

# 中国船用油品发展现状及展望

## Status and outlook of shipping-use fuel development in China

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2014年2月  
February 2014



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# 主要内容 Agenda

- 绪论 Introduction
- 船用柴油机对燃料的要求  
Requirements of Marine Diesel Engines for Fuels
- 国内外船用燃料标准  
Domestic and International Standards on Marine Fuels
- 展望 Outlook

# 船用发动机（一）

## Marine Engines I

船用柴油机具有功率范围宽、能耗低，续航力强、机动性好、使用维修方便等优良性能，目前在船舶动力装置中占有绝对主导地位。船用柴油机包括低速机、中速机和高速机。

Marine diesel engines have the following excellent performances: wide power range, low power consumption, strong endurance, good maneuverability, easy maintenance, etc. Currently, marine diesel have absolute predominance in marine power plants. Marine diesel engines include low-speed, medium-speed and high-speed engines.



# 船用发动机（二）

## Marine Engines II

船用低速柴油机（400r/min以下）多数为二冲程，单机功率可达75000KW、油耗155g/kWh-165g/kWh，是油船、干散货船、集装箱船等三大主力船舶的主要动力设备。

Low-speed marine diesel engines (400r/min), mostly two-stroke, single power up to 75,000KW, oil consumption 155g/kWh-165g/kWh, the main engine equipment of three major vessels: oil tankers, dry and bulk carriers, and container vessels.





# 船用发动机（三）

## Marine Engines III

船用中速柴油机（400r/min-1200r/min）大多为四冲程，单机功率可达26500KW，油耗171g/kWh-180g/kWh，一般作为三大主力船舶的辅机，驱动发电机、空气压缩机和水泵等。1000KW以上的中速机（800r/min -1200r/min）也可作为千吨级客运班轮、作业船、滚装船等船舶的主机。

Medium-speed marine diesel engines (400r/min-1,200r/min) are mostly four-stroke, single power up to 26,500KW, oil consumption 171g/kWh-180g/kWh, generally serving as the auxiliary engine of three major vessels to drive generators, air compressors, pumps, etc. 1,000KW and above medium-speed engines (800r/min-1,200r/min) can also serve as the main engine of KT-class passenger liners, operation vessels, ro-ro vessels, etc.



# 船用发动机（四）

## Marine Engines IV

船用高速柴油机（1200r/min -1800r/min）为四冲程，单机功率可达6500KW，油耗约198g/kWh-210g/kWh，一般用于远洋船舶及沿海船舶的发电机组，也可作为高速船舶的主机。

High-speed marine diesel engines (1,200r/min-1,800r/min), four-stroke, single power up to 6,500KW, oil consumption about 198g/kWh-210g/kWh, generally used as the generator set of ocean-going vessels and coastal vessels, can also be used as the main engine of high-speed vessels.



# 船用发动机（五）

## Marine Engines V

- 船用柴油机的发展
- The development of marine diesel engines
  - 采取工况控制或废气后处理等技术满足日趋严格的排放法规要求；
  - 大幅度提高燃油喷射压力；
  - 提高连续服役的可靠性和综合经济性。
  - Control of operating conditions, exhaust after-treatment and other technologies are adopted to meet the increasingly stringent requirements of emission laws and regulations;
  - Significantly increasing fuel injection pressure;
  - Improving the reliability, and comprehensive economy of continuous service.
- 国产中速柴油机：功率小，主要用于渔船和内河航行船舶。
- Domestic medium-speed diesel engines: low power, mainly used for fishing vessels and inland waterway vessels.





# 远洋船舶柴油机燃油处理系统

## Fuel Treatment System of Diesel Engines for Ocean-going Vessels

- 远洋船舶柴油机的燃油系统中均装有燃油处理设备，如分油机、过滤器和加热器等
- The fuel treatment systems of diesel engines for ocean-going vessels are all equipped with fuel-treatment equipment, e.g. oil separators, filters and heaters.
- 通常不同来源的商品燃料油分储于能够完全排干的燃油沉降柜中，经过沉降后的燃油再经离心式分油机分离出残渣和水分，然后进入日用柜，日用柜中燃料油进入精密设备前再经过精密过滤器。为保证燃油的正常流动和分离要求，在整个燃油系统的诸多部位均设有自动控制加热器。
- Usually, commodity fuel oils of different sources are separately stored in completely drained fuel oil sedimentation tanks. Residue and water are separated from sedimented fuel oil by the centrifugal oil separator. Then fuel oil is transmitted into daily service tanks. Fuel oil in daily service tanks passes prior to entering the precision filters prior to entering precision equipment. In order to ensure the regular flow of fuel and separation, automatic controlling heaters are installed in many parts of the fuel system.



