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FUEL QUALITY RELATED TO UNSEAWORTHINESS

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ABSTRACT

The article examines various aspects of fuel quality based on the parameters given in international marine fuel standards. We consider the effects on engine performance of deviations from these standards, which under certain conditions can affect the seaworthiness of the vessel.

Key words: fuel quality, specification, onboard treatment

1. INTRODUCTION

The concept of seaworthiness originated from man's instinct for self-preservation when he made his first primitive log canoes. If the vessel worked satisfactorily, i.e. if it did not sink, then it could be considered seaworthy. In this instance seaworthiness referred to stability.

Today the objective of providing a seaworthy vessel is a complex undertaking which involves the hull and machinery, equipment, stores and crew. Whilst within the confines of charter parties, seaworthiness relates to protection of cargo; to the world at large, seaworthiness conveys the concept of suitability, and safety. Conversely, an unseaworthy vessel is considered as a potential disaster, which may result in loss of life and cause long-term environmental damage. Incidents such as the Amoco Cadiz (1978) and Exxon Valdez (1989) resulted in enormous environmental damage. The Braer incident in 1993 initially looked as if it could lead to a major ecological disaster not only for the UK but also for the Norwegian coastline, but fortunately this did not occur.

It should be noted that the burden of proving unseaworthiness rests on those who make the allegation. Technically, various aspects of fuel quality could, under certain circumstances, lead to such a condition.

2. FUEL SPECIFICATION

In considering various aspects of fuel quality, reference needs to be made to a specification. ISO 8217:1996 (Petroleum products - Fuels (Class F) - Specifications of marine fuels) relates to the fuel at the time and place of custody transfer (namely the ship's rail).

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The standard makes no reference to the fuel requiring some onboard treatment before it is actually burnt and the extent of such treatment depends upon the grade. Grades such as DMX, DMA and DMB only require filtration, whilst DMC and the residual grades require further treatment for use in internal combustion engines. It should be noted that whilst various components of the fuel system, including filtration, are subject to periodic survey for classification purposes, there are no classification survey requirements for the fuel treatment system. By custom and practice, treatment of residual fuels almost always involves separation by both gravitation and the use of a centrifugal separator.

3. DENSITY

During the development of the specification, 991 kg/ m^3 at 15°C was adopted as the density limit at which water could be removed by a centrifuge operating with a water seal. Various papers have been published on water removal and the density limit, and inclusion of the parameter in the specification for the reasons given implies that centrifugal treatment is required. If the vessel is fitted with centrifuges with a water seal and the density is greater than 991 kg/ m^3 at 15°C, difficulties will be experienced in maintaining the water seal, and ineffective purification will result. In extreme cases, changing the separator from a purifier to a clarifier could avoid problems on a temporary basis, provided that there is only negligible water in the fuel.

4. VISCOSITY

The size of the centrifuge required is a function of the fuel flow and the viscosity of the fuel to be treated. Some older vessels were designed for only IFI80 with a non-pressurised system. Whilst the sizing of the centrifuges is satisfactory for this viscosity, attempts to treat a higher viscosity fuel and maintain the throughput will lead to a tendency for the centrifuge to act as nothing more than a pump due to the limited capacity of the machine. The design viscosity also determines the size of the fuel oil heater. Hence, the correct viscosity is one of the aspects of fuel quality that must be considered when assessing the efficiency of the fuel treatment plant. If the viscosity of the fuel supplied is greater than that for which the fuel system was designed, there is a possibility that the machinery burning the fuel will not operate under design conditions. Incorrect atomisation due to insufficient preheating can lead to increased peak pressure and rapid damage to the ring/ liner interface. In the case of the prime mover, this could lead to engine failure and loss of propulsion or, in auxiliary systems, to a power blackout.

