To:	All X-1R distributors	From:	Nigel McKenzie
Cc:		Date	18th September 2009
Subject:	Engineering Bulletin, terminology and information regarding Fuel Oils in an industrial setting		

Fuel Oil Terminology,
Various grades of fuel are referred to by different names depending on the terminology of the supplier.

Gas oil or LFO is used in some smaller engines or those operated in environmentally-sensitive areas. This grade of fuel is marketed under various names including gas oil, bunker gas oil and marine gas oil. Such a fuel is a light distillate with a clear and bright appearance. It is a clean fuel in that it does not contain any residual fuel components. On the other hand, diesel fuel may contain a small amount of residual fuel and be dark or black in colour. It is known by various names including light diesel and marine distillate. Blended diesel oil does contain some residue and is frequently known as marine diesel oil.

A range of intermediate fuels is often available which have a higher viscosity than the cheapest distillate fuel available. They are supplied to a stated viscosity. Such products are given different designations depending on the supplier and include such terms as light marine fuel, intermediate fuels, thin fuel oils and interfuels. The maximum viscosity at 50°C in centiStokes is often suffixed to the designation IF. For example, IF 180 would be an interfuel with a maximum viscosity of 180 cSt at 50°C. The figure shows the fuel names used by some major oil companies.

Residual fuels are the highest viscosity and thus the cheapest and most common fuel available for use in large diesel engines. Suppliers of residual fuels or HFO use various names, including the terms bunker C fuel, heavy fuel oil, bunker fuel oil,industrial fuel oil (IFO) and marine fuel oil. The term HFO also covers some interfuels.

Fuel Oil Density
Fuel Oil Density is the absolute relationship between mass and volume at a stated temperature. The SI unit is kg/m 3 at a reference temperature, typically 15°C.

Knowledge of density is required for quantity calculations. The value also needs to be known in order to select the optimum size of gravity disc for the centrifuge. In addition, the density gives an indication of other fuel characteristics, including specific energy and ignition quality (CCAI).

Specific gravity of a substance is the ratio of the mass of a given volume to the mass of an equal volume of water at the same temperature. As it is a ratio there are no units.

Relative density (RD) of a substance is the ratio of the mass of a given volume at a temperature t1 to the mass of a given volume of pure water at temperature t2. Like specific gravity, RD is a ratio and hence no units. For example, RD at 20/4°C. Since

1m 3 of pure water at 4°C has a mass of 1000kg, the density of a substance at t1°C is equivalent to the RD at t1/4°C.

In the United States and some other countries, the density of petroleum products is defined in terms of API gravity. This is an arbitrary scale adopted by the American Petroleum Institute for expressing the relative density of oils.

The terms 'density in vacuo' or 'density in air' are sometimes used on fuel delivery or bunker receipt notes. As density is the absolute relationship between mass and volume and not its weight to volume, by definition density is in vacuo. Although often used, the term 'density in air' is incorrect and should be referred to as a 'weight factor'. This is because a substance weighed in air is supported to a small extent by the buoyancy of air acting on it. Thus the weight of a liquid in air is slightly less than the weight in vacuo. There is no simple relationship between density and 'weight factor' but for bunker fuels the difference approximates to 1.1 kg/m 3 . To convert density at 15°C to the 'weight factor' at 15°C, 1.1 kg/m 3 should be deducted.

Densities are measured over a range of temperatures, usually for convenience, at the temperature at which the fuel is stored. The value is then corrected back in test equipment or by the use of standard tables to the reference

Dynamic Viscosity,
Dynamic viscosity is a property of the internal resistance of a fluid that opposes the motion of adjacent layers.

The unit of measure of this resistance in SI units is a Pascal.s. Frequently the unit of a Poise is used, where 1 Pascal.s = 10 Poise. It should be noted that dynamic viscosity is also referred to as absolute viscosity.

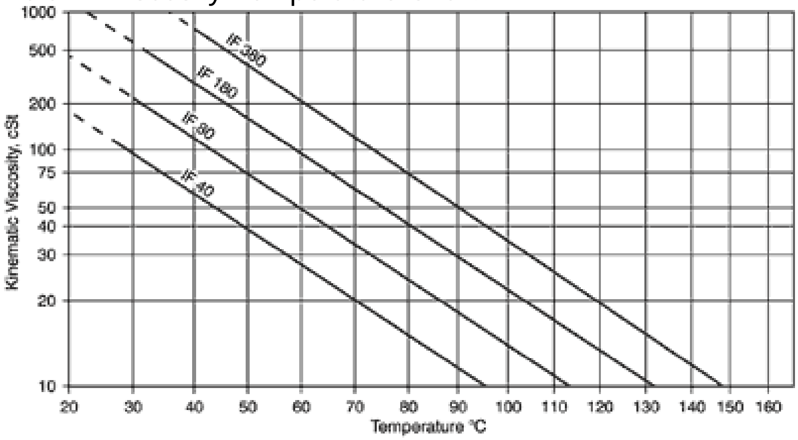
For distillate fuels the reference temperature used is 40°C. However for residual fuels 50°C is still commonly used, even though the most common specification (ISO 8217) has a reference temperature of 100°C.

Temperature and Viscosity Relationship,
Each fuel has its own temperature / viscosity relationship and this is shown for a typical oil.

Oil suppliers publish temperature / viscosity charts, however it should be appreciated that these charts are based on average data of a large number of representative fuels. As the relationship depends on its crude oil source and the refinery processes employed, estimations made from the charts cannot be regarded as precise. In general the difference is small for the lower viscosity fuels but it becomes wider as the viscosity of the fuel increases.

