

## LESSON 1

### Diesel engines

The majority of ships around the world continue to be powered exclusively by diesel engines. 世界范围内大多数船舶都是采用柴油机作为动力。

The predominance of diesel engines has come from improved engine efficiencies and designs compared to other forms of propulsion such as steam or gas turbines.

与蒸汽机、燃气轮机等形式的动力装置相比，无论是效率上的提高，还是设计上的进步，柴油机都体现出了一定的优势。

Many combinations and configurations of diesel engine power plant exist. All provide the energy to do the work of moving the ship using diesel engines.

存在有很多种联合形式及结构形式的柴油机动力装置，他们都能够利用柴油机为船舶提供推动力。

#### Slow speed diesel engines 低速柴油机

Slow speed diesel engines are large, especially tall, and heavy and operate on the two-stroke cycle.

低速柴油机是体积较大、缸体较长、机身较重的二冲程柴油机。

These are the largest diesel engines ever built. Engine powers up to 100 000kw are available from a single engine.

它们是已建造过的最大型的柴油机，它们的单机可用功率可达 100000 kw。

They are tall to allow for long strokes which improve engine efficiency .the large physical allow for long strokes which improve engine efficiency.

较长的缸体能提供一个较长的冲程，有助于提高柴油机的效率。

The large physical size of the engine and components leads to slow rotational speed with speeds up to 300rpm considered to be slow.

柴油机及其部件的物理体积较大，导致其回转速度较低，尽管能够加速到 300 rpm，但还是被认为是低速机。

For equivalent power output, the two-stroke diesel engine is significantly lighter than its comparable four-stroke relative.

对于相同的功率输出，相对于四冲程柴油机，二冲程柴油机的重量明显轻很多。

This is most apparent for large power requirements where the two-stroke engine produces much more power for the same weight.

对于大功率需求场合这是一个最明显的优势，二冲程柴油机能够在相同的重量情况下，发出更大的功率。

Large, slow speed, two-stroke marine diesel engines offer the advantages of:

大型、低速、二冲程船用柴油机的优点如下：

1. Burning poorer quality, cheaper fuel 燃烧劣质、低价的燃油
2. Providing large power from a single, less complicated machine comprising fewer individual cylinders and moving parts 一个仅有几个独立汽缸和运动部件组成的、低复杂程度的柴油机就能提供较大的功率。
3. Having a low rotational speed allowing them to be directly coupled to the propeller and

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removing the need for transmission machinery such as clutches and gearboxes etc. 回转速度较低，能够直接和螺旋桨连接，不需要像离合器、齿轮箱等的中间传动机构。

4. Being reversible and thus eliminating the need for reversing gear or controllable pitch propellers.

Merchant ships driven by slow speed diesel engine will usually have a single large main engine directly coupled to a single fixed pitch propeller. The thrust forces from the propeller will be transferred to the hull of the ship through a thrust bearing built into a thrust block, the thrust block may be built as part of the slow speed engine, and this system is supported by diesel generators providing the ship's electrical power.

因为能够倒转，所以就不需要换向机构和可调距螺旋桨。利用低速柴油机驱动的商业船，通常只有一台直接连到定距桨上的大型主机。

#### **Medium speed, four-stroke diesel engines 中速四冲程柴油机**

Medium speed engines operate in speed ranges from 300 to 900 rpm. The majority of medium speed engines operate on the four-stroke cycle.

中速机的运转速度范围是 300 —900 rpm，大多数的中速机都是**四冲程柴油机**。

They are most common as the propulsion engines in smaller ships, ro-ro and passenger ships.

They are used widely as the electrical power generation engines in most merchant cargo ships.

它们在小型船舶、滚装船舶以及客船上应用较多，在大多数的商用货船上被广泛用作发电机的原动机。

Four-stroke engines have more moving parts, are more complex and produce less power for equivalent weight compared to two-stroke slow speed engines. Medium speed engines do, however, offer several advantages which make them attractive for marine applications.

**四冲程柴油机有较多的运动部件，也更加复杂一些，跟二冲程低速柴油机相比相同的重量发出的功率较少。然而，中速柴油机也有一些导致它们在船上使用的优点。**

1. The engines are compact---they are not long or high, this allows them to fit in engine rooms with low head space such as those in ro-ro ships. Fitted under the vehicle deck. 它们不长也不高，机型紧凑，这就使它们适合安装在空间较低的机舱当中，比如在滚装船上，它们就安装在汽车甲板的下面。
2. Medium speed engines use less oil than slow speed engines.中速机比低速机更省油。
3. Recent developments have produced medium speed engines capable of burning low quality heavy fuel oil.近年来的发展也使中速机能够燃用低质燃料油
4. Engines of considerable power, to 25,000kw and more, have been developed, allowing a large power system to be achieved with compact engines and engine room. This makes them suitable for passenger ship applications where the smaller the space provided for engines and machinery the more space is available for paying passengers. 25,000kw 甚至更大功率的中速机已经被开发出来，这就使得能够利用较小体积的柴油机和较小空间的机舱达到较大的功率。这样就适合在客船上安装使用中速机，柴油机和机械设备占用的空间较小，能够为旅客提供出更多的可用空间。

Most medium-speed diesel engines are non-reversible meaning that a controllable pitch propeller is usually employed to cater for astern thrust.

大多数的中速柴油机是不可倒转的，这就意味着通常要利用变距桨实现向后的推力。

Propulsion system compared to an equivalent ship with a matched slow speed propulsion system operating at optimum conditions, when used as the primary source of power for propulsion

applications medium-speed engines can be used in a number of configurations.

对于同样的船舶，相比于配备低速推进系统，配备中速推进系统的情况下，动力装置能始终工作于最佳工况。当用作船舶推进系统主要动力源时，中速机可以应用在各种结构的船型上。

### Single propulsion engine 单主机推进

A ship's propeller operates most efficiently at low rotational speed especially in the case of the large diameter propellers used in cargo ships.

船舶螺旋桨在低转速运行时具有最高的效率，特别是当大直径的螺旋桨安装在货船上的时候更是这样。

The slow speed two-stroke engine can be directly coupled to the propeller as the maximum efficiency of each can be matched at a suitable rotational speed.

低速二冲程主机可以直接连接到螺旋桨上，如果以合适的转速匹配，主机和螺旋桨都能达到最高的效率。

In the case of the medium speed engine the output speed of the engine must be reduced to one more suitable for the propeller.

在使用中速机的情况下，主机输出的速度必须要降到适合螺旋桨工作的转速。

This is done using a reduction gearbox. To reduce the load on the engine during starting it is necessary to uncouple the propeller shaft from the drive shaft. This is done via a clutch which is often incorporated as part of the gearbox. The output shaft of gearbox then drives the controllable pitch propeller.

这通过变速齿轮箱来实现。为了在启动时降低主机负荷，有必要通过脱开驱动轴与螺旋桨轴的耦合。这可以通过减速齿轮箱内部的离合器组件来实现。齿轮箱的输出轴驱动可调距螺旋桨。

The output shaft of the engine is coupled to the gearbox. The output shaft of the gearbox drives the CPP through a clutch arrangement.

主机的输出轴连接到齿轮箱上，齿轮箱的输出轴通过离合器机构驱动可调距螺旋桨

The oil supply to and from the propeller is fed into the propeller shaft through an oil distribution box. This box is attached to a collar running on a section of the propeller shafting, thrust forces maybe accommodated in a separate thrust block and bearing.

供给螺旋桨以及从螺旋桨返回的油，是通过一个油液分配箱供给到螺旋桨轴内部。这个分配箱安装在螺旋桨轴上的一个连续的凸肩上，推力可以通过独立的推力块和推力轴承传递。

Many gearbox designs incorporate the clutch, thrust bearings and CPP oil distribution box into the same casing as the reduction gears, this design has the following advantages.

许多减速齿轮箱在设计时，将离合器、推力轴承和可调距螺旋桨的油液分配箱与减速齿轮一起整合在齿轮箱内部。这样设计有如下的优点：

1. The engine transmission package uses components that are known to be compatible and have been proven to work together reliably. 使用各组成部件一起工作的主机传动系统，各部件能协调运转并且工作可靠。
2. The cost and complexity of installation is less than if separate, standalone components were to be used. 与各部分单独使用相比，这种整合在一起的装置费用和复杂程度都较低。
3. The entire installation is smaller in size, especially length, than the separate units. 整个装置尺寸较小，尤其是长度比分开布置的单元小很多。

4. Negotiations and correspondence etc are simplified as only one supplier need be dealt with. 因为只需要跟一个供应商联系，所以商谈以及联系等也简化了。

#### **Multiple propulsion engines 多主机推动**

Larger vessels and ships using medium-speed engines usually use two or more engines to provide power to the propeller. Multiple engine installations can have several configurations. The first two arrangements discussed in this section have engines driving a propeller through a transmission gearing system. Other propulsion arrangements using multiple engines are possible. A number of these possibilities are discussed later in the section.

使用中速机的大型船舶通常使用两台或者更多的主机来给螺旋桨提供动力，安装多台主机可以有多种的布置方式。两种布置方式将在这一段进行讨论，第一，所有主机通过一个传动机构驱动螺旋桨。第二，使用多台主机的推进布置方式也是可能的。一系列的可能性在这一段的后半部分讨论。

#### **Single propeller shaft with geared drive 单轴驱动**

Multiple engines can be arranged to drive a single propeller. This is usually done by using a multiple input reduction gear. All the engines are arranged around the gearbox, each engine is connected to the gearbox through a clutch allowing multiple stages of power output to the propeller. A single output from the gearbox drives the propeller through a thrust bearing and CPP oil distribution collar, if fitted.

多台主机驱动一个螺旋桨轴，通常是通过多台主机向一个减速齿轮箱输入动力，所有这些主机围绕着减速齿轮箱布置，每一台主机都通过一个离合器与齿轮箱相连，输出到螺旋桨上的功率可以多级调节，齿轮箱的唯一输出端通过推力轴承、可调距浆油液分配箱凸肩（如果安装）驱动螺旋桨。

#### **Multiple propeller shafts 多轴驱动**

Some vessels are propelled by more than one propeller, for example some ferries, passenger ships, special purpose ships, offshore vessels and ro-ro vessels etc. The majority of multiple propeller applications are smaller vessels requiring added manoeuvrability. This is not always the case as some very large ships have been built with two propellers. These large ships have had two propellers directly coupled to slow speed engines. This effectively produces a ship with two engine rooms, one for each engine. In smaller vessels the engine configurations are usually extensions of the single or multiple engines, single shaft arrangements mentioned above. Medium-or high-speed engines are usually used in these cases. In vessels such as catamarans with propeller drives, one drive system is mounted on each of the hulls. This creates two engine rooms. Two examples, the first of a catamaran, the second a twin screw ship.

有一些船平行布置多个螺旋桨，例如，一些渡船、客船、特殊用途船、近海船和滚装船等。多螺旋桨形式主要用在机动性要求高的小型船上。非常大型的船不总是都配置双螺旋桨，如果配置的话，两个螺旋桨就直接连接到两台低速机上，这样一艘船就会有两个机舱，每个机舱放置一台主机。在一些较小的船上，发动机通常布置成一台或多台的形式，而输出则布置成前面提及的单轴形式，这种情况下通常会采用中速或高速机。螺旋桨驱动的双体船就是驱动系统分别安装在两个船体上，这样就会产生两个机舱，这是一个例子，另一个例子就是双螺旋桨的船。

#### **High-speed diesel engines 高速柴油机**

The most common diesel engine throughout the world is the high-speed engine. The majority of these engines operate on the four-stroke cycle but a significant proportion utilize the two-stroke cycle. These engines have running speeds over 1000rpm and are ideally suited to driving

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land-based vehicles such as busses and trucks. the application of high-speed diesel engines as propulsion engines at sea is limited to smaller vessels such as tugs, ferries and barges etc. they are regularly used for electrical power generation in support of a medium-speed propulsion engine, on larger ships their use is limited to emergency power generation to small applications such as diesel driven emergency pumps and compressors.

世界范围内最普通的柴油机是高速柴油机，高速柴油机大部分是四冲程柴油机，但也有一部分是二冲程机。高速机的转速高于 1000rpm，比较适合驱动陆地上的车辆，比如公共汽车、卡车等。高速柴油机如果用作海上交通工具的推进器的话，也仅限于一些像拖船、渡船和驳船等小型船舶上。它们通常在中速机船上用作发电机的原动机，在大型船上他们仅用来给一些小型设备比如柴油机驱动的应急泵、空气压缩机等作为应急发电机用。

The acceptance of high-speed engines in ships has grown in recent years with the development of larger horsepower engines, this has been assisted by co-operation between traditional medium-and slow-speed engine manufacturers with high-speed engine manufacturers, these manufacturers have begun to produce engines capable of supplying power in ranges that formerly fell between those of medium-and high-speed engines.

在近些年随着更大功率柴油机的发展，高速柴油机在船舶上的应用得到了提高，这得利于传统中低速柴油机生产厂与高速柴油机生产厂的合作，这些生产厂开始生产位于中速机与高速机之间这些以前被遗漏的机型。

The propulsion layouts used with high-speed engines parallel those mentioned above for medium-speed engines.

The diesel-electric propulsion system described above for medium-speed engines is equally applicable to high-speed engines. The scale of system and applicability will be reduced.

推进系统的设计采用高速机平行布置，这种布置形式在前面中速机部分提过。前面提到用中速机发出的电能来推进船舶的系统，同样适用于高速柴油机。但是系统的标准和适用性都将降低。

## LESSON 2

### Working Principle Of Diesel Engines

#### 柴油机工作原理

#### FOUR STROKE CYCLE DIESEL ENGINES 四冲程柴油机

The events of each of the four stroke cycle diesel engine are suction, compression, expansion and exhaust. 每个四冲程柴油机的行程包括吸气，压缩，膨胀和排气。 Starting with the piston at the top of the cylinder, the induction stroke is performed as the piston moves down. 吸气行程是通过位于气缸内最高点的活塞下行实现。 During this stroke the inlet valve remains open and a charge of air is drawn into the cylinder. 在这个行程中，进气阀始终开启，同时增压空气被吸进气缸 The piston then returns to the top of the cylinder whilst both inlet and exhaust valves remain closed and the charge of air is compressed. 然后进排气阀保持关闭，活塞返回在气缸内的最高点，增压空气被压缩。 The compression raises the temperature of the air and as the piston reaches the end of this stroke, a controlled amount of fuel is injected into the cylinder in the form of a fine spray. 压缩行程会升高空气温度，随着活塞达到行程的终点，一定数量的燃油以雾化形式喷射到气缸内部。 On coming into contact with the hot air the fuel ignites causing a rapid rise in pressure which drives the piston downwards on the expansion stroke. 通过与热空气的接

触，燃油会被点燃，引起气缸内压力迅速升高，驱动活塞在膨胀行程向下移动。As the piston reaches the bottom of the cylinder for the second time the exhaust valve is opened and during the upward and fourth stroke the hot spent gases are expelled through it.随着活塞第二次达到在气缸内的最低点，排气阀被打开，热的废气通过活塞上行从排气阀被排出。

If the charge of air entering the cylinder during the induction stroke is drawn in by the piston movement only without being assisted in any way, then the engine is said to be naturally aspirated.假如在吸气行程中进入气缸的增压空气只通过活塞的上下移动被吸入，而没有辅助机械，那么这就是自然吸气柴油机。

The power of any diesel engine is determined by the amount of fuel that can be burnt in each cylinder per cycle and the speed at which it can be run. 任何柴油机的功率都是通过每个循环喷入气缸燃烧的燃油量和它的运转速度决定。The rotational speed is limited by the forces arising from the inertia of the moving parts.而旋转速度受到运动部件的惯性力限制。 In the case of a naturally aspirated engine the amount of fuel that can be burnt is limited by the mass of air drawn into the cylinder during the induction stroke. 对于自然吸气柴油机来说，参与燃烧的燃油量受到吸气行程中吸入到气缸空气量的限制。Diesel fuel requires about 14.5 times its own mass of air for complete combustion. 柴油大约需要其自身质量的14.5倍空气量才能实现完全燃烧。The time available for combustion in the diesel cycle is very short; if only the chemically correct amount of air were provided, the fuel would not have time to burn completely and, in practice, almost twice this quantity is found to be necessary.在柴油机循环中，燃烧持续的时间非常短暂；假如只有化学反应的空气量，那么燃油就没有时间进行完全燃烧，在实际循环当中，两倍的空气量是必须的。