5. FLASH POINT

On rare occasions it may be found that a vessel has a fuel oil with a flash point below 60°C. Such a fuel is unsuitable for use within the machinery space of ships classed for unrestricted service, as laid down by international legislation. However, due to operational requirements this fuel may have to be burnt in order to reach port, provided that the vessel's underwriters have agreed. The fuel supplier should be put on notice and the vessel's classification society should be advised of the condition of the fuel. The crew should be advised that hot-working metallic parts, smoking or using any other heat source should be avoided in the vicinity of the fuel storage tanks and vents. The purpose of defining a minimum flash point is to minimise fire risk during normal storage and handling. However, the flash point is not a reliable indicator of the flammability conditions that can exist in headspaces of tanks containing fuel oil. In practical terms this means that a residual fuel can have the potential to produce a flammable atmosphere in the tank headspace, even when stored at a temperature below the measured flash point.

It should be noted that, in some countries, gas oil and diesel fuel is produced for the local land-based market to a national specification. Included in such a specification is usually a minimum flash point and this value may be below that required by international legislation for normal marine use.

6. POUR POINT

Historically, there have been occasions when a vessel's fuel system has malfunctioned because of high pour point fuel. This usually applies to vessels with no fuel tank heating arrangements, which trade internationally. For this reason the following note was included in the specification: "Purchasers should ensure that this pour point is suitable for equipment onboard, especially if the vessel is operating in both hemispheres, the North and South." For residual fuels, some areas of the world will supply high pour-point fuels, which sometimes exceed the specification limit of 30°C. If a fuel in storage falls to a temperature below the pour point, wax will precipitate out of solution and settle on the inside of the tank and on the heating coils. When heating is reapplied, the heating effect can be limited by the thermal insulating nature of the wax. In extreme circumstances, the fuel will solidify and it can only be removed from the tank manually. Loss of pump suction will eventually result in the inability to meet engine consumption requirements.

7. CARBON RESIDUE

The carbon residue of a fuel is the tendency to form carbon deposits under high temperature conditions in the absence of air, and is now usually expressed as Micro Carbon Residue (MCR). This property is generally considered to give an approximate indication of the carbonaceous deposit forming tendencies of the fuel. The values resulting from secondary conversion processes such as visbreaking are higher than those from other refining processes. Some older engines may experience difficulty when burning fuels with an MCR greater than 12% wt, especially at low load conditions. Where such engines are used for power generation purposes, the possibility of electrical power failure increases, due to increased carbonaceous deposits. Operational experience has shown that the present generation of marine engines designed for burning residual fuel can tolerate a wide range of MCR values with no adverse effect.

8. ASH

The ash level is related to the inorganic material in the fuel oil. The actual value depends upon three factors: firstly, the ash present in the crude oil; secondly, the refinery processes employed; and, thirdly, possible subsequent contamination due to sand, dirt, and rust scale. Excessive ash levels are invariably caused by the inclusion of some waste material in the fuel, which will increase the tendency for engine fouling. Increased levels of ash in fuels that have been through an onboard treatment plant will result in poor performance. In extreme cases, choking of the engine can occur, with subsequent loss of power and engine failure.

9. WATER

Free water, which may be fresh, brackish, or saline, can normally be removed satisfactorily by the centrifuge, unless tightly emulsified. Excessive uncontrolled water retained in the fuel after treatment, for whatever reason, can lead to total engine failure. Whilst it is likely that emulsified water, even saline, will not result in immediate failure, it is almost certain that, at some unpredictable point, failure of fuel pumps and injectors will occur.

10. SULPHUR

Sulphur is the principal non hydrocarbon in all marine fuels. It is a naturally occurring element in crude oil which is concentrated in the residual component; hence the amount of sulphur depends mainly on the source of the crude oil and, to a lesser extent, upon the refining process. The level of sulphur has a marginal effect on the specific energy of the fuel. For example, a 4% wt sulphur fuel compared to a 1%, wt sulphur fuel will cause a reduction of about 0.75 MJ/kg, or some 2%. In general, the corrosive wear, resulting from the burning of the sulphur in the fuel, can be controlled by an alkaline lubricant and suitable lubrication. If low sulphur fuel is burnt continuously, there may be some economic advantage in using a less alkaline lubricant. In the medium-term, maintenance costs may increase if the lubricant/lubrication is not matched to the sulphur content.