# 船用柴油机对燃料油的使用情况 Use of Fuel Oils in Marine Diesel Engines

- 一般远洋船舶低速机使用馏分和残渣两种类型燃料油，馏分燃料油在离港、靠港和在有环保法规要求的海域使用。离港一定距离后可通过阀门切换为残渣燃料油
- **Generally, two types of fuel oils are used in the low-speed diesel engines of ocean-going vessels: distillate and residual. Distillate fuel oil is used when the vessel is departing from or reaching the port and on the seas subject to environmental laws and regulations. After the vessel departs from the port for certain distance, valves may be switched for residual fuel oil.**
  - 馏分燃料油牌号的选用，根据航行海域及港口地域环保法规的限制而定。普通柴油GB 252
  - The selection of the designation of distillate fuel oils is based on the seas and laws and regulations for port areas. Ordinary diesel GB 252
  - 残渣燃料油牌号由船东确定，受制于船舶设计。 GB/T 17411 《船用燃料油》/ISO 8217-2005 《船用燃料规格》
  - The designation of residual fuel oil is determined by the owner and subject to vessel design. GB/T 17411 Marine Fuel Oils / ISO 8217-2005 Specifications of Marine Fuels
- 内河航行船舶：普通柴油、渣油等
- **Inland waterway vessels: ordinary diesel oils, residual oils, etc.**



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# 船用柴油机对燃料油的使用情况

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# 船用燃料油主要性能要求

## Requirements for the Main Properties of Marine Fuel Oils

- 运动黏度 Kinematic viscosity
- 密度 Density
- 灰分 Ash
- 硫含量 Sulfur content
- 残炭 Carbon residue
- 水分和沉淀物 Water and sediment
- 使用过的润滑油 (ULO)  
Used lubricating oil (ULO)

# 运动黏度 Kinematic Viscosity

- 低速船用柴油机的设计可以燃用最大700cSt黏度等级的燃料油，目前以低灰分、低密度的180号和380号残渣燃料油为主。
- Low-speed marine diesel engines are designed to use fuel oils with the viscosity grade up to 700cSt, mainly 180 and 380 residual fuel oil with low ash content and low density.
- 中速机一般使用馏分燃料油，但为降低成本，经技术改造后的中速机已能够使用180cSt以下的残渣燃料油。
- Generally, distillate fuel oil is used in medium-speed diesel engines. However, to cut costs, residual fuel oil with the viscosity grade lower than 180cSt can be used in technologically transformed medium-speed diesel engines.
- 加热系统调节燃油黏度，通常所要求的燃料油喷射粘度约为12cSt，如果使用50℃黏度为380cSt的燃料油，相应喷射温度约为137℃。如果使用50℃黏度为420cSt的燃料油，则喷射温度约为139℃。
- Fuel viscosity is adjusted for the heating system. Usually, the injection viscosity required by fuel oils is about 12cSt. If 50℃ fuel oil with the viscosity of 380cSt is used, the corresponding injection temperature is approximately 137℃. If 50℃ fuel oil with the viscosity of 420cSt is used, the injection temperature is approximately 139℃.





# 密度 Density

- 高密度燃料油含有较多的残炭和沥青质,燃烧性能比较差。
- High-density fuel oil contains a large amount of residual carbon and asphaltene, with poor combustion performance.
- 分油机分离水分的能力受油品密度的限制。普通分油机分离燃油的密度为 $991\text{kg/m}^3$ , 新型分油机可分离最高达 $1013\text{kg/m}^3$ 的高密度燃油。
- The capability of the oil separator in water separation is subject to the density of oil products. The density of fuel oil separated by ordinary oil separators is  $991\text{kg/m}^3$ . New oil separators can separate fuel oil with the density of up to  $1,013\text{kg/m}^3$ .
- 在ISO 8217-2005标准中, 对各牌号油品均规定了最大密度限值, 且与前一版本相比低黏度牌号残渣燃料油的密度限值有所降低。
- The ISO 8217-2005 standard stipulates the maximum limit values of density for all designations of oil products. The limit values of density of designations of residual fuel oil with low viscosity is lower than that of the previous version.