The viscosity determines the storage and handling temperature if the pour point of the fuel is low. Typical maximum fuel viscosity for transfer is 800 - 1000 cSt. The temperature for atomisation of the fuel also depends on viscosity.

Below: Viscosity Temperature Chart



Fuel Oil Flash Point,
The flash point of a fuel is the temperature at which vapour given off will ignite when an external flame is applied under standardised conditions.

A flash point is defined to minimise fire risk during normal storage and handling. The minimum flash point for fuel in the machinery space of a merchant ship is governed by international legislation and the value is 60°C. For fuels used for emergency purposes, external to the machinery space, the flash point must be greater than 43°C. The normal maximum storage temperature of a fuel is 10°C below the flash point, unless special arrangements are otherwise made.

Fuel Oil Pour Point,
The pour point is the lowest temperature at which a fuel can be handled without excessive amounts of wax crystals forming out of solution. If a fuel is below the pour point, wax will begin to separate out and this will block filters. Also, the wax will build up on tank bottoms and on heating coils. When heat is reapplied difficulties may be experienced in getting the wax to re-dissolve because of its insulating nature. In extreme cases, manual cleaning of tanks may be necessary.

Although some diesel oil is sometimes delivered as a clean product, for the purpose of wax indication it is considered as 'black'. This is because it may be delivered through the same transfer lines as residual fuels and can thus be mixed with considerable amounts of wax-laden residual fuel.

Carbon Residuals,
The carbon residue of a fuel is the tendency to form carbon deposits under high temperature conditions in an inert atmosphere. It may be expressed as Ramsbottom Carbon Residue (RCR), Conradson Carbon Residue (CCR) or Micro Carbon Residue (MCR). Numerically, the CCR value is the same as that of MCR. The carbon residue value is considered by some to give an approximate indication of the combustibility and deposit forming tendencies of the fuel.

> 20 %   Problematic
10- 12 %   Straight run fuels
15 - 16 %   Average

(MAC Comment: The carbon residue value of a fuel depends upon the refinery processes employed in its manufacture. For straight run fuels, the typical value is 10-

12% m/m, whilst for fuels derived from secondary conversion processing the value depends upon the severity of the processes applied. On a global basis, this is typically 15-16% m/m but in some areas can be as high as 20)

Water in Fuel,
Usually the level of water in the fuel is very low and 0.1- 0.2% by volume is typical. The introduction of water can come from a number of sources, which include tank condensation, tank leakage or deliberate adulteration. Where steam is used for tank heating purposes, heating coil leakage is another potential source of water. A further potential source is the purifier itself if the gravity disc is incorrect for the density of fuel being treated.

The profit margins on fuel deliveries are often very small and it is tempting to improve this by water addition that is often difficult to detect in a visual examination. Reputable suppliers will deliver fuel with a water content far below ISO 8217 maximum limits.

In practice, the nature of the actual water present may be fresh, brackish or salt depending on the level of sodium as determined by elemental analysis. On a world-wide basis the salt content of sea water varies, but usually in first order terms 100mg/kg of sodium is associated with 1% of sea water. Gross water contamination will be removed in the settling tanks with the final water being removed by the centrifuge. The figure shows the histogram of water content of residual fuels delivered in to the marine market world-wide.

Sulphur in Fuel,
Sulphur is a naturally-occurring element in crude oil and concentrated in the residual component of the crude oil distillation process. Hence the amount of sulphur in the fuel oil depends mainly on the source of the crude oil and to a lesser extent on the refining process. Typically, for residual fuel on a world-wide basis, the value is in the order of 2-4% m/m. The figure shows a histogram of sulphur in residual fuels world-wide. The level of sulphur has a marginal effect on specific energy. In the combustion process in a diesel engine, the presence of sulphur in the fuel can potentially give rise to corrosive wear. This can be minimised by suitable operating conditions and lubrication with alkaline lubricant for the cylinder liner.

Vanadium and Sodium,
Vanadium is a metal that is present in all crude oils in an oil-soluble form. 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 the residual fuel. The majority of residual fuels have vanadium levels of less than 150mg/kg. However some fuels have a vanadium level greater than 400mg/kg. There is no economic process for removing vanadium from either the crude oil or residue.

In general, fuel as delivered contains a small amount of sodium, and typically this is below 50mg/kg. The presence of sea water increases this value by approximately 100mg/kg for each per cent sea water. If not removed in the fuel treatment process, a high level of sodium will give rise to post-combustion deposits in the turbocharger. These can normally be removed by water washing. Vanadium and sodium in combination and at high levels can result in high temperature corrosion damage to valve and turbocharger components - see Section 4 for a more detailed discussion of the effects of Vanadium and Sodium contamination.

Combustibility,
The ignition quality of a fuel is a measure of the relative ease by which it will ignite. For distillate fuels, this is measured by the cetane number. Cetane number is determined by testing in a special engine with a variable compression ratio. The higher the number, the more easily will the fuel ignite in the engine.

On a world-wide basis, the density of residual fuel is typically in the range 975-990kg/m 3 and the sulphur level 2-4% m/m, hence the figure shows the variation in specific energy. For practical purposes, specific energy can be calculated from empirical equations. Of these there are two, one for the net specific energy (QN) which is applicable for a diesel engine, and the other the gross specific energy (QG) for boilers when all the water vapour is condensed out.

The specific energy of a fuel expressed in MJ/kg depends on the composition. For residual fuel, the main constituents are carbon and hydrogen, both of which release energy on combustion. Sulphur also releases energy on combustion but to a lesser extent than carbon and hydrogen. The density is mainly proportional to the ratio of carbon and hydrogen atoms in the fuel.

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