11. VANADIUM

Vanadium is a metal contaminant that is present in all crude oils in oil-soluble form, and the levels found in residual fuels depend mainly on the crude oil source, with those from Venezuela and Mexico having the highest levels. The actual level is also related to the concentrating effect of the refinery processes used in the production of residual fuel. On combustion of the fuel, the most corrosive ashes are vanadium pentoxide and sodium sulphate, and the temperature at which these ashes form a deposit depends on the vanadium/sodium ratio of the fuel. Some engine manufacturers, besides specifying levels of vanadium and sodium, also give a limiting ratio. High temperature corrosion and fouling are phenomena that can mainly be attributed to the vanadium and sodium in the fuel, as well as to the ash deposits which adhere to exhaust valves and turbochargers.

As a result, the efficiency of these units is reduced and severe corrosion can take place. The extent of hot corrosion and fouling is generally contained at an acceptable level by adequate design and operation of the engine. Control of temperature is the principal means by which corrosion is minimised and in modern designs this is limited to 450°C. Some engine builders use nimonic steels in valve manufacture, whilst others use stellite facing. In each case the objective is to increase the resistance to the effect of ash compounds. In some engines, however, the use of high vanadium fuels and those with a critical vanadium/ sodium ratio can result in significant corrosion and fouling. If the engine is used in a system for power generation, this will increase the possibility of electrical power failure.

12. CATALYTIC FINES

Whilst there may be very small quantities of silicon, in the form of sand, and aluminium in crude oil, it is generally accepted that if silicon and aluminium are found in fuel oil, this probably indicates the presence of catalytic fines. These fines are particles arising from the catalytic cracking process in the refinery and are in the form of complex aluminium-silicates. Depending on which catalyst is used, this particulate matter varies both in size and hardness. During the 1980s, the generally accepted parameter for limiting the amount of catalytic fines in the fuel was by specifying a limit for aluminium, which was 30 mg/kg. As has already been mentioned, the composition of the catalyst is variable, and now the amount of catalyst present is controlled by limiting the combination of aluminium and silicon to a maximum of 80 mg/kg. Operational experience has shown that excessive catalytic fines can lead to high ring/ linear wear and degradation of the fuel pumps. In extreme cases, where the catalytic fines are at levels greater than the onboard treatment plant can adequately reduce, the wear can be so great that the engine fails to function.

13. SEDIMENT STABILITY AND COMPATIBILITY

In the process of blending a particular grade of fuel, the properties of the blend are determined by the proportion and source of each of the components used in the blend, particularly with reference to stability and sediment.

Stability of residual fuel may be defined as the ability of a fuel to remain in an unchanged condition despite circumstances which may tend to cause changes: or more simply, as the resistance of oil to breakdown. Conversely, instability would be the tendency of a residual fuel to produce a deposit of asphaltenic matter as a function of time and/or temperature.

Sediment by extraction is a measure of the content of what are mostly organic materials in the fuel and, as such, is of limited relevance. These materials are insoluble contaminants such as sand, dirt and rust scale, and are not derived from the fuel. What is of greater importance is the total sediment content of the fuel, which can include hydrocarbon material related to stability.

There are various filtration test methods for determining sediment levels under defined conditions. These are the existent, accelerated and potential tests. On a routine basis, FOBAS conducts the sediment accelerated test. The advantage of this test is that it is shorter in duration when compared to the potential test that requires 24 h preparation time. During a FOBAS analysis, if a high value is determined, additional sediment tests are carried out to assess the quality of the fuel as delivered.