# 灰分 Ash

- 船用燃料油通常是由渣油和轻质馏分油调和而成，采用二次加工的渣油掺调出的产品与用直馏渣油掺调出的产品相比，含有残留的催化剂微粒，其中含有较高的钒、镍、铝、钠和硅等化合物，会加剧气缸套和活塞环的颗粒磨损与腐蚀磨损，破坏排气阀的密封性。
- Marine fuel oils are usually the mixture of residual oil and light distillate oil. In contrast with products mixed with straight-run residual oil, those mixed with reprocessed residual oil contain residual catalyst particles, with a large amount of vanadium, nickel, aluminum, sodium, silicon and other compounds. Such products may aggravate the particle wear and corrosion wear of cylinder liners and piston ring and damage the tightness of exhaust valves.
- 市场上的残渣燃料油灰分含量相差较大，有些高灰分燃料油不能用作船舶燃料，只能用于工业炉窑。根据ISO 8217-2005, GB/T 17411中残渣燃料油的灰分指标由不大于0.2%修改为不大于0.15%。
- The ash content of residual fuel oils in the market differs a lot with each other. Some fuel oils with high ash content cannot be used as marine fuels. Such fuel oils can only be used in industrial furnaces. According to ISO 8217-2005, The indicator of ash content in residual fuel oils is modified from not higher than 0.2% to not higher than 0.15% in GB/T 17411.





# 残炭 Carbon Residue

- 残炭和10%蒸余物残炭是间接说明燃料在燃烧室内燃烧时发生结焦积炭倾向的指标。一般轻柴油采用10%蒸馏残余物残炭指标，对于重质燃料油则规定全样品残炭。使用残炭较高的燃料油，因燃烧室积炭堆积较快，设备检修期可能缩短。
- Carbon residue and 10% leavings of carbon residue are an indicator which implies that coking and carbon buildup during the the combustion of fuels in the combustion chamber. Generally, the indicator of 10% leavings of carbon residue is used for light diesel oil. All samples of carbon residue are used for heavy fuel oil. If fuel oils with high content of carbon residue are used, the equipment overhaul interval is likely to be shortened due to the quick accumulation of carbon buildup in the combustion chamber.
- 高速机用轻柴油的10%蒸馏残余物残炭最高不应超过0.3%；中、低速柴油机转速低，燃油喷进燃烧室后，有较长的蒸发和混合时间，可与空气充分混合、气化而基本完全燃烧，因此大型低速二冲程柴油机使用燃油的残炭最高可达22%。
- The percentage of 10% leavings of carbon residue in light diesel oil for high-speed diesel engines shall not exceed 0.3%. Low- and medium-speed diesel engines feature low speed of rotation. After fuel oils are injected into the combustion chamber, there is a long time for evaporation and mixing, allowing fuel oils to be mixed with air for gasification and basically complete combustion. Therefore, the maximum percentage of carbon residue in fuel oils for large low-speed two-stroke diesel engines may be 22%.



# 水分和沉淀 Water and Sediment

- 燃料油经船用燃油系统中沉降柜、分油机、日用柜等处理措施后，水分能够减少到允许使用的范围（0.2%以下）。但过量水分将影响油品稳定性及热值并造成系统腐蚀，ISO 8217-2005，高黏度残渣燃料油中水含量已由1996版的不大于1.0修改为不大于0.5。
- After fuel oils are treated in the sedimentation tank, oil separator and daily service tank in the marine fuel oil system, water can be reduced to the level within the allowable scope (0.2%). However, excessive water may affect the stability and heat value of oil products and cause system corrosion. In ISO 8217-2005, the water content in residual fuel oil with high viscosity is modified from not higher than 1.0 in 1996 to not higher than 0.5.
- 过量的沥青质和杂质等沉淀物会使处理它的设备发生故障。ISO标准中采用“总实际沉淀物”和“总潜在沉淀物”分别对应馏分燃料油和残渣燃料油。
- Excessive asphalt, impurity and other sediments may cause the failure of equipment for treatment. According to the ISO standard, "total sediment existent" and "total sediment potential" are used for distillate fuels and residual fuels respectively.