The cylinder can be charged with a greater mass of air by supplying it under pressure. The air is pressurized in a compressor, sometimes termed a blower, and fed to the induction manifold of the engine. The process is called pressure charging or supercharging.气缸可以在一定压力下充入大量空气。空气在压气机（有时称为鼓风机）中被压缩，然后供给到柴油机的进气总管。这个过程被称为增压。

In some special cases the compressor is driven mechanically from the engine crankshaft. 在有些特殊的装置中，压气机的机械驱动通过柴油机曲轴来实现。More usually, some of the energy present in the exhaust gas is utilized by passing it through a turbine which is directly coupled to a centrifugal compressor. The compressor and turbine together form a free running unit, separate from the engine, known as a turbocharger.更为常见的是利用排气的部分能量，让其通过涡轮机，而涡轮机直接和离心式的压气机连接，这样压气机和涡轮机组合成一个和柴油机分离开来的自由运转机构，这个装置称为涡轮增压器。

The pressure of the air in the inlet manifold to the cylinders of a turbocharged engine is termed the boost pressure.涡轮增压柴油机气缸的进气总管压力被称为增压压力。 In engines having a high boost pressure the air leaving the compressor is hot and it is beneficial and sometime, necessary to cool it as this assists in increasing the mass of air filling the cylinders and in keeping the internal parts of the engine cool. The air is cooled by passing it through an intercooler. 在高增压柴油机中，离开压气机的高温空气对柴油机来说是有利的，但有时必需的冷却有助于提高进入到气缸的空气量，有助于冷却柴油机的内部元件。增压空气的冷却可以通过空气冷却器实现。The quantity of air provided by turbocharger is so great that the amount of fuel that can be burnt in each cylinder per cycle (and hence the power) is not limited on this account but by the temperature which the exhaust valves, cylinder heads and pistons can withstand.由于涡轮增压器的空气进气量太大，所以每个循环下气缸的烧油量（输出功率）

是没有界限的，但是会受到排气阀，气缸头和活塞的承受温度限制。

## **TWO STROKE CYCLE DIESEL ENGINES 二冲程柴油机**

**Two stroke cycle diesel engines take several forms. 二冲程柴油机有多种结构。**

**One form** has a valve in the cylinder head through which the exhaust gases leave the cylinder and ports around the lower part of the cylinder through which the air enters.一种结构是在气缸头上安装排气阀，在气缸下部加工一圈环绕的空气进气口。

At the bottom dead centre the exhaust valve and the inlet ports are both open at the same time. The pressure of the air in the inlet manifold is arranged to be higher than the pressure in the exhaust manifold so that on entering the cylinder it sweeps out the exhaust gases and fills the cylinder with a fresh charge. This process of displacing the spent gases in the cylinder by the incoming air is termed scavenging.在下止点，排气阀和进气阀同时开启。进气总管的空气压力大于排气总管的压力，这样就可以清扫废气，让气缸充满新鲜空气。这种新气替换气缸内废气的过程称为扫气。

As the piston rises it cuts off the inlet ports and the exhaust valve is arranged to close at the same time. Compression of the charge of air takes place and fuel is injected into the hot compressed air as top dead centre is approached. Combustion occurs and the piston is driven downwards on the expansion stroke. 随着活塞上行，进气口关闭，同时排气阀也被关闭，开始对空气进行压缩。在活塞接近上止点时，燃油喷入到高温空气当中，发生燃烧，开始膨胀，驱动活塞下行。Towards the end of this stroke the exhaust valve is opened allowing the exhaust gases to escape and the pressure in the cylinder fall below that of the air manifold. Shortly afterwards, as the inlet ports are opened by the downward moving piston, the scavenging air enters and displaces the remaining exhaust gas in preparation for the next cycle.在膨胀行程接近结束时，排气阀打开，开始排气，此时气缸压力降至进气总管压力以下。不久以后，随着下行的活塞打开进气口，扫气空气进入气缸替换剩余的废气，准备进行下一循环。

**Another form** of two stroke cycle engines is known as the opposed piston type. In operation it is very similar to the type just described, the chief difference being that the exhaust gases leave the cylinder via ports controlled by the upper piston instead of through a valve.二冲程柴油机的另一种结构是对置活塞式柴油机。它和刚才描述的柴油机运转相似，主要的区别在于：废气经过上部活塞控制的气口，而不是气阀离开气缸。

The two pistons may have the same length of stroke or the piston controlling the exhaust ports may have a shorter stroke than the one controlling the inlet ports. 两个活塞有相同的行程长度，或者控制排气口的活塞比控制进气口的活塞行程短。Power is obtained from both pistons and a variety of mechanisms is available to connect them together. 做功通过两个活塞运动实现，多种机构用于它们的连接。The two most commonly used are separate crankshafts geared together and side connecting rods for the upper piston operated from extra cranks formed on the single crankshaft. 最为常用的机构是采用独立的曲轴，上部活塞的连杆作用在一个曲轴的额外曲柄上。The piston controlling the exhaust ports is usually given a few degrees lead over the piston controlling the inlet ports in order to allow the cylinder pressure to blow down before the scavenge air enters. 活塞控制的排气口开启角度比活塞控制的进气口开启有少许提前，为了是让扫气进入气缸之前，利用气缸压力进行排气。

In the two stroke engines described so far the scavenging is carried out from one end of the cylinder to the other. This is termed uniflow scavenging. 到目前为止描述的二冲程柴油机扫气是从气缸的一端流动到另一端实现，这种方式称为直流扫气。Another arrangement appears

where inlet and exhaust ports are both at the same end of the cylinder. The path taken by the scavenging air leads to the term "loop scavenge" being used to describe this form of two stroke cycle engine. The events of the cycle are exactly the same as for the other forms.另一种布置形式是进排气口在气缸的同一端面,这种结构二冲程柴油机的扫气流动轨迹叫做回流扫气,而柴油机的循环过程和其它柴油机相同。The loop scavenge engine is mechanically simpler than the other types but because one piston controls both inlet and exhaust ports, it is usually necessary to provide light, quick-acting non-return valves in the inlet port to prevent backflow of exhaust gas before the cylinder has blown down to a pressure lower than that in the scavenge air manifold.回流扫气柴油机比其它柴油机机械结构简单,但是因为一个活塞控制进排气口,通常在气缸自身排气压力低于进气总管压力之前,需要在进气口布置一个重量轻,能够快速动作的止回阀来阻止废气逆流。

All two stroke cycle diesel engines require the scavenge air to be at a pressure above that in the exhaust manifold and a scavenge blower is necessary to provide this slightly pressurized air.所有的二冲程柴油机需要扫气压力大于排气总管压力,所以需要有一个扫气风机提供有一定压力的空气。Scavenge blowers may be reciprocating air pumps driven directly from the crankshaft or running gear, or roots blowers or centrifugal compressors driven indirectly from the crankshaft by chain drives or gearing.扫气风机可能是往复式空气泵,由曲轴或运转机构间接驱动,也可能是鲁式风机或离心风机,通过曲轴的链传动或齿轮机构间接驱动。The volume of air displaced by the scavenge air blower is a little in excess of the swept volume of the cylinders in order to ensure that scavenging is complete.为了保证扫气彻底,由扫气鼓风机替换的空气体积要稍微大于气缸的总容积。

Two stroke cycle engines can be turbocharged in the same way as four stroke cycle engines. In most cases a scavenge blower, mechanically driven, is retained to assist the turbocharger.二冲程柴油机和四冲程柴油机的涡轮增压方式相同。在多数情况下,机械式驱动的扫气风机保持开启协助涡轮增压器工作。The flow of air may all pass through the compressor of the turbocharger and then through the scavenge blower in series, or part of it may pass through the compressor and part through the scavenge blower in parallel.所有的流动空气都经过涡轮增压器的压气机,然后经过串联的扫气风机,或者是一部分空气经过压气机,另一部分经过和压气机并联的扫气风机。In the latter case the size of the blower required is smaller but it has to be capable of dealing with the full boost pressure ratio. Crosshead type engines sometimes use the undersides of their pistons as scavenge blowers to assist a turbocharged cycle.在后一种情况中,所需要的风机尺寸较小,但是必须保证全部的增压比。十字头式柴油机有时使用活塞的底面作为扫气风机,来协助完成涡轮增压循环。

## LESSON 3

### Engine Construction I 柴油机结构

#### Traditional Engine Structure 传统柴油机结构

A traditional engine structure arrangement comprises a cylinder block which accommodates the cylinder liners, the block differs in design depending on whether the engine is of in-line or Vee form. The block has spaces to accommodate camshaft drive arrangements (chain or gear), a housing for the camshaft and doors allowing access to the crankcase. The block is a single casting

to ensure rigidity. Cast iron is the usual material. Supporting the cylinder block is the bedplate with its main bearing housings and mounting feet, which connect to the ship's structure. In some cases tie rods are employed to maintain the main bearing housings and engine block in compression. The steel tie rods pass from the upper part of the cylinder block to the lower face of the bedplate below the main bearing housing. Smaller engines often have no tie rods as the structural section thickness is great enough to keep tensile stresses reasonable during peak pressure periods. With a casting there is a minimum section thickness requirement to ensure that the molten metal flows readily to all parts and this thickness is often greater than that dictated by actual stress considerations. Accurate alignment between bedplate and cylinder block is essential to effective stress transmission and engine operation.

传统柴油的结构中包含有一个用来安装汽缸套的汽缸体，发动机是直列式布置还是 V 型布置就造成了汽缸体设计形式上的差异。机体结构有用来容纳凸轮驱动机构（链条或齿轮）、凸轮轴和进入曲轴箱道门的空间。为了保证刚度，机体结构通常是由铸铁材料铸成一个整体。机座上面安放有汽缸体，其上面带有主轴承座和把机座固定到船体机构上的地脚。有些情况下，用贯穿螺栓以一定压力把主轴承座和汽缸体连接在一起，钢制的贯穿螺栓从汽缸体的上部一直通到机座的下表面（主轴承下部）。小型柴油机没有贯穿螺栓，因为其构件的厚度足够克服由于最高爆发压力所产生的张力。如果是铸铁机体的话，就很少有构件厚度方面的要求，为了保证熔化的铁水能够容易地流到所有的部位，构件的厚度一般要比能承受实际应力的厚度大得多。机座和汽缸体之间正确调整，对于柴油机的有效传递以及柴油机的正常运转都是非常必要的。

#### **Modern Cast Monoblock Structure** 现代整体铸造结构

Engines designed during the 1990s generally employ a cast monoblock form of construction with the cylinder block and bedplate forming a single cast iron structure. This nodular iron casting provides considerable rigidity due to its single-piece design and construction. In some engines additional strengthening can be provided by long tie rods extending from the lower face of the main bearing to the upper part of the structure. Tie rods are also employed between the upper face of the cylinder head and the lower face of the intermediate frame structure to ensure that combustion loads are transmitted from the cylinder head to the engine frame structure. The use of tie rods does not imply a weakness in design and is an effective use of a strengthening mechanism where it is needed. A rigid structure is necessary in order to preserve alignment of all engine parts, particularly the crankshaft and camshaft, and to minimize problems related to vibration of the structure. Some engines (e.g. Wartsila Vasa 38) have the air inlet manifold as an integrated part of the engine block while many water and oil channels are cast-in or machined as part of the engine structure. Such features make for easier maintenance, improved accessibility and a reduction in the number of engine parts.

在 20 世纪 90 年代，柴油机设计开始运用整体铸造结构，把汽缸体和机座一起铸造成一个铸铁构件。由于设计和构造上的整体性，使得球墨铸铁件非常的坚固。一些柴油机还利用长贯穿螺栓从主轴承的下表面通到构件的上部为整个机体进行额外加强。贯穿螺栓也用在汽缸头的上表面和机架的下表面之间，以保证把燃烧负荷从汽缸盖传到机架上。使用贯穿螺栓并不是意味着设计上存在缺陷，而是在需要的地方有效地利用加强机构。一个刚性结构应该保证主机各部件，尤其是曲轴和凸轮轴的精确位置，将结构的振动问题降到最低。一些机型（如：Wartsila Vasa 38）将进气总管与机体集成在一起，而水和油的通道则采用铸造或车削后，做为机体结构的部件。这样设计特性简化了维修保养，提高了可达性，降低了主机部件的数量。

With monoblock structures, a sub-frame is required to act as the engine sump. This sub-frame, which bolts directly to the lower face of the engine structure, takes no load and can be manufactured from welded plate. Lubricating oil suction pipes and strainers are arranged within the sump.

对于整体结构来说，下部结构被用作柴油机的油底壳。油底壳用螺栓直接连接到主机整体结构的下表面上，不承受负荷，可用金属板焊接制成。润滑油的吸入口和过滤器都安装在油底壳中。

### **Main Bearings 主轴承**

Main bearing support housings are cast as part of traditional bedplate arrangements, and these combine adequate rigidity for the crankshaft with relative ease of bearing adjustment.

主轴承座作为传统机座的一部分也是铸铁的，轴承座和机座具有足够的刚度，这样轴承的调整就相对容易

Bearing replacement requires lifting the bearing cap, which is held from above with studs and nuts.

轴承更换的时候需要卸下轴承盖，轴承盖是从上部用螺栓螺母固定的。

Although this type of arrangement can, in theory, be incorporated within a monoblock engine structure, it is not used. An underslung main bearing support system is preferred. Nodular cast-iron bearing caps are held from below by means of two hydraulically tensioned studs.

尽管理论上可把这种设计的轴承盖与整体式机体结构做成一体，但实际中并不这样做。一般首选悬挂式的主轴承支撑系统，球墨铸铁轴承盖利用两个液压张紧螺栓从下面固定。

These bearing caps are guided laterally into the engine block at the top and bottom and the hydraulic jacks are often permanently fitted to allow for ease of maintenance. Hydraulically tensioned horizontal side studs support the main bearing caps and with the vertical studs and lateral guide arrangements provide a very rigid main bearing support for the crankshaft.

主轴承盖可从上部和下部横向导入机体结构，为了方便维护保养经常安装固定式的液压千斤顶。水平布置得液压张紧螺栓支撑轴承盖，再加上垂直螺栓和侧向楔形块，就给曲轴的轴承提供了一个很大刚性的支撑。

Main bearings for medium speed engines currently in use are of the thin shell type. 中速机普遍使用薄瓦性的主轴承。Similar bearing shells are employed for bottom end bearings.底部轴承也利用相似的轴瓦。This type of bearing essentially consists of a thin steel backing shell with a layer, or layers, of bearing material cast, flashed or deposited on the rubbing surface. 这种类型的轴瓦基本上是在薄钢衬壳内部的粗糙的表面上浇注或沉淀一层或多层的轴承材料。This type of bearing is prefinished and does not require scraping to fit; indeed no scraping is possible due to the thin layer of bearing material present. 这种类型的轴承只需要表面抛光，不需要过多处理，实际上由于轴承材料层很薄没有必要进行刮擦等处理。Over the years bearing materials have changed to meet the operating conditions. 多年来为了满足工作条件，轴承材料进行了不断地改进。Early arrangements simply had a layer of white metal on the steel backing shell but this gave way to the multi-layer bearing with a layer of lead-bronze or copper between the steel and white metal in order to improve adhesion. 早期的轴瓦只是简单的在薄钢衬壳内部浇注一层白合金，但是这种制作方法为多层轴瓦提供了借鉴，多层轴瓦是在薄钢衬壳和白合金之间又加了一层铅青铜或者黄铜来提高金属间的粘着力。This layer also provided an emergency bearing surface. 添加的这一层也提供了一个应急轴承面。The use of overlay material provides a degree of protection against corrosion, while a thin layer of nickel prevents the lead in the overlay from

migrating into the lead-bronze layer 覆镀材料能够对腐蚀提供一定程度的保护，覆镀一薄层的镍就能够防止铅向青铜层的迁移。The backs of the steel shells may have a soft layer which is designed to prevent corrosion. 钢衬壳也可以加一层软材料防止腐蚀。During the 1990s a number of engine builders returned to bi-metal bearings which employ a layer of aluminium-tin on the steel backing shell. 在 20 实际 90 年代，一些柴油机厂又从新生产在钢衬壳内部加一层锡铝合金的双金属轴承。Others employ a multiple layer bearing with a tin-antimony rubbing surface over a copper-lead layer on the steel backing shell. 另外一些厂家利用在钢衬壳内部的铜合金层之上又加了一层表面粗糙的锡锑合金生产多层轴瓦。Bearing technology continues to change to meet the demands of higher loads but problems of lubricants contaminated by water and residual fuels must also be overcome. 轴承技术不断发展为满足了更大负荷的需要，但是还需要克服由于水和残油对润滑油所造成的污染问题。