Whilst every fuel is manufactured to be stable in itself, in that it does not have a tendency to produce asphaltenic sludge, it does not necessarily follow that two stable fuels are compatible when blended or mixed together. Incompatibility is the tendency of a residual fuel to produce a deposit on dilution, or on blending with other fuel oils. A blend is regarded as stable if it is homogeneous immediately after preparation, remains so in storage and at no time produces or tends to produce sludge to a significant degree. Under these circumstances the fuels forming the blend can be considered as compatible with each other.

In the event of lack of stability or the incompatibility of two fuels, it is likely that filter and centrifuge blockage will be experienced. Such blockages may restrict the flow of fuel to the engine, resulting in limited power output. Also, such fuel is chemically altered, such that its combustion characteristic is different. This gives prolonged burning, resulting in total damage to cylinder components. Should there be a difficulty in identifying the nature of this material, a small portion should be placed in an open container and allowed to float in a vessel containing water at a temperature of 60-70°C. A waxy material will melt but an asphaltenic sludge will not.

14. IGNITION QUALITY

The empirical parameters related to ignition quality of CCAI and CII developed in the 1980s both provide an empirical method for ranking residual fuels, but these methods only indicate one part of the multistage process of burn ability. On a worldwide basis there are some residual fuels which have unusual burning characteristics, thus imposing an additional load on the ring/liner interface. If this is not controlled, there is a danger that excessive maintenance will be incurred and, in extreme cases, there is danger of engine failure. In marine diesel engines, ignition performance requirements of residual fuels are primarily determined by engine type and, more significantly, by engine operating conditions. Fuel factors influence ignition characteristics to a much lesser extent. It is for this reason that no general limit for ignition quality can be applied, since a value which may be problematic for one engine under adverse conditions may perform quite satisfactorily in many other circumstances.

15. OTHER FUEL PROPERTIES

It is anticipated that other aspects will be included in the fuel specification as this continues to evolve. In the process of this evolution, it should always be born in mind that the inclusion of additional parameters must be reasonable, useful and economical.

16. CONCLUSIONS

The quality of fuel as it is delivered to the vessel can affect seaworthiness, as can the subsequent onboard treatment of the fuel. In a world where fuel quality is variable, there is a need for more adequate measures to govern the effectiveness of onboard fuel treatment. The evolutionary process of developing such measures is likely to be preceded by guidance notes.

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APENDICE: RELACIÓN ENTRE CALIDAD DEL COMBUSTIBLE Y NAVEGABILIDAD

El artículo examina diversos aspectos de la calidad del combustible, en base a los parámetros establecidos en los Estándar o Normas Internacionales sobre Combustible Marinos. Los efectos de la desviación de estos estándares o normas, hay que tenerlos en cuenta en el rendimiento de las máquinas, que bajo ciertas condiciones puede afectar a la navegabilidad de la embarcación.

Introducción

Hoy la empresa de proporcionar una nave en condiciones de navegar es complicada, al estar compuesta por el casco y la maquinaria, equipos, bodegas y tripulación. Una embarcación incapaz de navegar es considerada como un desastre potencial, que causa un daño medioambiental a largo plazo, además de la pérdida de vidas humanas.

Norma Del Combustible

La norma ISO 8217:1996 (Productos del Petróleo - Combustibles (Clase F) - Normas de Combustibles Marinos) relaciona el combustible con el momento y el lugar para su traslado. Los estándares no hacen ninguna referencia al combustible que requiere de un tratamiento a bordo antes de que sea realmente quemado y la magnitud de tal tratamiento depende de su calidad.

Densidad

Durante el desarrollo de la norma, 991 kg/m^3 a 15° C se adoptó como el límite de densidad a que podría eliminarse el agua de una centrifugadora que opera con un precinto de agua.

Viscosidad

El tamaño de la centrifugadora requerida es función de la circulación de combustible y de la viscosidad del combustible a ser tratado.

Por lo tanto, la viscosidad exacta es una de los aspectos de la calidad del combustible que deben ser considerados cuándo se fija la tasa de eficiencia de la planta de tratamiento de combustible.