# 硫含量 Sulfur Content

- 燃料油中硫含量高容易导致存储系统、过滤系统和燃烧系统金属的严重腐蚀磨损，其燃烧产物SO<sub>x</sub>对人体和环境产生严重影响。由于远洋船舶多数时间航行于海上，因此国际船用燃料油标准中硫含量一直未做严格限制。但随着国际海事组织（IMO）国际防污公约的实施，船用燃料油的硫含量将逐渐降低。
- High content of sulfur in fuel oil is very likely to cause serious metal corrosion and wear of storage systems, filter systems and combustion system. Its combustion products SO<sub>x</sub> have a serious influence on humans and the environment. Since ocean-going vessels are basically at sea, no strict limitations have been defined on the content of sulfur in international marine fuel oil standards. But with the implementation of MARPOL of the International Maritime Organization (IMO), the content of sulfur in marine fuel oils will decrease gradually.

# 使用过的润滑油(ULO)

## Used Lubricating Oil (ULO)

- 新版ISO 8217规格中增加了对船用燃料油中是否存在废润滑油的检测项目，标准指标为钙含量不大于30mg/kg、锌含量不大于15mg/kg、磷含量不大于15mg/kg。判断依据是如果燃料油中钙、锌和磷的含量中一项或多项低于规格规定值,则可认为该燃料油中不含废润滑油。若3项指标均超过标准规定,则认为该燃料油中含有废润滑油。
- A new test item regarding the existence of waste lubricating oil in marine fuel oils is included in the new edition of ISO 8217 Standard indicators: max limit of calcium 30mg/kg, max limit of zinc 15mg/kg, max limit of phosphorus 15mg/kg. The basement of judgment is that if one or more items of the content of calcium, zinc and phosphorus is lower than the max limit, it may be assumed that there isn't waste lubricating oil in the marine fuel oil. If all the 3 indicators exceed the max limit, it's assumed that the marine fuel oil contains waste lubricating oil.



# 国外柴油分类的情况

## Foreign Classification of Diesel Oils

国家 Country	柴油种类 Type of diesel	柴油类别名称 Category of diesel	相应标准 St美国 standards
美国 USA	4	车用柴油 Automotive diesel fuels	ASTM D 975-04a
		燃料油（馏分型） Fuel oils (distillate)	ASTM D396-02
		燃气轮机燃料 Gas turbine fuel oils	ASTMD 2880-00
		船用燃料 Marine fuels	ASTMD2069-91（1998）
英国 UK	3	车用柴油 Automotive fuels, diesel	BS EN590:2004
		农业工业用柴油 Agricultural and industrial diesel	BS 2869:1998
		船用燃料油（馏分型） Marine fuel oils (distillate)	BS MA 100:1996





# 国外柴油分类的情况

## Foreign Classification of Diesel Oils

德国 Germany	2	车用柴油 Automotive diesel fuels	DIN EN 590:2004
		轻质燃料油 Light fuel oils	DIN 51603-1:2003
俄罗斯 Russia	2	高速柴油机用柴油 Diesel fuels for high-speed diesel engines	ГОСТ 305-82 (修订5从1990年10月1日实施) (5th revised version implemented as from October 1, 1990)
		中低速柴油机用柴油 Diesel fuels for medium- and low-speed diesel engines	ГОСТ 1667-68 (修订5从1998年11月12日发布) 5th revised version issued on November 12, 1998)
日本 Japan	2	车用柴油 (轻油) Automotive diesels (light oils)	JIS K2204:1997
		A重油 A heavy oils	JIS K2205:1991



# 2007国内柴油的消费结构

## Breakdown of Domestic Diesel Consumption in 2007

柴油 Diesel		消费量（万吨） Consumption (10,000 tons)	比例， % Percentage, %
1. 柴油车 Diesel-engined vehicle	乘用车 Passenger vehicle	24	0.20
	商用车 Commercial vehicle	4,348	35.75
2. 农机用油 Oils for agricultural machinery		2,537	20.86
3. 农用车 Agricultural vehicle		1,147	9.43
4. 渔业 Fishery		663	5.45
5. 水路运输 Water transportation		833	6.85
6. 工矿企业 Industrial and mining enterprises		663	5.45