### **Crankshaft 曲轴**

Crankshafts for medium speed engines are solid forgings from a single alloy steel ingot. 中速机的曲轴是用一块合金钢锭实锻而成的。Solid forging avoids stress problems, which would result from the presence of shrink fits, and ensures even stress transmission between journals, webs and pins. 实锻避免了因收缩配合带来的应力问题，避免了轴颈、曲柄臂和曲柄销上的应力集中。There are very rigorous Classification Society rules governing the dimensioning of crankshafts, based on a combination of theory and experience. 基于理论和实践经验的结合，船级社规则对曲轴的尺寸有严格的要求。Current designs make considerable use of computer finite element analysis which allows a wide range of loadings, dimensions and cylinder firing orders to be analysed before any manufacture takes place. 现在的设计利用了计算机有限元分析方法，在任何生产之前，都对大负荷范围、不同尺寸和汽缸点火顺序等进行分析。

A crankshaft must be able to transmit the torque developed during operation. 曲轴必须能够传递柴油机工作过程中所产生的扭矩。This torque imposes stresses on the crankshaft journals. 扭矩在曲轴轴颈上产生扭转力。Pins are subject to direct stresses from the connecting rods, which impose bending and shear stresses. 曲柄销承受从连杆传来的力，这个力会在曲柄销上弯曲力和剪切力。Webs bend due to this loading but they also have a tendency to twist. 由于这个负荷曲柄臂会产生弯曲，但是它们也有一个扭转的趋势。Crankshafts will bend under load as each cylinder unit section acts like a simply supported beam, with the main bearings acting as the supports. 曲轴像一个被简单支起来的梁，主轴承就像支撑体，这样曲轴在每一个缸所产生的负荷的作用下就会产生弯曲，Loadings vary with time making the analysis of stresses a complex matter, further complicated by the presence of oil holes through journals, webs and pins. 负荷随着时间的变化使应力的分析变得复杂，轴颈、曲柄臂和曲柄销中钻孔后使应力的分析变得更加复杂

The firing order of an engine is primarily chosen to reduce engine torque fluctuations and minimize vibration. 对于降低扭矩的波动和降低振动，发动机点火顺序的选择很重要。Any final solution must be something of a compromise as other factors have to be considered including exhaust arrangements, bending loads on the crankshaft and torsional vibration. 任何最终方案都是一个折中选择，因为排气布置、曲轴上的弯曲负荷和扭转振动等其他因素也要考虑。Reciprocating masses—the pistons, connecting rods, webs and crankpins induce vertical forces which can result in vibration. 往复运动质量，如活塞、连杆、曲柄和曲柄销都会产生垂直方向上的力，进而导致振动。Reducing the mass of these components through the use of lighter materials and removal of all unnecessary materials will help to minimize vibration but will not eliminate the problem. 通过使用轻金属和去除不必要的材料都会降低这些组件的质量，减轻

振动，但不会消除这个问题。Most medium speed engine crankshafts are machined all over in order to reduce excess weight.为了去除多余的重量，中速机的曲轴需要整体车削。They are provided with adequate fillets at all changes of section in order to avoid stress raisers which could give rise to Fatigue. 为了防止应力集中造成应力疲劳，在任何横截面积的改变处都加上足够的圆倒角，Changes in section occur between journal and webs, crankpins and webs, and at oil holes. 截面改变一般产生于轴颈和曲柄连接处、曲柄和曲柄销连接处及一些油孔处。In many cases balance weights are fitted to some or all of the webs, these are designed to oppose the vibration induced by the reciprocating masses. 一些情况下，会在部分或全部曲柄上安装配重，这些配重用来抑制由往复质量产生的振动。The solution is only partial as a rotary mass will not only induce vertical forces to oppose the reciprocating masses but it will also induce variable sideways forces, causing transverse vibration. 只有部分配重充当回转质量，这不仅会产生垂直方向上的力平衡往复质量，还会产生变化的横向力，引起横向振动。The size and positioning of balance weights are carefully arranged by the designer and should not be changed.配重的大小和安装位置需要由设计者仔细选择，并且不应改变。

### **Connecting Rod 连杆**

Connecting rods are forged from alloy steel and machined all over. 连杆是由合金钢锻造并进行车削。The basic connecting rod requires a provision for attaching it to the crankpin, at the bottom or large end bearing, and to the piston at the gudgeon pin, the top or small end bearing. 最基本的连杆在底端或大端轴承处，需要一个机构把它连接到曲柄销上，在上端或小端轴承处需要一个机构把它通过活塞销连接到活塞上。The small end generally consists of a bush inserted in a hole bored in the top of the connecting rod. 连杆小端通常在钻孔内安装一个衬套。The bush may be a simple bronze affair but some engines, particularly a high powered unit, have white metal lined, or tri-metal, bushes. 衬套是个简单的青铜件，但是一些柴油机尤其是大功率的机型，会在衬套内部再衬上白合金，或者使用三合金衬套。Lubrication for the top end bearing comes from the crankshaft via the bottom end and a hole drilled in the connecting rod. 给连杆顶端轴承润滑的油，是由曲轴经过连杆底端和连杆上的钻孔供入的。This passageway is also used to conduct cooling oil to the piston. 这个通道也用来为活塞输送冷却油。Because of the high loadings on the small end bearings and the absence of complete rotary motion, an adequate supply of lubricant is essential at all times. 因为小端轴承的负荷重，并且缺少完全的回转运动，所以在任何时候向小端输送足够的润滑油是非常重要的。Stepped small end bearings are used to provide a large bearing surface on which the piston force may act via the gudgeon pin. 用踏板轴承提供大的承载表面，活塞力经活塞销传到小端。

The large end bearing of connecting rod can present certain maintenance problems. 连杆大端轴承也会出现维护保养的问题。The traditional fixed centre connecting rod has the upper part of the large end housing forged as part of the rod, which means that the lower part of the connecting rod is wide in order to accommodate the bearing shell and securing bolts. 传统的固定中心式连杆大端的上半部分是和连杆锻造在一起的，也意味着连杆大端的下半部分是开放式的，可以安装轴瓦和紧固螺栓。In order to remove the piston, with the connecting rod still attached, the bottom part of the connecting rod must be no wider than the cylinder bore through which it will be lifted. 为了能够在连杆不拆除的情况下吊起活塞，连杆底部不能够比缸套内径大，这样活塞可以通过缸套吊出来。Modern engines employ large diameter crank pins in order to provide large area bearings and low bearing loads. 现代柴油机采用大直径的曲柄销来提供大的承载面积，降低轴承单位负荷。A fixed centre connecting rod design would not be suitable. Alternative arrangements are available.固定中心式设计将不是一个合适的备用方案。

Bearing shells for large end bearings are similar to main bearing shells but are provided with large oil holes in a central channel. 连杆大端轴瓦和主轴承的轴瓦相似，但是会在中心油路加大润滑油的供给。These allow oil to flow from holes in the crankpin, through the bearing, to passageways in the large end and then up the hole in the connecting rod. 这样润滑油就会通过曲柄销上的油孔、主轴承、连杆大端上的通路向上流向连杆中的油路。Tags on the bearing halves mate with location points in the housings ensure correct alignment. 轴瓦上的销钉和轴承座上的点相对应，保证正确的定位。As with main bearings the thin shells rely on the accuracy of the bore machined in the large end to preserve a true circular shape. 连杆大端内孔的精确加工，对于薄的轴瓦保持圆环起决定作用。Correct tightening of the large end bolts is, therefore, essential.因此，大端连接螺栓的正确紧固也是很重要的。

The articulated connecting rod arrangement has a single large end bearing block to which both connecting rods are attached. 主副连杆式连杆（又称关节式连杆）有一个单独的大端轴承体，主副连杆连到轴承体上。The master rod is connected rigidly by means of a palm end, while the slave rod is attached by an articulated arrangement, such as a pin and bush.主连杆通过平的端面刚性连接到轴承体上，副连杆通过一个销和衬套的铰链机构连到轴承体上。This is necessary because the motions of both pistons, and of their connecting rods and large ends, differ as the crank rotates. 当曲轴回转的时候，由于两个活塞、它们的连杆和大端的运动是不同的，所以这种设计是有必要的。The articulated large end arrangement has cylinder centre in line across the engine and both pistons may be removed without touching the large end bearing. 铰链式大端的设计（主副连杆式结构），主机各个缸的中心线在同一平面上，两个活塞都可以在不影响大端轴承的情况下拆除。

## LESSON 4

### Engine Construction II

#### PISTONS AND PISTON RINGS 活塞、活塞环

Pistons for medium speed engines must be capable of withstanding the gas loads experienced during peak firing periods without any appreciable leakage. 中速柴油机的活塞必须能够承受最高燃烧时所产生的气体负荷，并且没有明显的漏泄。As a result the sealing arrangements provided by the piston rings must be effective, even though lubrication at the top of the cylinder may be marginal. 即使是汽缸的顶部润滑油的量较少，活塞环也必须达到密封效果，Unlike crosshead engines most medium speed engines rely on splash lubrication from the crankcase, which must be controlled by scraper rings located on the piston crown or on the skirt. 不像十字头式柴油机，许多中速柴油机采用飞溅式润滑，润滑油量通过位于活塞头或活塞裙上的刮油环来控制。A skirt is necessary on two stroke cycle engines in order to seal the ports when the piston is at the top of its stroke.二冲程柴油机必须设有活塞裙，当活塞位于行程顶部的时候用来关闭气口。In a four stroke engine, the skirt also guides the piston into the cylinder, countering the side thrusts caused by the angularity of the connecting rod.在四冲程柴油机中，活塞裙在汽缸中起导向作用，并且承受由于连杆倾斜所产生的侧推力。

A piston assembly consists essentially of the piston crown, the skirt, a gudgeon pin and a number of piston rings. 活塞的主要组件有活塞头、活塞裙、活塞销和一些活塞环。The crown is subject to the highest combustion pressure and thermal load. 活塞头承受燃烧所产生的高温

高压, It may also suffer from impingement by the combustion flame if the atomiser spray is defective. 如果雾化器效果差的话, 还需要经受火焰的冲击。Piston crowns are of the dished type to provide a combustion chamber between the piston crown and the cylinder head. 活塞头是中凹形的, 与汽缸盖形成燃烧室。To give the desired combustion, the shape of the bowl formed in the crown depends on many factors, including the choice of atomiser spray. 良好的燃烧效果取决于很多因素, 包括活塞头的形状和喷油器的选择。The flat rim of the piston surrounding the dished combustion chamber generally contains cut-out sections to prevent the piston from hitting the inlet and exhaust valves. 活塞中凹形顶部的圆环面上通常有凹坑用来防止进排气阀撞击到活塞。The piston crown is generally made from high quality, deformation resistant forged steel and contains internal cooling surfaces and the provision for a number of piston rings. 活塞头通常采用质量好且耐变形的锻钢制作, 其内部有冷却空间, 外部有安装活塞环的环槽。The crown may taper slightly in order to allow for thermal expansion while in service. 活塞头可以有轻微得锥度, 以适应其工作时的热膨胀。During operation the upper part of the crown becomes hotter than the lower part so it will expand more. 在工作时, 活塞头上部会比下部热, 所以也膨胀的多。Tapering allows a narrow clearance between piston and liner to be maintained. 这个锥度就使得活塞和缸套之间保持一个小的间隙。

批注 [s3]: 语序有问题

批注 [s4]: 外部有环槽

A piston skirt guides the piston in the cylinder, minimising the tipping of the piston which causes high contact pressures at upper and lower parts of the piston/skirt assembly and disturbs gas sealing of the rings. 活塞裙引导活塞在汽缸中运行, 减轻活塞的倾斜。倾斜会引起活塞上部和下部组件产生高接触压力以及破坏活塞环的密封。The piston skirt is subject to lower thermal and mechanical loads than the crown and can be made from materials of lower strength. 活塞裙所受的热负荷及机械负荷都比活塞头低, 可以用低强度的材料制作。It is subject to greater rubbing against the liner, however, and should have a lower coefficient of friction. 活塞裙与汽缸套之间摩擦严重, 最好选用摩擦系数低的材料, Nodular cast-iron is often used for piston skirts due to its low coefficient of friction and ability to be readily cast into a fairly complex shape. 球墨铸铁的摩擦系数较低, 并且能够很容易救助造成复杂形状, 所以经常采用球墨铸铁制作活塞裙。Aluminium is also used for piston skirts. Its low density is an advantage in terms of inertia forces, although it has a higher coefficient of thermal expansion than nodular cast iron. 铝也经常用来制作活塞裙, 虽然它比球墨铸铁的热膨胀系数大, 但是由于它的密度低利于减小惯性力。At low loads an aluminium skirt will give increased cylinder clearance compared with one of nodular iron, so the piston axis will differ slightly from the cylinder axis. 与球墨铸铁的活塞裙相比, 铝制活塞裙在低负荷时的汽缸间隙较大, 所以活塞的轴线会稍微偏离汽缸中心线。At reduced loads an aluminium skirt will therefore not provide as stable a platform for the piston rings as a nodular iron skirt. 负荷降低时, 铝制活塞裙不会像球墨铸铁活塞裙那样为活塞环提供一个稳定的平台。The skirt does not need to be perfectly cylindrical, as long as it is shaped to assist the formation of an effective lubricant film between piston and liner. 活塞裙不必要加工成一个理想的圆柱体, 只要他能够在活塞和汽缸套之间形成一个有效地润滑油膜就可以。Some skirts taper slightly from bottom to top while others are of oval section, with the minor axis parallel to the axis of the gudgeon pin. 一些活塞裙会从底部向上有一个锥度, 一些会有椭圆横截面, 椭圆的短轴平行也活塞销的轴线。

In most engines the top three rings are classed as compression rings, although the upper ring takes most of the gas loading. 大多数柴油机中最上面的三道活塞环是压缩环(气环) Ring materials should be compatible with the liner material in order to avoid scuffing as the rings rub over the liner surface. 活塞环的材料应该与汽缸套的材料相适应, 避免活塞环擦过汽缸套表

面时造成擦伤。Rings must retain their initial spring at operational temperatures and pressures, resist thermal cracking and maintain their mechanical strength. 活塞环必须在工作压力和温度下保持初始的弹性，不出现热裂纹并保持机械强度。Ideally they should have some self lubricating properties.理想的情况下，它们应该有一定的自润滑特性。Cast iron is an ideal material but for modern conditions alloying elements such as manganese, chromium and molybdenum are employed to improve mechanical strength, heat resistance and self-lubrication. 铸铁是一种理想的材料，现在也把一些合金元素如锰、铬和钼加入到铸铁当中用来提高机械强度、耐热性和自润滑能力。

### **Cylinder Liners 汽缸套**

Cylinder liners are centrifugally cast from nodular or close grained cast iron to obtain good mechanical strength and wear resistance. 汽缸套是利用球墨铸铁或者细晶粒铸铁离心铸造，已获得良好的机械强度和耐磨性。A rigid liner bore which is free of distortion is ideal and, with the provision of good lubrication, provides optimum running conditions for the piston and piston rings. 理想情况下，如果有良好的润滑，活塞和活塞环工作于最佳条件，一个刚性汽缸套是不会变形的，Liners fit into the cylinder block, but for many highly rated engines the cylinder block does not always house the water jacket which is instead provided by means of a separate unit mounted above the block. 汽缸套安装在汽缸体上，但是一些大功率的柴油机汽缸体不总是都带有水冷却腔，而是在汽缸体上部安装一个独立的冷却单元。Such an arrangement provides cooling just where it is required, at the upper part of the cylinder liner, and also avoids the risk of cooling water leaking into the crankcase or of oil from the crankcase gaining entry to the cooling water system. 这样的布置恰好冷却了汽缸套的上部，避免了冷却水泄漏进曲轴箱和曲轴箱内部的油进入冷却系统的危险。The liner is located within this jacket unit and sealing rings are provided to prevent water leakage.汽缸套位于水套的内部，用密封圈防止水漏泄，The jacket unit sits on the cylinder block and is held in place by the cylinder head.水套安装在汽缸体上，用汽缸盖定位。Although such jackets may not be shrink fits with the liner they should be neat fits and add strength to the upper part of the liner under working conditions.尽管水套盒汽缸套之间不是红套安装，他们也应该配合良好，当缸套处于工作条件下，水套应该对汽缸套上部施加一定的力。Individual jackets ensure low cylinder liner distortion and prevent any one cylinder causing distortion of neighbouring cylinders.单独的水套设计保证汽缸套变形低，防止缸套受其它缸影响而变形。The liners must be a neat fit in the cylinder block to prevent distortion. 汽缸套必须要良好地安装在汽缸套上防止变形。For two stroke engines it is essential that the correct angular position is obtained, so exhaust and air inlet ports are aligned with their respective passages. 二冲程柴油机汽缸套要有正确的安装角度，要使进排气口正好与它们各自的通道成一线。Sealing rings are still provided between the liner and the cylinder block, even though there may be no water jacket in the block, to prevent oil leaking into the cylinder block section. 即使汽缸体上没有水套，在汽缸套和汽缸体之间也要有密封圈，防止油漏泄到汽缸体内。Where the cylinder block provides a water jacket for the cylinder liner, sealing rings are required at the lower part of the liner. 这种情况下，汽缸体就作为汽缸套的水套，密封圈安装在汽缸套的下部。Some sealing arrangement is also needed in the liner above the jacket. 在衬套里也需要其它一些密封，It is usual to provide a telltale between the two lower sealing rings, so that water leaking past the upper seal ring or oil leaking past the lower ring may be readily detected.它在两道较低密封环之间形成了一个指示器，所以如果水从上面的密封环漏泄或者油从下面的密封环漏泄都可以容易地检测出来。An alternative to having a jacket around the upper part of the liner is to have a solid upper section liner of the desired thickness for

strength, and to provide some sort of cooling, usually bore cooling.一种替代方法是围绕汽缸套的上部设计水套,也就是钻孔冷却。缸套的上部较厚,提供足够的强度,也可以实现一些冷却。

