuel

9.1.4 **Pour Point Test**- ASTM D97.

9.1.5 **Flash Point Test** - ASTM D93.

9.1.6 **Hydrolytic Stability Test** - ASTM D7061.

9.1.7 **FTIR Curve Test** - ASTM E1252.

9.1.8 **Magnesium Content Test**- ASTM D6595, D4951, D5185 AES-ICP or EDTA Titration ASTM D511.

9.1.9 **Trace Metals Test** -For Na, K, Ca, V, Pb, Ni, Zn, Al, Si – ASTM 6595 - D4951 D5185 AES-ICP: The Presence of such Impurities Lead to High Temperature corrosion known as Sulfidation Attack.

9.1.10 **Particle Size Test**: Small Size of such Fuel Additives lead to higher activity during the Combustion, which means that Magnesium is consumed more efficiently in the Vanadium Inhibition process.

10. Packaging

10.1 Fuel Additives be Packed in Tightly Closed Containers, Suitable, Clean, Dry, and Free from Dust and Preventing any Leakage of the Product. The Container shall Neither Affect nor be Affected by the Product. Such as IBC (Intermediate Bulk Container) Capacity 1000 . Liter or Standard Steel Drum (Cap.208 lit) or ISO Tank as per the Requirement of the Customer.

11.0 Labeling:

11.1 Each Container shall be legibly and indelibly marked with the following information in English:

11.1.1 Name and Class of the Fuel Additive.

11.1.2 Name of the Manufacturer and/or his Trademark.

11.1.3 Country of Origin.

11.1.4 Volume of Contents in Liters.

11.1.5 Batch Number and Date of Production & Expiry.

11.1.6 The Following Precautionary Phrases with the Characteristic Symbol:

- Inflammable.
- Any Toxicity of the Fuel Additives Should be stated on the label so as to warn the user that proper handling is required.
- Keep Away From Heat And Flame.
- Damaged Packages must remove to a Safe Places.

:REFERENCES	**المراجع:**
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.Specification of Saudi Electrical Company for Oil–Soluble Magnesium (Mg Sulfonate) Additives. Concentrations (Mg ٪١١,٢٠,٢٨-٣٠)	. مواصفة الشركة السعودية للكهرباء لإضافات الماغنيسيوم المذاب في الزيت (سلفونات الماغنسيوم) تركيزات (Mg% ٣٠-١١,٢٠,٢٨)
.Turbotect Ltd. (Power Generation Technology) Fuel Additives to control High Temperature Corrosion High Temperature Corrosion of Gas Turbine Blades and Vanes.	. ورقة بحثية لشركةتيربوتكت المحدودة (تقنية توليد الطاقة) إضافات الوقود المستخدمة للحد من تأثير التآكل عند درجات الحرارة العالية لشفرات وريش التوربينات الغازية.
.Grecian Magnesite R & D center Technical note / version 1 /02.03.15 ”Fuel Additives“	. ورقة بحثية لمركز جرسيان ماجنيسيت للبحث والتطوير ملاحظة فنية / نسخة ١/ ٢٠١٥/٠٣/٠٢ . "إضافات الوقود".
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.Bertomeu Co. Magnesium as a solution against the corrosion problems derived from the combustion of the Heavy Fuel Oil or Crude oil.	. ورقة بحثية من شركة بيرتميو الماغنيسيوم كحل ضد مشاكل التآكل المستمدة من إحتراق زيت الوقود الثقيل أو الزيت الخام
.Specification of International Companies of Fuel Additives such as	. مواصفات الشركات العالمية المنتجة لإضافات الوقود مثل
A. L MG USA	A. ال ام جى الأمريكية
B. Pentol Germany	B. بنتول الألمانية
C. Chemtura USA	C. شيمتورا الولايات المتحدة الأمريكية
D. Sun Chemical Japan	D. صن للكمياويات اليابانية
E. Baker Hughes / Petrolite UK/SFA Int USA. (Properties of Oil Soluble Mg Compounds used in Fuel Additives).	E. بيكر هيوز/بترولیت/اس اف اية الولايات المتحدة. (مواصفات مركبات الماغنسيوم المذابة في الزيت المستخدمة(
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