In recent years the International Standards Organization (ISO) and the American Society for Testing and Materials (ASTM) have published standard specifications for marine fuels. The ASTM Standard Specification D 2069 was adopted in 1991 and is intended to be technically equivalent to the ISO Specification 8217 adopted in 1987. In summary, these documents set out specifications for 19 grades of marine fuels: four distillate fuels and 15 residual fuels. Despite the existence of such specifications, marine fuels continue to be referred to using broad categories such as Marine Diesel Oil (MDO), Intermediate Fuel Oil (IFO), and Bunker C.

MDOs are generally formulated from middle distillates, typically containing less than 10% residuum. Table 1 is a summary of MDO physical properties. As can been seen from Table 1, fuel oil viscosities are generally specified at elevated temperatures. In the case of MDOs, the already low viscosities are not likely to increase significantly at the lower temperatures more typically encountered in the environment.

Table 1 Physical Properties of Marine Diesel Oils

Property	Range	Median
Density at 15 °C (g/mL)	0.839 to 0.903	0.863
Viscosity at 40 °C (cSt)	2.9 to 11	5.2
Flash point (°C)	71 to 116	104
Pour point (°C)	-23 to -5	-1

IFOs are blends of heavy residual fuels with enough distillate to lower the viscosity to that required. For example, IFO 180 would be the designation for any intermediate fuel oil having a viscosity of 180 cSt at 50 °C. IFO 180 is a widely used blend, generally containing less than 10% distillate, the remaining 90% being a heavy residual fuel (IFO 380+ or Bunker C). The term “Bunker C” should be used to refer only to straight run heavy residual fuels that have not been blended with any distillate. IFOs with designation of 380+ will usually have properties equivalent to those of Bunker C. Table 2 is a summary of the physical properties of IFO 180 and Bunker C. Unlike MDO, IFO 180 and Bunker C will undergo significant viscosity increases at lower temperatures.

Table 2 Physical Properties of IFO 180 and Bunker C

Property	IFO 180	Bunker C
Density at 15 °C (g/mL)	0.924 to 0.990	0.869 to 0.982
Viscosity at 50 °C (cSt)	182-241	392-450
Viscosity at 15 °C (cSt)	2000+	9000+
Flash point (°C)	82 to 99	83 to 99
Pour point (°C)	-12 to 35	-9 to 43

Table 3 summarizes the natural dispersion and evaporation behaviours of MDO, IFO 180 and Bunker C and also indicates if chemical dispersants are effective or their use recommended. MDO will disperse readily in high sea states and will also evaporate up to 50% in two days, and completely in approximately 5 days. Chemical dispersants, although effective on MDO spills are not recommended as natural dispersion is likely. The distillate component of IFO behaves independently of the residual component, dispersing and evaporating in the same manner as MDO. Bunker C will remain essentially unchanged even after long periods of time. Chemical dispersants are not effective with either IFO 180 or Bunker C.

Table 4 summarizes information available on the aquatic toxicity and effect on the environment of MDO, IFO 180, and Bunker C. MDO, and refined fuels in general, such as diesel and gasoline, have high aquatic toxicity values due to their relatively high content of naphthalenes. The aquatic toxicity of Bunker C is relatively low because it contains only small quantities of compounds that are soluble in water. The distillate component of IFO behaves independently of the residual component, with aquatic toxicity similar to that of MDO. Bunker C, on the water or along the shoreline, will remain essentially unchanged even after long periods of time.

Table 3 Behaviour of Marine Fuel Oils Spilled at Sea

	MDO	IFO 180	Bunker C
Evaporation	10% to 40% in 2 days, 50% in 5 days, depending on residuum content	distillate component will evaporate as MDO; the residual fuel will not evaporate	will not evaporate more than a few %
Natural Dispersion	in high seas, will mostly disperse in 5 days	will not disperse	will not disperse
Chemical Dispersion	effective to a certain degree	ineffective; not recommended	ineffective; not recommended
Recovery Enhancement Agent (Elastol ™)	effective but not recommended for open sea conditions; does not affect evaporation, flash point	ineffective; not recommended	ineffective; not recommended
Beach Cleaning Agent (Corexit 9580 ™)	high probability of being effective; not toxic to rainbow trout	effective in both salt and fresh water; not toxic to rainbow trout	effective in both salt and fresh water; not toxic to rainbow trout
Emulsification	forms unstable emulsions in high energy situations	does not usually emulsify, depending on origin	does not usually emulsify, depending on origin
In-situ Burning	effective; requires a minimum of 3 mm thickness	effective; requires longer ignition time and a minimum of 3 mm thickness	effective; requires longer ignition time and a minimum of 3 mm thickness

Table 4 Aquatic Toxicity and Environmental Fate

	MDO	IFO 180	Bunker C
Aquatic Toxicity	high aquatic toxicity based on tests with automotive diesel and *Daphnia magna*	moderate; between MDO and Bunker C	low aquatic toxicity based on tests with Bunker C (light) and *Daphnia magna*
Environmental Fate	rapid natural degradation or remediation in water and surface sediments, on the order of days to months	moderate; between MDO and Bunker C	slow natural degradation or remediation in water and sediments, on the order of months to years; difficult to clean up
Recommended Countermeasures	mechanical containment and recovery and/or contained in-situ burning in open water; use caution with in-situ burning on shorelines (especially marshes) and determine effect on local vegetation and wildlife prior to use.	moderate; between MDO and Bunker C	mechanical containment and recovery and/or contained in-situ burning in open water; use caution with in-situ burning on shorelines (especially marshes) and determine effect on local vegetation and wildlife prior to use.