#### **CYLINDER HEAD 汽缸盖**

The cylinder head must effectively close the upper part of the cylinder and provide space for air inlet and exhaust valves, a fuel injector and a number of other fittings such as air start valve, relief valve and indicator cock. 汽缸盖必须有效地封住汽缸的上部,为进排气阀、燃油喷射器,还其他一些装置如:空气启动阀、安全阀和示功考克等提供安装空间, In Vee type engines it is usual to fit air start valves to one bank of cylinders only. 在V型机上,通常只在一系列汽缸上安装启动空气阀。The head must resist mechanical stress due to peak firing pressure and must also be cooled to maintain strength. 汽缸盖必须能够承受爆发压力所产生的机械应力,必须冷却以保持强度。As with cylinder liners, cooling can present problems related to thermal stress and an effective system of coolant circulation is needed. 汽缸套的冷却可能存在热应力问题Although many cylinder heads still employ cored-out cooling spaces, some engines (e.g. Sulzer 'Z' range) make use of bore cooling systems. 尽管很多汽缸盖采用中空冷却腔冷却,但是一些柴油机(如:苏尔寿Z系列)采用钻孔冷却方式。In some cases combined bore and cavity cooling is used, with the bores located at the lower face closest to the combustion chamber where the cooling effect is critical. 一些时候,钻孔冷却和冷却腔冷却会混合应用,钻孔在汽缸盖的下表面紧靠燃烧室,这里的冷却效果很关键。This lower face is known as the 'flame plate'.下表面一般称作“底板” The cylinder head sits on the top of the liner and holds it in place. 汽缸盖位于汽缸套上面,并固定汽缸套A number of hydraulically tightened studs are usually employed to hold the head onto the cylinder block.一些液压上紧螺栓通常用来把汽缸盖固定到汽缸体上 Cooling water flows from the cylinder liner to the cylinder head either directly, with self sealing connections, or by means of connecting pipes. 汽缸套和汽缸盖之间密封连接或采用连接管后,冷却水直接从汽缸套流向汽缸盖Water outlet flow is from the top of the head to a common flow pipe. 冷却水从汽缸盖上部流出到一个公共管路。Some form of air vent arrangement is usually provided at the water outlet pipe to ensure removal of air from the coolant passageways following overhaul.在冷却水出口管通常安装一些除气装置,用以大修后从冷却管路中驱除气体。 For most engines each unit, cylinder liner jacket and head, can be isolated from the coolant circulating system so it is only necessary to drain the unit being overhauled. 对于大多数柴油机,汽缸套、水套和汽缸盖各单元都可以从冷却循环中独立出来,所以各单元大修时仅需要单独放空。The cylinder head also connects to the air inlet and exhaust trunkings, passageways are cast into the cylinder head to permit the flow of combustion air and exhaust gas.汽缸盖也连接到空气入口和排气管,这些通道铸造在汽缸盖上,允许新鲜空气流入废气排出。

## **LESSON 5**

### **Lubricating Oil Of Today 现今的润滑油**

The fuel of today contains more sulphur and slow burning components such as asphaltenes than before. 现今的燃油比以前含有更多的硫和不易燃烧的成分如沥青。The aromaticity of

fuels has increased. 燃油里的芳香族化合物也增加。Engine design has changed, aimed towards reduced operating costs. 为了降低运行成本, 柴油机的设计也改变了。The output per cylinder, the engine pressures and temperatures, have increased in order to make it possible to burn less, but heavier fuel. 每个汽缸输出的压力和温度都增加了, 这样可以燃烧更少、更差的油。The lube oil consumption is reduced. 润滑油的消耗量增加了。To hold back on the investment cost there is a trend towards smaller sump volumes. 为了降低投资成本, 也有一个向小型油底壳的发展趋势。

These changes increase the stress on and the amount of contaminants in the lube oil. 这些改变增加了应力和润滑油中污染物的数量。Further, as effects of the increased use of heavy fuel the classification societies indicate bearing problems with focus on the lubricating oils. 进一步来说, 船级社指出随着低质燃料油使用增加的影响, 轴承的一些问题主要集中在润滑油上。The lube oils today have been developed to meet the increased demands. 现今的润滑油为了适应不断增加的要求, 也有了很大的发展。Higher sulphur content in the fuel oil has been counteracted by a higher TBN. 含硫值较高燃油的总碱值较高的润滑油中和其酸性产物。In order to keep the engine clean and avoid agglomeration of sludge particles, more detergent and dispersant additives are used. 为了保持气缸内的清洁, 避免泥渣颗粒结块会使用更多的清洁剂和分散剂。The trend towards reduce manning in the engine room less man-hours for adjusting, cleaning and repair of the equipment. 为了降低机舱里的人员配员, 调整、清洁和修理设备的工时也要少。

The increased contaminants in the lube oils must be efficiently removed by cleaning equipment with a constantly high separation performance. 润滑油里增加的污染物必须要通过一个稳定的高分离性的设备有效的清除。The detergent and dispersant properties of the lube oil make separation a difficult task. 润滑油中清洁剂和分散剂的存在使得润滑油分离困难。These additives keep the particles small or even break them up. 这些添加剂的存在使得颗粒更小甚至使颗粒破碎。Removal of water is also made difficult due to the increased dispersant properties. 由于分散性能的增加, 清除水也变得困难。In extreme cases it is even possible that the lube oil picks up water from the water seal of a purifier if the oil and water are brought into turbulent content with each other. 在一些极端的情况下, 润滑油可能从分油机的水封水中吸收水, 如果水和润滑油剧烈的混合在一起。Another complicating factor is that some of the additives e.g. over-base detergents, are more or less sensitive to contact with water and will deplete and form deposits themselves. 另外一些复杂的因素是一些添加剂, 如高碱性清洁剂几乎都对水接触比较敏感, 自身浓度降低并形成沉淀。Combustion by-products in the lube oil also increase due to the changed properties of the fuel oil. 燃油性质的变化也会导致润滑油中燃烧副产品增加。Separated sludge is stickier, which makes it difficult to discharge from self-cleaning centrifugal separators. 分离出来的泥渣是粘稠的, 要从自清洗分离机上清除掉这种泥渣很困难。

Conventional cleaning plants are based on purifier type separators. 传统的清洁装置是基于净化器式分油机。During operation, cleaned oil and separated water continuously discharged. 在运转过程中, 清洁的油和分离出来的水连续排出来。An interface is formed in the bowl between the water and the oil. 在水和油之间在分离筒内部形成一个油水分界面。This interface position is affected by several factors, such as density, viscosity, temperature and flow rate. 这个分界面的位置取决于几个因素, 如密度、粘度、温度和流量。

To achieve the best possible separator, the interface must be located between the outer edge of the top disc and the disc stack. 为了获得最好的分离效果, 分界面必须位于盖盘的外边缘和分离盘组之间。If the interface enters the disc stack, the oil to be cleaned will pass only through the lower part of the disk stack, since the upper part is blocked with water. 如果分界面进入分离

批注 [s5]: 不理解

盘，要清洁的油就只从分离盘下部经过，上半空间充满了水。 Thus, separation is inefficient because only part of the disc stack is being used. Should the interface move outside the top disc the oil will escape through the water outlet. 因此分离效果不好，这是因为只有部分分离盘片有效利用。 To obtain a correct interface the purifier must be fitted with a correct gravity disc. 为了获得正确的分界面，分油机必须安装正确的重力环。 A too large gravity disc may cause a broken water seal and oil losses. 一个太大的比重环会破坏水封造成跑油。 A too small gravity disc contributes to poor separation efficiency and carries over of water into the clean oil outlet. 一个太小的分离盘会导致分离效果差，还会造成净油口出水。

During separation, the basic problem in treating lube oil in purifiers is the gravity disc. 在分离润滑油过程中，主要问题是重力环的选择。 The interface position will move into the disc stack if the temperature increases or if the flow rate, density or viscosity decrease. 如果温度升高或者流量、密度、粘度降低，分离界面都会移向分离盘， Should the interface enter the disc stack water will escape with the cleaned oil into the oil outlet. 如果分离界面进入分离盘片，将会造成出油口跑水 The interface position will move towards the periphery if the temperature decreases or if the flow rate, density or viscosity increase. 如果温度降低或者流量、密度、粘度升高，分离界面将会向外边缘移动。 Should the interface reach the outside of the top disc a broken water seal will occur, with consequent oil loss checking and fitting the gravity disc is a time-consuming and unpleasant task. 如果分界面到了盖盘的外面，那么水封就会被破坏，就会跑油，检查更换重力环是一个耗时费力的工作。 Since the correct gravity disc is defined as the largest disc that does not cause a broken water seal, it can be a frustrating trial-and-error process. 正确的重力环是一个不破坏水封的最大的环，找出正确的重力环是一个麻烦的试凑过程。 Alarm for broken water seals can be frequent. 经常会出现水封破坏报警， Consequently, the gravity disc selected not to be big enough and there is a risk that the oil is not adequately cleaned. 因此重力环不要选择太大，但是也有一个油不能充分净化的问题。 Oil losses are reduced by addition of displacement water to the separator bowl prior to a sludge discharge. (排渣) 跑油可以通过在排渣过程之前向分离桶额外供入一些置换水得到减轻 This pushes the interface into the disc stack, and increases the volume of water in the bowl. 这时分界面向分离盘内部移动，分离桶内部水的体积增加。 Sludge that has not settled in the sludge space will enter the disc stack, and deposits might be formed on the discs. 没有在泥渣空间沉下来的泥渣也进入分离盘片，就有可能在分离盘片上沉淀下来。

With a total discharge type purifier large oil losses occur on sludge discharge. 全排放型分油机会在排渣过程中造成大量跑油。 The entire contents of the separator bowl are emptied, including not only sludge and separated water but also the oil between the water layer and the centre of the bowl. 整个分离桶内部是空的，不仅包括泥渣和分离出来的水也包括水层和分离桶中心之间的油。 It is impossible to have full displacement of the oil in the bowl without water escaping with the cleaned oil, hence the oil loss with total discharge. 不可能在没有一点水从出油口流出的情况下，完全把分离桶内部的油置换出去，所以全排放情况下总会跑油。 With a partial discharge type purifier there are virtually no oil losses. 实际上部分排放型分油机不会跑油。 The bowl is opened for a shorter period of time, in this type to permit only sludge and water to be discharged. 分离桶只开启很短的时间，这种型号的分油机只允许排放泥渣和水。

## LESSON 7

### Sea Water System 海水系统

Problems are often encountered in sea water systems due to corrosion and erosion phenomena. 由于腐蚀和侵蚀现象使海水系统面临很多问题。These problems arise due to the inherent aggressive chemical nature of sea water or due to the abrasive nature of solids carried in the water causing erosion, or even blockage of passage ways by large agglomerations of biological material, seaweed, shell fish, etc. 这些问题的出现是由于海水内在的化学侵蚀性或者海水中携带的磨蚀性的固体所造成的冲蚀, 或者是一些通路被一些生物、海草贝类等的结块所堵塞。System features that require special consideration in view of the above factors are discussed and may be categorized as follows. 对于以上讨论过的因素系统特性要求进行特别考虑, 可分类如下:

#### **Sea water strainers 海水过滤器**

An incorrect choice of mesh size for the main sea water strainers will frequently give rise to problems of either choking or allowing the passage of excessively large particles into the ship's system. 主海水过滤器网孔规格的选择不正确会经常导致问题出现, 或者是堵塞或者是让特别大的颗粒物通过, 进入船舶系统。

In performing its designed function the sea water strainer will obviously collect material at a rate depending on the degree of contamination of the salt water surrounding the ship. 按照设计功能, 海水过滤器能够依据船舶周围海水的污染程度, 以一定的速率有效地过滤海水中存在的物质, The cleaning of filters must be part of a regular routine and not a chore resorted to when problems occur. 海水过滤器的清洁必须是一项常规性的工作, 不应该是当问题发生时的临时工作。The frequency of cleaning can only be determined in relation to a particular ship and its duty, but even when a routine is established abnormal conditions may well result in the need for more frequent cleaning. 清洁的频率和具体的工作只能由各个船舶决定, 即使制定一个惯例, 一些不正常的条件出现后也需要加大清洁频率。

#### **Distribution pipework 分配管路**

In many cases a single pump is used to supply a number of auxiliary sets and in this case distribution pipework will be used, possibly in the form of a ring main, to supply the various auxiliary sets. 在很多情况下, 一台泵用来给很多辅助设备服务, 这时会用到分配管路 (有可能是环形管路) 来供给各种辅助设备。The danger points here are sudden changes in section or direction where erosion damage may occur, and at any necking down of the pipe, for example where the furthest engine is taken from the main supply rail, where agglomerations of weed, etc. may well occur. 在一些截面或者方向突然改变的危险点会出现侵蚀破坏, 在管路的颈缩处海草等就容易结块聚集, 如最远处的机械从主供给管路引支管处。At every opportunity inspection and attention should be given to these specific areas. 在任何检查的时候, 应该注意这些特殊的区域。

#### **Galvanic corrosion 电流腐蚀**

It must always be recognized that any two dissimilar material immersed in a high conductivity electrolyte, i.e. sea water, forms a galvanic cell. 必须认识到, 任何两种不相似的物质浸在高导电性的电解液中 (如海水) 都会形成原电池。Such a cell will result in rapid attack of the less noble material (anode) transferring material in the form of neutral salts to the more noble cathode. 这样的原电池会使惰性材料 (阳极) 迅速受到腐蚀, 以中性盐的形式向更加惰性的阴极转移物质。This principle is used to advantage where, for example, zinc rods are used sacrificially to protect heat exchanger headers, or even the ship's hull itself. 这个原理可以有效利

用，如用牺牲锌棒来保护热交换器盖，或者是保护船体。

In some cases, manufacturers deliberately incorporate less noble materials in order to ensure that the more critical areas are preferentially protected. 一些情况下，生产厂故意混合一些低惰性材料，以使得更加重要的区域到优先保护。A good example is where copper nickel heat exchanger tubes benefit from the proximity of iron pipework or headers. 一个很好的例子是铜镍热交换器管从附近的铁管或端盖得到保护。It is important that the effect of such protection is not excessive to the extent that the life of the sacrificial end is uneconomic. 重要的是这样的保护效果不能太过度消耗牺牲级的使用寿命，这样是不经济的。Where dissimilar metals are used some relief may be given by insulating the dissimilar metals by gaskets and bolt sleeves. 这种不相似金属可以通过衬垫或套筒把这两种金属绝缘隔开，使它们的原电池现象减轻。The next step is perhaps to coat the inside surfaces of the less noble element with epoxy paint or nylon. 接下来可能是把低惰性原件用环氧树脂漆或者尼龙包起来。However, the process carries two dangers in that the protection given to the remainder of the circuit is lost, and the smallest defect in the coating is immediately the focus of intensive local attack-the smallest pin-hole in the coating will lead to rapid penetration. 然而，这个过程也包含着两个危险，一旦电路一部分的保护失效，在保护层上很小的损坏就会立即形成强烈的局部集中侵蚀，保护层上很小的孔洞很快就刺穿。In these circumstances, therefore, the safest answer is to install sacrificial anodes. 这种情况，最安全的做法是安装牺牲阳极。It should be noted that efficient electrical contact must be made between the anode and the element it is required to protect, as in this case an active cell is required to be formed. 需要注意的是在阳极和被保护的原件之间要有有效地电连接，这样起作用的原电池就形成了。

#### Sea water pump 海水泵

The most frequent problems with salt water pumps are erosion or cavitation damage to the impeller, corrosion to internals and damage or wear to the rotating seal element. 海水泵最容易发生的问题是叶轮的冲蚀和穴蚀、内部的腐蚀及旋转密封部件的损坏和磨损。

#### Heat exchanger headers 热交换器端盖

The headers of heat exchangers form a natural collecting point for all kinds of debris passing through the salt water system, due to the reduction in flow velocity which occurs within them. 热交换器端盖可以形成一个自然收集点，收集各种通过海水系统的碎片。This in turn leads to blockage of the lower tubes by sand, weed, etc. and can also lead to increased local velocities at the inlets to the tubes causing **curing** of the tube ends due to turbulence. 这样就导致了热交换器下部的管子被沙子、海草等堵住，进而使管子入口速度增加，由于湍流使管子端部产生穴蚀。

批注 [s6]: Caving??