Flash Point

En el caso infrecuente de que una embarcación tenga un combustible con un Flash Point inferior a 60º C, es inadecuado para el uso dentro del espacio de la maquinaria, como se enmarca bajo la legislación internacional. Cualquier origen de calor debe ser evitado en las inmediaciones de los tanques de almacenamiento de combustible. El propósito de definir un flash point mínimo, es reducir al máximo el riesgo de incendio, durante los procesos de estiba y la maniobra.

Punto de Vertido

Históricamente, ha habido ocasiones en las cuales, un sistema de combustible de una nave se ha estropeado debido a combustible con un punto de vertido alto. Esto generalmente es aplicable a naves con tanques de combustible sin una normativa en los calentadores que operan internacionalmente. Para combustibles residuales, algunas áreas del mundo son propensas al suministro de combustibles con punto de vertido altos, que exceden el límite de la norma de 30º C.

Residuo De Carbono

El residuo de carbono de un combustible es la tendencia a formar depósitos de carbono, bajo condiciones altas de temperatura, en ausencia de aire y se define en general como Residuo Micro Carbónico (MCR).

Experiencia operacionales han demostrado que la actual generación de maquinas marinas, pueden tolerar un amplio rango de valores MCR sin efectos adversos.

Ceniza

El nivel de ceniza está relacionado con la materia orgánica presente en el combustible. Los valores actuales dependen primeramente, de la ceniza presente en el petróleo crudo, en segundo lugar, de los procesos de refinería empleados y en tercer lugar, de la posible contaminación debido a arena, tierra y óxidos.

Niveles excesivos de ceniza son siempre causados por la inclusión de desperdicios de materiales en el combustible, que incrementan la tendencia de fallos en la maquinaria.

Agua

Soltar agua fresca, salobre o salina es normal y satisfactoriamente evacuada por la centrifugadora, a menos que esté fuertemente emulsionada. El agua excesiva e incontrolada, contenida en el combustible después del tratamiento, puede provocar un fallo total de la maquinaria.

Azufre

El azufre es el no-hidrocarburo principal en todos combustibles marinos. Es normal encontrar este elemento en el petróleo crudo. El nivel de azufre tiene un ligero efecto sobre la energía específica del combustible. En general, el desgaste por corrosión, resultante de la combustión del azufre en el combustible.

Vanadio

El Vanadio es un metal contaminante, que está presente en todos los petróleos en crudo, en forma de solución oleosa, y los niveles encontrados en combustibles residuales dependen principalmente del origen del petróleo crudo. El nivel actual está relacionado por tanto con el efecto de concentración de los procesos de refinamiento utilizados en la producción del combustible residual. La corrosión a altas temperaturas y fallos son fenómenos que pueden ser atribuidos al vanadio y al sodio presente en el combustible.

Minúsculas Partículas Catalíticas

Estas partículas se generan a partir de procesos de ruptura catalítica en la refinería y se encuentran en forma de silicatos alumínicos complejos, dependiendo del catalizador usado; esta partícula varía tanto en su tamaño como en su dureza. En la actualidad se limita la cantidad presente a una combinación de aluminio y silicio no superior a 80 mg/kg.

Estabilidad De Sedimento Y Compatibilidad

En el proceso de mezclado de un tipo particular de combustible, las propiedades de la mezcla están determinadas por la proporción y por el origen de los componentes usados; particularmente en lo referente a la estabilidad y a la sedimentación. La estabilidad de un combustible residual se puede definir como la resistencia del fuel a deteriorarse.

Calidad De Encendido

Los parámetros experimentales relacionados con la calidad de encendido de CCAI de y CII desarrollados en la década de los 80, proporcionan un método experimental para la clasificación de combustibles residuales.

CONCLUSIONES

La calidad del combustible suministrado a la embarcación puede afectar a la navegabilidad, así como el subsiguiente tratamiento del combustible a bordo. En un mundo dónde es común la inconstante calidad del combustible, hay una necesidad por establecer medidas más adecuadas que regulen la efectividad del tratamiento del combustible a bordo.