# 2007国内柴油的消费结构

## Breakdown of Domestic Diesel Consumption in 2007

7. 铁路运输 Railway transportation	534	4.39
8. 电力 Power	394	3.24
9. 楼堂馆所 Halls and buildings	399	3.28
10. 建筑施工 Building construction	379	3.12
11. 其他 Others	240	1.97
合计 Total	12,162	100



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# 不同阶段车用柴油与普通柴油主要指标的比较

## A Comparison of Main Indicators for Automotive Diesels and Regular Diesels at Different Stages

项目 Item	GB 252-2000	GB252-2011	GB/T 19147-2003	GB 19147-2009
牌号设置 Designation	10/5/0/-10/-20/-35/-50	10/5/0/-10/-20/-35/-50	10/5/0/-10/-20/-35/-50	5/0/-10/-20/-35/-50
着火性 Ignitability 十六烷值 不小于 Cetane number not lower than 十六烷指数 不小于 Cetane index not lower than	45 ---	45 43	49/46/45 46/43/43	49/46/45 46/43/43
硫含量, % 不大于 Sulfur content, % not higher than	0.2	0.2/0.035	0.05	0.035
多环芳烃含量, % 不大于 Polycyclic aromatic hydrocarbon content, % not higher than	---	---	---	11
润滑性, um 不大于 Lubricity, um not higher than	---	---	460	460



# 不同阶段车用柴油与普通柴油主要指标的比较

## A Comparison of Main Indicators for Automotive Diesels and Regular Diesels at Different Stages

酸度, mgKOH/100mL 不大于 Acidity, mgKOH/100mL not higher than	7	7	---	---
色度, 号 不大于 Chroma, number not higher than	3.5	3.5	---	---
密度 (20℃) , kg/m <sup>3</sup> 不大于 Density (20℃), kg/m <sup>3</sup> , not higher than	实测 Actual measurement	实测 Actual measurement	820-860/800-840	810-850/790-840



# 车用柴油 (IV/V) 的主要技术要求

## Main Technical Requirements for Automotive Diesel (IV/V)

### (GB 19147-2013)

Item	5	0	-10	-20	-35	-50
酸度, mgKOH/100mL      不大于 Acidity, mgKOH/100mL not hither than	7					
硫含量, %(质量分数)      不大于 Sulfur content,% (mass fraction) not higher than	0.0050/0.0010					
润滑性（HFRR） Lubricity (HFRR)校正磨痕直径 （60℃） μm    不大于Corrected diameter of grinding track (60℃) μg/m not higher than	460					
多环芳烃, %（质量分数）    不大于 Polycyclic aromatic hydrocarbon,% (mass fraction) not higher than	11					
着火性: Ignitability: 十六烷值                  不小于 Cetane number not lower than	49/51			46/49	45/47	
密度(20℃), kg / m³ Density (20℃), kg/m³	810-850			790-840		
脂肪酸甲酯, %（体积分数）    不大于 Fatty acid methyl esters,% (volume fraction) not higher than	1.0					



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# 车用柴油 (V) GB 19147 实施进程

## Automotive Diesel Fuel (V) GB 19147 Implementation Process

- 实施日期: 2013年6月8日

Date of implementation: June 8, 2013

- 过渡期 Period of transition

- 表1 (硫含量: 350ppm) : 2011年7月1日

- 表2 (硫含量: 50ppm) : 2014年12月31日

- 表3 (硫含量: 10ppm) : 2017年12月31日

- Table 1 (sulfur content: 350ppm): July 1, 2011

- Table 2 (sulfur content: 50ppm): December 31, 2014

- Table 3 (sulfur content: 10ppm): December 31, 2017



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# 展望 Outlook

- 船用燃料需按照船用发动机的需求进行规划、布局；
- Marine fuel oils need to be planned and distributed in accordance with the demand for marine engines;
- 普通柴油的升级需详细论证；
- The upgrade of ordinary diesel oils need detailed demonstration;
- 更多的组分将会用于船用燃料，质量控制将成为主要矛盾。
- More components will be used in marine fuel oils. Quality control will be the principal contradiction.



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谢谢！  
Thank you!



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