#### Heat exchanger 热交换器

Heat exchanger tubes are frequently attacked by sea water because of turbulence within the tubes causing pitting and eventual leakage. 由于管内部海水的湍流，热交换器的管子经常受到海水的侵蚀，在管子上造成麻点最后漏泄。Alternatively, a build-up of corrosion products may cause a local turbulence, leading to eventual local pitting. 或者是，出现腐蚀导致局部湍流，最后出现麻点蚀斑。A general build-up of deposits resulting a loss of **thermal efficiency** and leads in turn to overheating problems. 出现一个普通的沉淀，就会导致热效率降低，进而导致过热问题。Regular cleaning will extend the life of heat exchanger tubes considerably. 定期清理会相当程度的延长热交换器的寿命。

批注 [s7]: Heat transfer

It is not possible, for the operator to control the corrosive nature of sea water but the two main subsidiary causes, flow velocity and entrained solids are within the control of the operator to a greater or lesser extent. 对于一个使用者不可能控制海水的腐蚀性，但是另两个次要原因，

流速和携带的固体应该被操作者控制在一定范围内。All the above potential trouble spots are in some way or another contributed to by either excessive flow, or entrained solids, and care in maintaining the sea water strainers in an effective condition and in maintaining the sea water flow at the designed figure will pay dividends in reducing replacement cost and maintenance work throughout the life of the machinery. 所有以上潜在问题点一定程度上都是因为流速过快或携带的固体物过多所造成的, 仔细维持海水滤器的有效工作状态, 保持海水在设计流速下工作将会对降低更换成本有好处, 设备的使用过程中应始终有维护保养。It should be emphasised that the results of excessive flow in particular can be dramatic, a 30 to 40 percent excess of flow may well decrease the life of heat exchanger tubes by a factor of 10.应该强调的是尤其是超流速时会导致非常夸张的结果, 流速升高30-40%热交换器管路的使用寿命会降低十倍。

## LESSON 8

### Maintenance Procedures

### For Reciprocating Air Compressors

### 空压机的维修程序

Since marine compressors are encountered in several forms of two major groups, comments on maintenance will be made by following the passage of air and oil through each form of machine.因为船用压缩机分为两大类型, 以多种形式存在, 所以在每种形式中, 空气和油的维护将通过下面的段落进行阐述。

#### **Air Filter空气滤器**

Although there are many types of air filters, it is unusual to find either the cell type or the oil bath type units in marine service, and certainly the automatic viscous-impingement intake air filters are only for use on very large land installations. 虽然有许多类型的空气滤器, 但是在船用滤器中, 壳式和油洗式滤器不是很常见, 当然自动式的粘滞撞击滤尘器只是在非常大型的陆上装置得到使用。The dry type of filter, as used on marine compressors, has a filtering media of either felted cloth or paper, the latter usually being slightly oil coated. 在船用压缩机上使用的干式滤器, 有一层毡布或纸质的过滤介质, 后者通常覆有少量的油膜。This type of filter is quite satisfactory although its strength is sometimes suspect on higher speed machines.虽然有时它的强度在高速机上令人怀疑, 但是这种型号滤器的过滤效果是非常令人满意的。The most widely used type of filter is the viscous impingement type filter, usually of cylindrical design and the filtering media usually being woven copper wire or nylon strands, which are, when cleaned, dipped in oil and allowed to drain before fitting. 最为广泛使用的滤器是粘滞撞击型的滤器, 通常设计成圆柱型, 而过滤介质通常是由编制的铜线或尼龙绳做成, 在安装之前需要清洁时, 可以浸到油里让杂质流走。The oil coating then traps the dirt quite satisfactorily, since the atmosphere for the marine compressor is usually fairly clean. 由于船用压缩机的周围大气非常干净, 滤器的油膜可以令人满意的困住污垢。This type of filter is also quite acceptable for oil free machines, if the unit is being used for control air.假如无油设备用于产生控制空气, 这种滤器对于它们也是令人满意的。First stage failures have, on occasions, been caused by some of the copper wire being teased loose and the pulsating air flow bending the strands backwards and forwards until a strand has broken free and lodged awkwardly in either a valve or piston clearance. 有时一些蓬松的铜丝会引起第一级压缩失效, 脉冲空气流会使滤丝前后弯曲直到其彻底脱

落,非常危险的聚集在阀或活塞的间隙处。In general, the nylon strand is much more resilient in this respect.通常,尼龙绳在这方面的适应性较强。It is essential that the filter is kept in a clean condition so that the air pressure drop across the filter is kept to an absolute minimum, and the engineer in charge of the compressors should accept as his responsibility the blanking off of the air inlet before any painting takes place, as should this area be painted it will cause too great a pressure drop. 保证滤器清洁是非常关键的,可使经过空气滤器的压力差保证在一个绝对的极小值,负责维护压缩机的轮机员必须承担责任,在刷油漆之前,堵住空气进气口,假如这个区域被油漆的话,会引起一个巨大的压力降。This point is well worth inspecting after any painting in the compressor vicinity.在空气压缩机附近刷完油漆之后,这个区域都值得仔细检查。

### **First Stage Valves—级气阀**

All modern marine compressors use automatic valves which operate on low pressure differential.所有的现代船用压缩机都使用低压差控制的自动阀。It is usual for the suction valve to have a lower spring pressure than the delivery valve and it is, therefore, most important that whenever a valve is stripped for cleaning and/or maintenance, the parts are put back correctly and even if springs look similar, that no interchange between suction and delivery valves is made.对于进气阀来说,通常它的弹簧力低于排气阀,因此在任何时候对阀进行拆检清洁或维修,把元件正确的放回原位都非常重要。即使弹簧力看起来相似,也不能把吸气阀和排气阀进行互换。When selecting spare springs or plates from the Spares Inventory, care must be taken that the right part is selected.当从备件清单上选择备用弹簧或阀盘时,必须注意选择正确的部件。The valve is the heart of the machine and, since it operates once every revolution, the valve movements are extremely frequent and, because of this, the valve lifts are kept extremely low to reduce impact forces.由于机器每次旋转时,阀件都要动作,并且动作的频率非常高,所以阀件是机器的核心。因为这个,阀的提升要保持足够的低来降低冲击力。The spring assembly design is very critical to ensure correct valve action.装配设计的弹簧力对保证阀的正确动作非常关键。It is extremely important, therefore, that the valve design is not altered in any way without contacting the compressor manufacturer.因此非常重要是在没有联系压缩机制造商的情况下,阀的设计不能以任何方式改变。Valve failure will occur due to wear and fatigue, and is a function of the compressor design; therefore, if failures occur from this facet on a frequent basis, it is almost certainly due to the wrong machine selection, or if on a lubricated machine, to insufficient oil carry over. Naturally, if the compressor is overheating wear and fatigue will occur.由于阀的磨损和疲劳,会引起它的失效,这和压缩机的设计有密切关系;因此假如在这个层面上发生故障,几乎可以确定是由于机器的错误选择引起的或者假如是一个油润滑机器,就是润滑油不足引起的。假如压缩机过热,磨损和疲劳将会自然的发生。

Failures will also occur due to the presence of foreign particles. If these are of a solid nature they are, normally, quite readily detected, since they will also usually affect other running parts. However, if in liquid form, this liquid is either being drawn into the machine or, in the case of non-oil free machines, is caused by excessive oil coming past worn pistons and rings.由于存在外来的颗粒物,也会发生故障。假如它们具有固体性质,正常情况很容易被发现,因为他们通常会影响到其它的运转部件。但是假如以液体形式存在,这种液体会被吸进机器内,或者对于无油机器来说,是由于过多的油流经破损活塞和活塞环。

Carbon deposits from the oil also cause valve wear and breakages, and it is, therefore, important that the compression chambers and oil usage are carefully examined. 由油产生的积碳也会引起阀的磨损和破坏,因此对压缩室和油量的仔细检查非常重要。On all non-oil free

machines some carboning of valves will usually take place but, providing the valves are not found excessively carboned when maintenance is carried out to the manufacturer's recommendations, the problem can be accepted as normal. 在所有的无油机器中, 通常也会发生阀的积碳, 但是当按照制造商的建议进行维修时, 阀上不会有过多的积碳, 这个问题可以认为正常。It is usual for the suction valve to be relatively free from carbon except on its bore contact side, where the carbon deposits should be fairly low, but the delivery valve will usually carbon up on both its inner and outer surfaces, since the air stream through the valve is hot and contaminated by the lubricating oils, except, of course, on oil free machines.通常对于吸气阀, 除了和气缸接触侧有少量积碳之外, 相对来说没有积碳, 但是排气阀会在内表面和外表面都有积碳, 因为经过气阀的气流非常热并容易被润滑油污染, 当然无油机器除外。

Valves should be removed, dismantled and inspected at frequent intervals, as recommended by the compressor manufacturer. 根据压缩制造商的推荐, 阀件必须频繁的拆除, 拆卸和检查。Depending on the condition of the valves, the intervals between inspections can be reduced or extended, providing worn parts can be replaced before failure. 根据气阀的工作情况, 检查间隔可以缩短或者延长, 保证破损的部件在失效前得到跟换。In the event of a broken valve being found, all the parts should be located, otherwise they might cause damage to other parts of the machine. Ail valve parts should be carefully and thoroughly cleaned with a cleansing fluid, using a soft brush. Sharp edged tools and wire brushes should never be used to clean valve seats and plates. 倘若发现阀件破损, 所有的破碎部分位置必须确定, 否则可能引起机器的其它部件损坏。所有的阀件部分必须仔细并彻底的用干净的流体和软刷清洁。尖锐的工具和铁丝刷不能用于阀座和阀盘的清洁。Ail parts which are worn, damaged or cracked must be replaced. Valve plates which are worn on one side should never be turned over and used. 所有破损, 毁坏或者有裂纹的部件必须更换。一侧破损的阀盘不能调转使用。To ensure good sealing between valve seat and plate, each part should be lightly lapped, separately, on a smooth flat surface. 为了保证阀座和阀盘良好的密封, 在光滑平整的表面上, 每个部件都应稍微磨平。After valves have been reassembled, check by using a small piece of wood that the plates are free to move and will fully open. 在阀件重新组装之后, 可以用一小块木头检查阀盘是否能自由运动并完全开启。Valves are usually seated in the cylinder either by metal to metal contact or using a gasket. 坐落在气缸上的阀件是金属与金属接触或者使用了一个垫圈。The former should be lapped together if there are signs of dents, nicks or scratches, to provide a leak-proof joint. 假如有伤痕, 刻痕或者擦伤的迹象, 前者必须在一起磨平来保证接合处防漏。In the case of gaskets it is best to fit new parts each time valves are inspected. 就垫圈来说最好每次对阀件检查时安装新的元件。When replacing the valves in the cylinder, special care should be taken to ensure that the suction and delivery valves are installed in their respective ports and that the correct clearance is maintained between the valves and pistons. 当更换气缸上的阀件时, 必须注意保证吸气和排气阀安装在各自的气口上, 并保持气阀和活塞之间有正确的余隙。

#### **First Stage Intercooler一级中冷器**

Intercoolers usually cause very little problem providing the water side of the tubes is kept free of fouling. 假如冷却管水侧没有污垢, 那么中冷器通常不会出现问题。On the air side, if the machine is correctly cooled and there have been no excessive temperatures caused by valve failures, etc. it should be relatively clean with only oil smear present. 在空气侧, 假如机器被正确的冷却, 就不会由于阀的故障等问题引起过高的温度, 空冷器要保证相对清洁并只有油点出现。If excessive temperatures have been present, it will often be found that the delivery valve, although showing signs of heat, is relatively free from carbon, but the cooler inlet is heavily

carboned on its immediate entrance. 假如出现过高的温度, 虽然排气阀有热的迹象, 但是相对来说在排气阀处通常没有积碳, 但是在靠近冷却器进口的地方有严重积碳。This carbon will sometimes also affect the relief valve, so carboning in this area is a defect that must be treated very seriously and the cooling of the machine investigated. 有时积碳也会影响安全阀, 所以这个区域的积碳是一个缺陷, 必须严格处理, 并检查机器的冷却效果。The function of the intercooler is to reduce the air temperature to as low a figure as possible before proceeding to the next stage, and in doing this it brings the air below its dew point and condensate is collected at the outlet end of the cooler. 中冷器的功能是在空气进入下一级之前把它的温度降到一个足够低的数值, 为了做到这一点, 要让空气在露点以下流动, 而凝水可以聚集在冷却器的出口端。It is extremely important that this condensate is kept drained from the machine, preferably by an automatic drain; alternatively by a partially opened drain valve. 极为重要的是保证机器内凝水要保持放残, 最好是自动放残; 一种替代方法是部分开启的放残阀。The seating of a drain valve which is partially open will quickly be damaged by wire drawing and cause maintenance problems. Manual blow down at frequent intervals, say every half to one hour, is not normally possible under present day operating conditions. 部分开启的放残阀阀座会由于金属丝划痕快速损坏并引起维修问题。经常手动放残, 比如说半小时到一小时, 在目前的日常工作情况下是不可以接受的。

#### **Second Stage Valves 二级气阀**

The configuration of these valves is identical to the first stage valves, except they are usually smaller, since the air is reduced in volume due to it having been compressed in the first stage, and also the scantlings are usually heavier since the stage pressure to be withstood is higher. 除了阀件较小以外, 这些阀件的外形和一级气阀是相同的, 因为空气在被第一级压缩之后体积会减小, 同时由于需要承受的级间压力升高, 阀件通常较为厚重。Maintenance should be carried out in a similar manner, and at the same intervals as the first stage valves. 维修可以以一级气阀相同的维修方式和维修间隔进行。

#### **After Cooler and Fusible Plug 后冷却器和易熔塞**

The comments on the intercooler are applicable to the after cooler, but since the pressures are higher and usually the inlet temperatures are also higher, the cleanliness of this cooler is more critical from a safety point of view. 对中冷器发表的看法适用于后冷却器, 但是从安全的观点来看, 因为空气压力变高并且进气温度较高, 后冷却器的清洁更为关键。It should be noted, however, that this cooler has absolutely no bearing on the compressor performance since its action takes place after all work has been done on the air, and its function is to bring the delivery temperature to a reasonable figure and, in doing so, remove condensate from the air. 然而必须注意后冷却器对压缩机的性能绝对没有影响, 因为它发生作用是在对空气所有做功完成之后, 并且它的功能是把排气温度降到一个合理的数值, 通过这个过程, 可以除掉空气中的凝水。

Although all marine compressors usually have a fusible plug fitted immediately on the outlet of the after cooler to meet Classification Society regulations, this fusible plug does not contribute to machine safety in any way whatever, but only to the safety of the system after the machine's outlet. 虽然所有的船用压缩机通常会在后冷却器的出口直接安装有易熔塞来满足船级社的规章制度, 但是它对机器安全性的任何方面都没有帮助, 只是对压缩机出口后的系统安全起作用。This can readily be seen by looking at the following calculations, which compare a machine running normally with a machine running with an abnormal outlet temperature from the cylinder, the temperature is still below the fusible point of the fusible plug at the after cooler outlet, due to the natural phenomenon of greater heat removal with the greater air temperature differential

between the cooling water and the air temperature. 这个可以很容易的通过下面的推断得出, 比较一个正常运转的机器和一个气缸出口温度不正常的运转机器, 由于在冷却水和空气温度之间有巨大的温差, 可以通过消除大量热量的自然现象, 让气体温度仍然低于在后冷却器出口上易熔塞的熔点。For example, the excessive air temperature could be caused by a badly seated valve, allowing recirculation to take place into the cylinder. 举个例子来说, 过高的空气温度可能是坏的阀座引起的, 即空气重新循环进入气缸。

## LESSON 9

# TURBOCHARGER SYSTEMS 涡轮增压器系统

Turbocharging is a method by which energy in the cylinder exhaust gas is used to provide air for combustion. 涡轮增压器利用汽缸排气的能量为燃烧过程提供空气。Four stroke cycle engines may operate in a normally aspirated mode, which means that the suction stroke of the piston draws air into the cylinder and so no pressurized air supply is necessary. 四冲程柴油机可以自然换气, 也就是说吸气行程是活塞把空气抽到气缸内, 不必要供入压缩空气。A two stroke cycle engine requires air to be supplied at a pressure above atmospheric and so some means of providing that pressurized supply is necessary. 二冲程柴油机需要高于大气压力供气, 因此必须要有一些供气方式也就是压力供气方式。A four stroke cycle engine can, therefore, operate without a pressurized combustion air supply but a two stroke cycle engine cannot. 因此一台四冲程柴油机没有压力供气可以正常工作, 但是一台二冲程柴油机却不行。However, the operation of a pressure charged four-stroke engine under non-pressure charged, or normally aspirated conditions, is not advised as it is likely to result in severe fouling and possible thermal damage. 然而, 一台增压式四冲程柴油机工作于没有增压或自然吸气状态是不明智的, 这样会导致严重的脏污或可能的热力损坏。

### **Turbocharger 涡轮增压器**

A turbocharger consists of two parts, the gas side which comprises the turbine and the air side which comprises the rotary compressor. 一个涡轮增压器有两部分组成, 废气侧是透平而空气侧是旋转的压气机。Turbine disc and compressor impeller are mounted on the same shaft. 涡轮盘和压气机叶轮固定在同一根轴上。For smaller units the rotor, which comprises two sections of shaft and a turbine disc, may be a single forging. 对于小型设备, 其转子的两个组成部分轴和涡轮盘可以铸成一体。For larger units the turbine disc is separate and the sections of shaft are attached by bolted flanges. 对于大型单元, 涡轮盘是分开式的, 通过螺栓与法兰和轴相连。Bearings support the rotor at its ends and the cast iron casing is water cooled. 轴承在转子的两端支撑, 铸铁外壳是水冷式的。At the compressor end the casing is of aluminum alloy and is uncooled. 压气机端的外壳是铝合金制作的非水冷式的。Some engines may be fitted with what are known as 'uncooled' turbochargers. 一些柴油机可能装配非冷却式的涡轮增压器。These are compact units with a bearing at the centre of the shaft, with the turbine disc and compressor impeller located at opposite ends of the rotor. 这些类型的增压器是紧凑型结构, 轴承位于轴的中部, 涡轮盘和压气机叶轮分别位于转子的两端。

### **Turbocharger Arrangement**

Although the design of turbochargers may differ the fundamental principles are the same for all models. 尽管各个增压器的设计不同, 但是对于所有模式的基本原理都是相同的。It is the principles which will be considered here, together with the arrangements as they relate to medium speed engines. 下面将讨论增压器的工作原理, 以及中速机增压器的安排布置。

A turbine consists of a single row of rotating blades mounted on a disc. 一个涡轮由一圈固定在涡轮盘上的旋转叶片所组成。Gas is directed onto the moving blades by an annular arrangement of nozzle blades. 通过喷嘴叶片的环形布置, 废气直接喷到旋转叶片上。Moving blades fit axially into the disc using inverted fir-tree roots, or similar. 旋转的叶片以反杉树根形或相似形状, 轴向安装在涡轮盘上。Blade design, both moving and fixed, is critical to performance and varies according to the type of turbine system. 无论是转动叶片还是固定叶片都要严格根据涡轮系统的类型来设计或做适当改变。Although the pulse system of turbocharging has been very popular for medium speed engines, and remains so, constant pressure systems are often employed where high powered engines are used for propulsion purposes. 尽管脉冲式涡轮增压器已经普遍用于中速柴油机, 但即使如此, 定压式增压系统也经常用在一些用于推进目的的大功率柴油机上。V type engines normally have separate turbochargers for each bank of cylinders. V型柴油机每一列汽缸单独使用一个增压器。

#### **Turbocharger, Pulse System 脉冲增压系统**

The pulse system makes use of the high pressure kinetic and thermal energy in the exhaust gas when the exhaust commences, and the timing of the exhaust is critical to turbocharger performance. 脉冲增压系统利用排气开始时废气中的高压动能和热能, 排气开始的时间对增压器的性能有较大影响。Early opening of the exhaust was often employed as a means of obtaining sufficient exhaust gas energy. 经常利用排气阀提前开启的方法来获得足够的排气能量。This system has proved popular as it enables the turbocharger to supply sufficient air for good combustion at all loads. 这种系统很受欢迎, 它在柴油机各种负荷下, 都能提供足够的空气, 保证燃烧良好。The pulse system employs relatively small bore pipes connecting the cylinders to the turbocharger, to avoid a loss of gas energy in the exhaust piping. 脉冲系统使用相对较细的管子连接汽缸和增压器, 避免排气管中废气能量的损失。Exhaust gas flows from each cylinder for about 120°; to avoid interference between pulses, groups of three cylinders are generally connected to particular sections of turbocharger nozzle. 每个汽缸废气的排放大约持续120°曲轴转角, 为了避免脉冲之间相互干扰, 每三个汽缸分成一组连接到增压器喷嘴的一个特定区域。This implies a multiple inlet arrangement for the turbine. 这就意味着一台增压器有多个进气口。A six-cylinder engine would require two turbocharger entries and a nine-cylinder engine, three entries, or two turbochargers. 一台六缸柴油机将有两个增压器进气口, 一台九缸柴油机将会有三个进气口或有两台增压器。Pulse systems are ideally suited to engines where frequent and large changes in load take place, such as those used for electrical generation, but their exhaust gas piping systems can become complex particularly for engines with a large number of cylinders. 脉冲式增压系统安装到负荷大小频繁变化的柴油机上比较理想, 比如用在发电机上。但是它们的排气系统可能变得复杂, 尤其是汽缸数目很多的柴油机。Turbine and nozzle blades must be designed to cope efficiently with the wide range of gas pressures which exist over a cycle, which implies relatively thick blade sections with well rounded entry noses. 涡轮和喷嘴的叶片必须设计能够有效地适应每个排气过程中排气压力的巨大变化, 这就要求叶片的截面相对较厚并且要有较好的圆形的进气口。

#### **Turbocharger, Constant Pressure System 定压增压系统**

The constant pressure turbocharging system has all cylinders supplying exhaust gas to a large

volume manifold, which then directs the gas to the turbocharger nozzle ring. 定压增压系统把各个缸的废气都排到一个大的废气总管中, 然后直接把废气供到喷嘴环。Pulse or kinetic energy is not required, so exhaust can commence later in the piston stroke achieving a slight increase in cylinder power. 不需要利用脉冲能和动能, 所以活塞行程中排气可以稍晚一点开始, 这样可以使每个汽缸的功率稍微有些提高。Exhaust gas in the manifold is maintained at a relatively steady pressure, at any particular engine load, and so the turbine and nozzle blades can be designed to suit steady conditions. 在任何特殊的柴油机负荷下, 排气总管中的废气维持在一个相对稳定的压力, 所以涡轮和喷嘴的叶片可以设计成适合稳定工况的形状。Blade sections tend to be thinner and have sharper noses than for pulse blading. 相对于脉冲式系统, 定压系统叶片的截面倾向于较薄且进气口比较尖一些。Constant pressure systems do not react as quickly to sudden load changes, but they are more efficient and have a relatively simple exhaust pipe arrangement. 定压系统对于突变负荷的反应不快, 但是它们效率高且排气管布置相对简单。

#### **Turbocharger Compressor 涡轮增压器的压气机**

The turbocharger turbine drives a rotary compressor which consists of an impeller and volute casing. 涡轮增压器的涡轮驱动一个由叶轮和蜗壳组成的压气机。Air enters the impeller at its centre or 'eye'; rotation of the impeller imparts a high velocity to the air which then moves outwards into the stationary diffuser and volute casing. 空气从中心的“眼”进入压气机叶轮, 叶轮的旋转传递给空气一个很高的速度, 然后空气流到外部一个静止的扩压器和蜗壳中。This casing has a steadily increasing cross sectional area and is like an inverted nozzle wrapped around the impeller. 蜗壳有一个不断增加的横截面积, 像一个反向的喷嘴缠绕在叶轮的外部。The volute converts velocity energy into pressure energy, just as a nozzle converts pressure energy into velocity energy, and the air leaves the compressor casing at a relatively low velocity but at increased pressure. 蜗壳把速度能转化为压力能, 就像一个喷嘴把压力能转化为速度能, 空气以一个相对较低的速度但是较高的压力离开压气机壳体。The impeller is basically a disc with a number of radial vanes which reduce in depth from the eye to the periphery. 叶轮是一个带有一些径向叶片的圆盘, 叶片的高度从中心向圆盘的边缘递减。The rotor assembly, comprising turbine, shaft and impeller, is a balanced set but the impeller can be removed from the rotor. 转子组件是由涡轮、轴和叶轮组成的一个平衡设备, 叶轮可以从转子上拆卸下来。The impeller fits onto the rotor using a splined connection. 叶轮通过花键连接到转子上。In order to preserve balance the impeller is made so it will only fit onto the rotor in a particular position, usually by having one of the splines larger than the rest. 为了保证平衡, 叶轮制作成只能安装在转子的特定位置上, 通常是花键中的一个键比其它的大一些。A suction filter is provided before the eye of the impeller to remove dust and oil particles which could build up on the impeller, volute and cooler, reducing performance. 叶轮中心吸入孔之前安装一个吸入滤器, 用来除去灰尘和油颗粒, 灰尘和油颗粒会在叶轮、蜗壳和空气冷却器上聚集, 降低增压器的性能。The filter acts as a silencer but insulating felt on the suction manifold also reduces noise. 滤器可以作为一个消音器, 但是吸气总管内部的绝缘毛毡也可以降低噪音。

#### **Intercooling 中间冷却器**

Air cooling is achieved by means of one or more intercoolers located between the impeller outlet and the air manifold, which runs the length of the engine. 空气冷却是通过一个或多个位于叶轮出口和空气主管之间的中冷却器来实现, 它和主机的长度一样。These coolers are comprised of a number of finned tubes through which cooling water flows, the air flowing over the fins. 冷却器是由一些带有翅片的管子组成, 冷却水在管内流动, 空气流过翅片。The use of fins increases the effective heat transfer surface area and allows a reduction in the physical

external dimensions of the cooler. 翅片的使用增加了有效传热面积, 允许冷却器物理外形尺寸降低。Provision must be made for thermal expansion of the tubes, generally by employing U-tubes which have in-built compensation for thermal expansion. 必须提供管路的热膨胀空间, 运用内置U形管补偿热膨胀。Water inlet and outlet headers are then provided on the same side of the cooler making for more accessible pipe connections. 冷却水的进出口端盖设计在冷却器的同一侧, 使管路连接更容易。In some cases water separators are fitted in order to remove any water drop which might form during cooling of the combustion air. 一些情况下会安装除水器来除掉在空气冷却过程中产生的水滴。Water entering the cylinder can remove the oil film from the cylinder liner but this is more of a problem with two stroke cycle engines, where the air enters through ports in the lower part of the liner rather than valves in the cylinder head. 水进入汽缸会破坏汽缸套上的油膜, 这个问题在二冲程柴油机中更为严重, 二冲程机中, 空气不是从汽缸盖上的进气阀进入汽缸, 而是从汽缸下部的进气口进入汽缸。

#### **Turbochargers Matching to Engine 涡轮增压器与柴油机的匹配**

Highly rated high powered engines used for propulsion must be capable of meeting a wide range of loads. 额定功率高的柴油机用来作为推进主机必须能够满足负荷的大范围变化。However, cylinder conditions must be kept within certain limits in terms of maximum pressure and temperature. 然而, 就最大压力和最高温度而言, 汽缸的工作条件也必须保持在一定的限度内。In many cases turbochargers are matched to the engine so that they produce nominal full output at about 85 per cent of engine power. 在很多情况下, 涡轮增压器与主机相匹配, 发出名义全负荷输出, 该负荷为柴油机功率的85%。At higher loads the engine produces too much exhaust gas energy for the turbine. 在高负荷下, 柴油机为涡轮机提供了过多的废气能量。A waste gate is fitted in the exhaust manifold to the turbine so that some of the exhaust gas can be directed to the uptake rather than passing through the turbine. 在通往涡轮机的废气总管上安装多余废气旁通挡板, 这样一些废气可以直接通往烟囱而不经涡轮机。Similarly an air waste gate may be fitted to the air supply manifold to release excess combustion air pressure. 类似也可以在空气总管上安装多余空气挡板, 用来释放过高的空气压力。Turbochargers fitted to engines have to deal with wide load ranges and they cannot be efficient at all loads. 柴油机的增压器必须能工作于各种负荷条件下, 但是它们不能在全负荷条件下都有较高的效率。At high loads too much combustion air may be supplied, which can have an adverse effect on the engine. 在高负荷时, 可能会向柴油机提供过多的空气, 但是却会对柴油造成不利的影响。The use of exhaust gas and air waste gates enables the turbocharger(s) to provide high charge air pressures at low powers. 废气和空气旁通挡板的使用能够使增压器以较低的功率向柴油机提供较高的进气压力。This improves fuel consumption, produces a reduction in thermal loadings and allows for better response to load changes. 这改善了燃油的燃烧, 降低了热负荷, 提高了负荷变化的响应。Engines running at variable speed may be fitted with a charge air bypass which effectively puts some of the charge air into the exhaust gas trunk under certain operating conditions. 变速工作的柴油机可能安装空气旁通装置, 该装置在一定工作条件下有效地把一些空气通入排气总管。The use of the charge air bypass permits the matching of valve overlap and turbocharger for best specific fuel oil consumption (SFOC) when the by-pass is closed and avoids the risk of turbocharger surging at lower powers when the bypass is open. 使用新鲜空气旁通允许气阀重叠和涡轮增压相匹配, 以保证当旁通关闭时, 有最佳燃油消耗率; 旁通阀打开时, 防止增压器在低负荷喘振。Depending on the engine design and operating conditions a charge air waste gate, exhaust waste gate and charge air bypass may be fitted. All devices are operated automatically by the engine's control system. 进气旁通挡板、废气旁通挡板和新鲜空气旁通门依

照设计和使用条件有可能安装，所有这些装置都是由柴油机控制系统来自动操作的。

## LESSON 10

# ENGINE GOVERNOR

### 柴油机调速器

A governor maintains the engine speed at the desired value no matter how much load is applied. 不管所用的负载如何变化，调速器能够保持柴油机的转速在一个期望值上。It achieves this by adjustment of the fuel pump racks. 可以通过燃油泵的齿条调整来实现。Any change in load will produce a change in engine speed, which will cause the governor to initiate a fuel change. 负载的任何变化将会产生一个柴油机转速的变化，从而引起调速器开始燃油调整。The governor is said to be speed sensing as a speed change has to take place before the governor can react to adjust the fuel setting. 调速器被认为是速度识别，因为速度变化发生在调速器对燃油设定做出反应之前。The simple mechanical governor employs rotating weights which move outward as the speed increases and inward as the speed reduces; this movement, acting through a system of linkages, can be used to regulate the fuel rack. 这种简单的机械式调速器采用飞重，当速度增加时，飞重向外移动，而当速度减少时，飞重向内移动；这种运动通过联动装置起作用，可以用于控制燃油齿条。Rather than having the rotating weights directly move the fuel linkage, hydraulic governors employ a servo system so the rotating weights only need to move a pilot valve in the hydraulic line. 液压调速器采用伺服系统，所以飞重只需要移动液压管路的控制阀，而不是让飞重直接移动燃油联动装置。This makes the governor more responsive. Governors of this type require a speed change to take place in order that they may initiate fuel rack adjustment. This is known as speed droop and there is a definite speed for each load therefore the governor cannot control to a single speed. 这样让调速器反应更加灵敏。为了实现燃油齿条的调整，这种类型的调速器需要产生一个速度变化，这就是速度降。每个负载有一个确定的速度，因此调速器不能控制单一的速度。A modification to the governor hydraulic system introduces a facility known as compensation which allows for further fuel adjustment after the main adjustment has taken place due to speed droop. 调速器液压系统的改变是采用一个补偿装置，可以让由于速度降引起的主要调整发生之后，允许进一步的燃油调整。Compensation restores the speed to its original desired value so the engine can operate at the same speed under all loads. Such a governor is said to be isochronous as the engine operates at a single speed. However, the governor is still speed sensing and so is not ideal for all applications. 补偿让速度恢复到原来的期望值，这样柴油机可以在所有负载下工作于同一速度。因为柴油机在单速下运转，所以这种调速器被认为是同步的。但是调速器始终进行速度监测，所以不是对于所有的应用都是理想的。

### Speed Sensing Governor 速度感应调速器

Where the engine drives an alternator any speed change results in a change in supply frequency. Large changes in electrical supply frequency can have an adverse effect on sensitive electronic equipment connected to that supply. 柴油机驱动的交流发电机的任何速度变化将导致供电频率的变化。供电频率大的变化对连接到电网上的敏感电子设备有一个有害的影响。Where electrical generation is involved it is possible to monitor the electrical load and use this as a means for actuating the governor response, rather than simply taking rotational speed as the

control signal. 在需要电力供给的地方就可以监控电力负载，使之作为促使调速器响应的一个手段，而不是简单的把旋转速度作为控制信号。 Such governors are known as load sensing. It is extremely difficult to make a mechanical governor load sensing, even with a hydraulic system, but an electronic governor can take account of the electrical load applied to the engine and so can be considered 'speed sensing'. 这种调速器被称为负载感应。机械调速器的负载感应是极为困难的，即使液压系统也是如此，但是电子调速器能够考虑应用到柴油机的电力负载，所以被认为是“速度感应”。

#### **Electronic Governor 电子调速器**

Electronic governors essentially comprise two parts, the digital control unit and the hydraulic actuator, which are interlinked but it is useful to consider them separately. 电子调速器有必不可少的两部分组成，电子控制单元和液压执行器，它们之间互相连接但是让两者分开是非常有帮助的。

#### **Electronic Governor Controller 电子调速器控制器**

The digital control may be considered as a 'black box' in which signals are processed to produce a control signal which is sent to the actuator. 电子控制可以被认为是一个“黑箱”，在“黑箱”里信号经过处理产生一个控制信号被送到执行器。The controller may be programmed in order to set points and parameters. The controller is a sensitive piece of electronic equipment and should not be mounted on the engine or in areas where it will be exposed to vibration, humidity or high temperatures. 为了设定控制点和控制参数，可以对控制器编程。控制器是一个敏感的电子设备，不能安装在柴油机上或者暴露于振动，潮湿或者高温的区域中。It should be ventilated in order to keep it cool and should be shielded from high-voltage or high-current devices which will cause electromagnetic interference. 为了保证控制器冷却必须保持通风，并要屏蔽将会引起电磁干扰的高压或大电流装置。Similar restrictions apply to the location of signal cables. Speed signals are taken from two speed transducers, one on each side of the flexible coupling which attaches the engine to the load. 同样的限制适用于电缆的安放位置。速度信号通过两个速度传感器采集，安装在连接柴油机和负载之间的弹性联轴器两侧。Failure of one transducer produces a minor alarm but allows continued operation with an electronic over speed value may be programmed into the controller in which case detection of over speed will cause the engine to be shut off. 一个速度传感器失效会产生一个小的报警但是允许电子设备的继续运行。超速数值可以编程进入控制器内，一旦检测到超速信号就会引起柴油机停车。If the load is provided by an electrical machine the output from that machine provides a signal for load sharing. Should this transducer fail the load on the engine will be determined by the position of the governor actuator output. 假如负载由电器设备驱动，那么电器设备会提供一个输出信号用来负载分配。万一传感器失效，柴油机上的负载将由液压执行器输出状态决定。The controller can also receive signals from other transducers including the engine's air inlet pressure, which allows the fuel to be limited when starting. After processing input signals in accordance with programmed requirements an output signal will be sent to the governor actuator. 控制器也能从其它的传感器接受信号，包括柴油机的进气压力，当起动的时候来限制燃油的供油量。在对输入信号按照程序要求处理之后，输出信号被送到调速器执行器。

#### **Electronic Governor Actuator 电子调速器执行器**

The actuator is a hydraulic device which moves the fuel linkage in response to a signal from the digital controller. The operating mechanism is contained within an oil filled casing. 执行器是一个液压装置，可以驱动燃油连杆，对来自于数字控制器的信号做出反应。这个工作机构放置在一个充满油液的箱子中。Oil pressure is provided by a servomotor pump driven by a shaft

connected to the engine camshaft. At the heart of the actuator is the torque motor beam, which is balanced when the engine is operating at the desired speed. 油液压力由一个伺服电动泵提供，它通过连接在柴油机凸轮轴上的轴系驱动。执行器的核心是一个力矩马达杆，通过柴油机工作在一个设定速度下与之平衡。

a. Consider a load increase. 负载增加时

The controller increases current to the torque motor which, in turn, causes the centre adjust end of the torque motor beam to be lowered. Oil flow through the nozzle is reduced, which increases pressure on the top of the pilot valve plunger. 控制器会增加力矩马达的电流，相应的会引起力矩马达杆的复位端降低。经过喷嘴的油液流量降低，从而导阀柱塞顶部的压力升高。This moves downward, uncovering the port which allows pressure oil to the lower face of the power piston, which in turn moves upwards, rotating the terminal shaft thereby increasing the fuel to the engine. 柱塞向下移动会打开油口，让压力油流向动力活塞的下端面，相应的会让活塞向上移动，旋转终端轴，因此增加了柴油机供油量。As the terminal shaft rotates the torque motor beam is pulled upwards by increased tension in the feedback spring, increasing the clearance between the centres adjust and the nozzle. 随着终端轴旋转，通过反馈弹簧张力增加，力矩马达杆被向上拉伸，增加复位端和喷嘴的间隙。Leakage past the nozzle increases, reducing the pressure on the upper face of the pilot valve plunger and allowing the pilot valve to move upwards. 经过喷嘴的泄漏量增加，降低了导阀活塞上端面的压力，从而让导阀向上移动。This cuts off further oil to the power piston, and movement of the fuel control linkage ceases. Balance is restored to the torque motor beam with downward force from the feedback spring being matched by upwards force from oil leakage from the nozzle. 这样会进一步切断到动力活塞的油液，并且燃油控制杆的运动停止。从反馈弹簧来的向下的力与喷嘴泄漏引起的向上的力相匹配，重新让力矩马达杆恢复平衡。The engine then operates at an increased fuel setting which matches the new load requirement at the set speed. 然后柴油机就工作在一个供油量增大后的设定位置，在设定转速下与新的负载要求相匹配。

b. Consider a load reduction. 负载减少时

A decrease in load produces a reduction in current acting on the torque motor, which tends to turn the beam in an anti-clockwise direction about the torque motor pivot, resulting in an increased clearance between the centre adjust and the nozzle. 负载减少会让作用在力矩马达上的电流降低，引起控制杆绕着力矩马达支点逆时针方向转动，导致复位端和喷嘴之间间隙加大。Pressure reduces on the upper face of the pilot valve plunger and the pilot valve moves upwards, allowing the lower face of the power piston to connect with the geromotor pump suction. 在导阀柱塞上端面的压力会降低，导阀向上移动，让动力活塞的下端面与伺服电动泵的吸入口连接。The power piston moves downwards, rotating the terminal shaft which reduces fuel to the engine and tension in the feedback spring. 动力活塞向下移动，旋转终端轴，从而降低柴油机供油量和减少反馈弹簧张力。The centre adjust end of the torque motor beam is forced down, thereby reducing clearance between the centre adjust and the nozzle. 力矩马达杆的复位端受力向下，因此减少了复位端和喷嘴之间的间隙。Leakage past the nozzle reduces pressure on the upper face of the pilot valve increases and the pilot valve moves upwards, shutting off the connection between the lower face of the power piston and pump suction. The engine now operates with reduced load and reduced fuel, but at the same original speed. 经过喷嘴的泄漏减少，在导阀上端面的压力就会升高，推动导阀向上移动，关闭动力活塞下端面与液压泵吸入口的连接。这样柴油机可以在低负荷和低耗油量下工作，但是和原来的旋转速度一样。

### Engine Over speed Trip 柴油机超速装置

An over speed trip is required to ensure the fuel supply will be removed from an engine should its speed exceed a predetermined value. 假如柴油机转速超过了预先设定值，那么需要一个超速装置保证柴油机的燃油供给被切断。Any over speed device requires manual resetting. It should not be able to automatically reset after speed is reduced as the reason for over speeding may still exist and the engine will race again.任何超速装置都需要手动重新设定。在柴油机速度下降以后，一定不能自动的重新设定，因为超速原因仍然可能存在，柴油机将会重新超速。Over speeding results if the engine load is suddenly removed by, for example, failure of a clutch or fracture of an alternator drive shaft. 举个例子来说，假如离合器失效或者发电机驱动轴断裂，柴油机的负载会突然消失，结果就会出现超速。It is unusual for over speeding to occur due to governor failure as fuel linkages are normally arranged so that failure in any part of the governor system results in fuel being shut off. 由于调速器失效而引起的超速是不正常的，因为一旦调速器系统任何部分失效，都会导致正常布置的燃油控制杆切断燃油。Some engines are fitted with two independent over speed devices, an electro-pneumatic device with a tripping speed set about 15 percent above the nominal speed and a mechanical device set to about 18 per cent above nominal speed.一些柴油机安装两个独立超速装置，一个电气装置，跳闸速度设定在正常速度的15%以上，一个机械装置，设定在正常速度的18%以上。The electro-pneumatic device, as fitted to Wartsila engines, has spring loaded pneumatic cylinders at each fuel pump, and when tripping occur each fuel pump rack is moved to the 'no-fuel' position.对于安装在瓦锡兰柴油机上的电气装置来说，在每个燃油泵上有一个弹簧加载气缸，当跳闸发生，每个燃油泵齿条就被移动到“停油”位置。During normal operation the spring force keeps the operating end of the rod clear of the pin at the end of the fuel rack, which can therefore be moved to any fuel position.在正常工作条件下，弹簧力保证控制杆的工作端没有和燃油齿条的末端销子接触，这样齿条就可以被移动到任何的油门位置。Should over speed occur a solenoid valve is actuated which allows air into the cylinder to act on the piston, moving it against the spring force. 一旦发生超速，电磁阀被触发，让空气进入到气缸内作用在活塞上，移动活塞来克服弹簧力。This causes the operating end of the piston rod to pull the pin on the end of the fuel rack fully over, shutting off fuel completely. 这样会引起活塞杆的工作端把燃油齿条末端的销子完全拉到一边，完整的切断供油。A simple mechanical device may have a spring loaded button set into the rotating camshaft; when the speed exceeds a certain value, centrifugal force causes the button to move outward against the spring and actuate a system of levers which will move the fuel regulating lever to the full-off position. Both over speed devices can be tripped manually if required.一个简单的机械装置可能有一个弹簧加载按钮组设置在旋转的凸轮轴上；当柴油机转速超过某一数值时，离心力会让按钮克服弹簧力向外移动，并且触发控制杆系统，将燃油控制杆移动到全关位置。按照需要两个超速装置可以被手动跳闸。

## LESSON 11

### INTELLIGENT ENGINES 智能柴油机

Both MAN B&W Diesel and New Sulzer Diesel demonstrated 'camshaft less' operation with

their research engines, applying electronically controlled fuel injection and exhaust valve actuation systems. MAN B&W 和New Sulzer 柴油机厂商利用他们研究的柴油机说明了无凸轮轴运行过程, 无凸轮轴柴油机应用电子技术控制燃油喷射系统和排气阀启闭系统。Continuing R&D will pave the way for a future generation of highly reliable 'intelligent engines': those which monitor their own condition and adjust parameters for optimum performance in all operating regimes, including fuel-optimized and emissions-optimized modes. 不断地开发研究为将来生产高可靠性的智能柴油机做好了准备, 在所有运行期间它们能够自己监测本身的工作状态, 不断调整参数实现最佳工作性能。包括燃油优化模式与排放优化模式。An intelligent engine-management system will effectively close the feedback loop by built-in expert knowledge. 智能柴油机的管理系统通过内置的专家知识形成有效地闭环反馈回路。

Engine performance data will be constantly monitored and compared with defined values in the expert system; if deviations are detected corrective action is automatically taken to restore the situation to normal. 不断地监测发动机的性能参数, 与专家系统规定的值进行比较, 如果发现偏差, 会自动采取正确的动作使系统状态恢复正常。A further step would incorporate not only engine optimizing functions but management responsibilities, such as maintenance planning and spare parts control. 进一步来看, 智能柴油机不仅包括柴油机的优化功能也包括管理方面的职责, 比如维护保养计划和备件控制等。

To meet the operational flexibility target, MAN B&W Diesel explains, it is necessary to be able to change the timing of the fuel injection and exhaust valve systems while the engine is running. 为了满足操作上的灵活性 (MAN B&W 柴油机厂商观点) 柴油机运转的时候, 必须能够改变燃油喷射系统和排气系统的正时, To achieve this objective with cam-driven units would involve a substantial mechanical complexity which would undermine engine reliability. 凸轮轴驱动单元为了实现这个目的就要增加大量机械复杂性, 这会降低柴油机的可靠性。

To meet the reliability target it is necessary to have a system which can actively protect the engine from damage due to overload, lack of maintenance and maladjustments. 为了满足可靠性, 必须要有一个系统, 它能够防止柴油机由于超负荷、疏于维护保养和误调整所造成的损坏。A condition monitoring system must be used to evaluate the general condition of the engine, thus maintaining its performance and keeping its operating parameters within prescribed limits. 一个状态监控系统必须用来评估柴油机的整体状态, 维持它的工作性能, 保证运行参数在规定的范围内。The condition monitoring and evaluation system is an on-line system with automatic sampling of all 'normal' engine performance data, supplemented by cylinder pressure measurements. 状态检测和评估系统是一种在线系统, 该系统能够自动抽取所有正常的柴油机性能参数, 再通过汽缸压力测量单元增补一些数据。The system will report and actively intervene when performance parameters show unsatisfactory deviations. 当性能参数间出现令人不满意的偏差, 这个系统将会汇报并积极调整。The cylinder pressure data delivered by the measuring system are used for various calculations: 汽缸压力数据由测量系统传送给用来各种计算:

1. The mean indicated pressure is determined as a check on cylinder load distribution as well as total engine output. 平均指示压力是用来检查各缸上的负荷分配和整个柴油机的功率输出。
2. The compression pressure is determined as an indicator of excessive leakage caused by, for example, a burnt exhaust valve or collapsed piston rings (the former condition is usually accompanied by an increased exhaust gas temperature in the cylinder in question). 压缩压力是一些过度漏泄的指示, 例如一个烧坏的排气阀或失效的活塞环都会引起

漏泄，排气阀烧坏通常伴有该缸排气温度升高的问题。

3. The cylinder wall temperature is monitored as an additional of the piston ring condition. 监测汽缸壁温度可以作为活塞环的额外检测。
4. The firing pressure is determined for injection timing control and for control of mechanical loads. 发火压力用力控制燃油喷射正时和机械负荷。
5. The rate of pressure rise and rate of heat release are determined for combustion quality evaluation as a warning in the event of 'bad fuels' and to indicate any risk of piston ring problems in the event of high  $dp/dt$  values. 压缩比升高和放热率用来评估燃烧质量，如果燃烧质量差的燃油也可以作为警告，如果有高的压力温度比，可以指示出活塞环存在问题的风险

The cylinder condition monitoring system is intended to detect faults such as blow-by past the piston rings, cylinder liner scuffing and abnormal combustion. 汽缸状态监控系统用来发现一些故障，如活塞环漏气、汽缸套刮伤和不正常燃烧。The detection of severe anomalies by the integrated systems triggers a changeover to a special operating mode for the engine, the 'engine protection mode'.一旦通过整个系统发现严重的不正常事件，就触发一个完全不同的特殊的运行模式，柴油机的保护模式。The control system will contain data for optimum operation in a number of different modes, such as 'fuel economy mode', 'emission controlled mode', 'reversing/crash stop mode' and various engine protection modes. 控制系统会中止从最优操作获得数据，而运行在一些不同的模式，如燃油经济模式、排放控制模式、倒车/突然停车模式和各种柴油机保护模式。The load limiter system (load diagram compliance system) aims to prevent any overloading of the engine in conditions such as heavy weather, fouled hull, shallow water, too heavy propeller layout or excessive shaft alternator output. 负荷限制系统的目的是防止柴油机在一些情况下有任何超负荷的现象发生，比如恶劣天气、船舶污底、浅水域、螺旋桨太重或者轴带发电机的输出过大。This function will appear as a natural part of future governor specifications.这些功能将看起来是未来管理规范中很正常的一部分。

The fuel injection system is operated without a conventional camshaft, using high pressure hydraulic oil from an engine-driven pump as a power source and an electronically controlled servo system to drive the injection pump plunger. 燃油喷射系统不用传统的凸轮轴驱动，而是利用柴油机轴带泵作动力源输出高压液压油来保证喷射系统工作，一个电子控制的伺服系统驱动喷射泵的柱塞。The INFI (intelligent fuel injection) system and the INVA (intelligent valve actuation) system for operating the exhaust valves, when operated in the electronic mode, receive the electronic signals to the control units. 当柴油机运行在电子模式，智能燃油喷射系统和操作排气阀的智能阀启闭系统从控制单元获得电信号。In the event of failure of the electronic control system the engine is controlled by a mechanical input supplied by a diminutive camshaft giving full redundancy.如果电子控制系统失效，柴油机通过备用的小型凸轮轴的机械输入来控制，

Unlike a conventional, cam-driven pump the INFI pump has a variable stroke and will only pressurize the amount of fuel to be injected at the relevant load. 不像传统的凸轮轴驱动的燃油喷射泵，智能燃油喷射泵有一个变化的冲程，在相应的负荷下压缩需要喷射的燃油量。In the electronic mode (that is, operating without a camshaft) the system can perform as a single injection system as well as a pre-injection system with a high degree of freedom to modulate the process in terms of injection rate, timing, duration, pressure, single/double injection, cam profile and so on. 在电子模式下（也就是没有凸轮轴驱动），喷射系统按单

批注 [s8]: 意思对否?

批注 [s9]: From?

喷射系统工作，也就是一个预喷射系统，它能够根据喷射率、喷射正时、喷射持续时间、喷射压力、单喷/双喷、凸轮轮廓等可以高度自由调整喷射过程。Several optimized injection patterns can be stored in the computer and chosen by the control system in order to operate the engine with optimum injection characteristics at several loads: from dead slow to overload as well as for starting, astern running and crash stop. 一些优化的喷射方式能够储存在计算机里，在一些负荷形势下，可由控制系统选择合适的方式，使柴油机以最好的燃油喷射特性工作，比如从微速到超负荷，还有启动、倒车和突然停止。Changeover from one to another of the stored injection characteristics is affected from one injection to the next. 突然从储存的一种喷油特性转换为另一种的时候，前一个喷油特性会影响的下一个喷油特性。The system is able to adjust the injection amount and injection timing for each cylinder individually in order to achieve the same load (mean indicated pressure) and the same firing pressure in all cylinders; or, in protection mode, to reduce the load and on a given single cylinder if the need arises. 系统能够单独调整每一个缸的喷的量和喷油正时，这样能够实现每一个缸达到相同的负荷（平均指示压力）和相同的发火压力，在保护模式时，如果某一个缸需要的话，可以单独降低该缸的负荷。

The exhaust valve system (INVA) is driven on the same principles as the fuel injection system, exploiting the same high pressure hydraulic oil supply and a similar facility for mechanical redundancy. 排气阀系统的动作原理与燃油喷射系统一样，同样利用高压液压油和相似的设备作为机械备用。The need for controlling exhaust valve operation is basically limited to timing the opening and closing of the valve. 控制排气阀的动作主要是限制启闭的正时，The control system is thus simpler than that for fuel injection. 因此排气阀的控制系统要燃油喷射系统简单。

Cylinder lubrication is controllable from the condition evaluation system so that the lubricating oil amount can be adjusted to match the engine load. 汽缸润滑系统可以通过状态评估系统控制，润滑油的量可以根据柴油机负荷调整。Dosage is increased in line with load changes and if the need is indicated by the cylinder condition monitoring system (in the event of liner scuffing and ring blow-by, for example). Such systems are already available for existing engines. 润滑油使用剂量的增加与柴油机负荷改变相一致，或者如果需要的话是由汽缸状态监控系统直接指示。

The turbocharging system control will incorporate control of the scavenge air pressure if a turbocharger with variable turbine nozzle geometry is used, and control of bypass valves, turbo compound system valves and turbocharger cut-off valves if such valves are incorporated in the system. 涡轮增压系统的控制包含扫气压力的控制（如果涡轮增压器使用变涡轮喷嘴结构）还包括旁通阀控制、涡轮混合系统阀控制和增压器隔离阀控制（如果系统中装配了这些阀）。Valves for any selective catalytic reduction (SCR) exhaust gas cleaning system installed will also be controlled. 如果安装了任何选择性催化还原排气处理系统，则该系统的阀也需要控制。

Operating modes may be selected from the bridge control system or by the system's own control system. 操作模式可以从驾驶台控制系统选择，也可以从机旁控制系统选择。The former case applies to the fuel economy modes and the emission-controlled modes (some of which may incorporate the use of an SCR system). 前一种情况下，主要考虑燃油经济模式和排放物控制模式（有时可能包含使用催化还原系统）The optimum reversing/crash stop modes are selected by the system itself when the bridge control system requests the engine to carry out the corresponding operation. 当驾驶台控制系统要求执行相应的操作，系统本身会选择倒车/突然停止的优化模式。Engine protection mode, in contrast, will be selected by the condition monitoring and evaluation system independently of actual operating modes (when this is not

considered to threaten ship safety).另一方面,不依赖于实际操作模式的状态监控系统 and 评估系统会选择柴油机保护模式(当这种选择不会危及船舶安全的时候)。

The fruit of MAN B&W Diesel's and Sulzer's R&D is now available commercially, their respective electronically-controlled ME and RT-flex engines being offered alongside the conventional models and increasingly specified for a wide range of tonnage. 现在,MAN B&W和Sulzer的开发研究成果已经开始商业化,它们各自的电子控制的ME和RT-flex机型和传统机型一起使用,越来越多地用在各种吨位的船上。

Research and development by Mitsubishi, the third force in low speed engines, has successfully sought weight reduction and enhanced compactness while retaining the performance and reliability demanded by the market. 低速柴油机的第三方力量——三菱的研究已经成功发现市场需要柴油机重量降低和增加紧凑性的同时继续保持良好的性能和可靠性 The Japanese designer's current UEC-LS type engines yield a specific power output of around three times that of the original UE series of the mid-1950s. 日本的设计者现在设计的 UEC-LS 型柴油机所产生的功率系数大约是原来 20 世纪 50 年代所产 UE 系列柴油机的三倍。The specific engine weight has been reduced by around 30 per cent over that period and the engine length in relation to power output has been shortened by one-third. Mitsubishi strengthened its long relationship as a Sulzer licensee in 2002 by forging a joint venture with the Wartsila Corporation to develop a new 500 mm bore design to be offered in two versions: a 'mechanical' RTA50C and an 'electronic' RT-flex 50C. 柴油机的比重已经比那个时期大约下降 30%,与功率输出相关的长度已经下降了三分之一。由于 Sulzer 执照持有者在 2002 年与 Wartsila 公司合资发展新的 500mm 缸径的柴油机,这种柴油机有两种形式:一种是机械式的 RTA50C,一种是电子式的 RT-flex 50C,所以三菱公司加强了它的长期关系

批注 [s10]: 不通, 在讨论

## LESSON 12

### Gas-Diesel And 2 Dual-Fuel Engines

#### 气体—柴油和双燃料发动机

Growing opportunities for dual-fuel and gas-diesel engines in land and marine power markets have stimulated designs from leading medium speed and low speed engine builders. 对于双燃料和气体—柴油发动机来说,在陆地和海洋动力的市场中,不断增加的机会激励了设计重要的中速和低速发动机的制造商。Development is driven by the increasing availability of gaseous fuels, the much lower level of noxious exhaust emissions associated with such fuels, reduced maintenance and longer intervals between overhauls for power plant. 使用气体燃料的不断增长驱动了它们的发展,相关燃料的有毒排放物越少,那么维修就会减少并且动力装置的大修间隔就会变长。

Valuable breakthroughs in mainstream markets have been made since 2000 with the specification of LNG-burning engines for propelling a small Norwegian double-ended ferry, offshore supply vessels and a 75 000 cube LNG carrier. 在主流市场里,有价值的突破性进展自从2000年就已经开始,特别是燃烧液化天然气的发动机用来推动小型的挪威首尾同型渡船,近海供应船和75 000立方的液化天然气船。

Natural gas is well established as a major contributor to the world's energy needs. 天然气已经被充分证明是世界能源需求的一个主要贡献方。It is derived from the raw gas from onshore and offshore fields as the dry, light fraction and mainly comprises methane and some ethane. 它是来自于陆地和近海区域的原料气体,干燥,轻馏分并且主要由甲烷和一些乙烷组成。It is

available directly at the gas field itself, in pipeline systems, condensed into liquid as LNG or compressed as **CNG**. 它可以直接被气田区域本身使用, 在管路系统里被冷凝成液体作为液化天然气或者压缩成压缩天然气。

Operation on natural gas results in very low emissions thanks to the clean-burning properties of the fuel and its low content of pollutants. 对天然气的使用会导致非常低的排放物, 由于燃料干净的燃烧特性以及低含量的污染物。Methane, the main constituent, is the most efficient hydrocarbon fuel in terms of energy content per amount of carbon; operation on natural gas accordingly reduces emissions of another key pollutant--carbon dioxide--by over 20 per cent compared with operation on diesel fuel. 在热碳比方面, 主要的组成成分甲烷是最有效的碳氢化合物燃料; 使用天然气会相应的降低另外一种主要污染物的排放—二氧化碳—与使用柴油相比会降低20%。Natural gas has very good combustion characteristics in an engine and, because it is lighter than air and has a high ignition temperature, is also a very safe fuel. 天然气在发动机里有非常良好的燃烧特性, 因为它比空气轻并有一个高的发火温度, 同时也是一种非常安全的燃料。

Wartsila's dual-fuel (DF) four-stroke engines can be run in either gas mode or liquid-fuelled diesel mode. 瓦锡兰双燃料四冲程发动机可以在气体模式或者液体燃料柴油模式下工作。In gas mode the engines work according to the lean-burn Otto principle, with a lean premixed air-gas mixture in the combustion chamber. (Lean burn means the mixture of air and gas in the cylinder has more air than is needed for complete combustion, reducing peak temperatures). 在气体模式下发动机根据稀薄燃烧的奥拓原理工作, 在燃烧室里有稀薄的预先混合的空气—天然气混合物。(稀薄燃烧表示为了燃烧完全, 降低最高燃烧温度, 气缸里空气和天然气的混合物中的空气比需要的空气量更多。Less NOx is produced and efficiency increases during leaner combustion because of the higher compression ratio and optimized injection timing. A lean mixture is also necessary to avoid knocking (self-ignition). 在稀薄燃烧过程中, 由于高的压缩比和优化的喷射定时, 氮氧化物的产生量更少, 效率变高。稀薄混合物也需要避免敲缸(自燃)。

The gas is fed into the cylinder in the air inlet channel during the intake stroke. 在吸气行程过程中, 天然气通过空气道供给到气缸中。Instead of a spark plug for ignition--normally used in lean-burn gas engines--the lean air-gas mixture is ignited by a small amount of diesel fuel injected into the combustion chamber. 在正常情况下, 稀薄燃烧的天然气发动机使用火花塞点火, 但是稀薄的空气—天然气混合物是通过喷射进入燃烧室内少量的柴油点燃的。This high energy source ensures reliable and powerful ignition of the mixture, which is needed when running with a high specific cylinder output and lean air-gas mixture. 这种高的能量源保证混合气体被可靠并且强力的点燃, 对于气缸输出与稀薄空气—天然气混合物之间的高比值发动机是必须的。To secure low NOx emissions it is essential that the amount of injected diesel fuel is very small. The Wartsila DF engines therefore use a 'micro-pilot injection', with less than 1 percent diesel fuel injected at nominal load, to achieve NOx emissions approximately one-tenth those of a standard diesel engine. 为了获得低的氮氧化物排放, 喷射的柴油必须是少量的。因此瓦锡兰的DF型发动机使用“微量控制”喷射, 喷入低于标准柴油机中正常载荷下消耗柴油的1%, 获得大约十分之一的氮氧化物排放量。

When the DF engine is running in gas mode with a pre-mixed air-gas mixture the combustion must be closely controlled to prevent knocking and misfiring. 当DF型柴油机使用预先混合的空气—天然气混合物在气体模式下工作时, 必须精密控制来防止敲缸和发火失败。The only reliable way to effect this, says Wartsila, is to use fully electronic control of both the pilot fuel injection and the gas admission on every cylinder head. 瓦锡兰公司说, 为了实现这一点, 只有

一个可靠的方法就是在每个气缸头上使用全电子控制的燃料预先喷射和天然气输入。The global air-fuel ratio is controlled by a waste gate valve, which allows some of the exhaust gases to bypass the turbine of the turbocharger. This ensures that the ratio is of the correct value independent of changing ambient conditions, such as the temperature.总的空气—燃料比是通过一个废气闸阀,允许一些排气经过涡轮增压器的涡轮机旁通。这样保证比率是一个准确的数值,不依赖于环境条件的变化,比如温度。

The quantity and timing of the injected pilot fuel are adjusted individually together with the cylinder-specific and global air-fuel ratio to keep every cylinder at the correct operating point and within the operating window between the knock and misfire limits. 引燃燃料的数量和定时是单独调整,与单位气缸和总的空气—燃料比一起保证每个气缸在合适的工作点上并且位于敲缸和发火失败的工作区间之间。This is the key factor for securing reliable operation in gas mode, automatically tuning the engine according to varying conditions, Wartsila explains.瓦锡兰解释,这是保证在气体模式下可靠运行的关键因素,根据变化的情况自动地对发动机调整。

In diesel mode the engine works according to the normal diesel concept using a traditional jerk pump fuel injection system: diesel fuel is injected at high pressure into the combustion chamber just before the top dead centre.在柴油模式下,根据正常的柴油观点,柴油机使用一个传统的高压燃油喷射泵的燃油喷射系统工作:柴油在上止点前被高压喷射进入燃烧室。Gas admission is de-activated but the pilot fuel remains activated to ensure reliable pilot ignition when the engine is transferred to gas operation.当发动机转变到气体模式运行时,进入的气体是没有活性的,但是引燃燃料能够保持能量确保可靠的引燃。

The gas pressure in the engine is less than 4 bars at full load, making a single-wall pipe design acceptable if the engine room is arranged with proper ventilation and gas detectors.假如机舱布置有合理的通风和气体检测器,发动机内的气体压力在全负荷下低于4巴,就可以设计制作一个值得接受的单壁管道。The gas valve on every cylinder head is a simple and robust, electronically-controlled solenoid valve, promising high reliability with long maintenance intervals.每个气缸头上的气阀是简单和坚固的,是一个电子控制式的电磁阀,可以确保很长维修间隔内的可靠性高。

The pilot fuel system is a common rail system with one engine-mounted high pressure pump supplying the pilot fuel to every injection valve at a constant pressure of 900 bars. Due to the high pressure a double-walled supply system is used with leak fuel detection and alarms.引燃燃料系统是在一个普遍的共轨系统上有一个机器,这个机器上安装有高压油泵以900巴的恒定压力供给引燃燃油到每个喷射阀。由于压力高,使用一个双壁的带有燃料泄漏检测和报警的供给系统。The injection valve is of twin-needle design, with the pilot fuel needle electronically controlled by the engine control system.喷射阀是双针阀设计,通过柴油机的控制系统对引燃燃料的针阀进行电子控制。It is important that the injection system can reliably handle the small amount of pilot fuel with minimum cycle-to-cycle variation. The main needle design is a conventional system in which mechanically-controlled pumps control the injection.非常重要是喷射系统能够在最低限度的循环变化下,可靠的处理少量的引燃燃料。主要的针阀结构是一个常规的系统,在系统内由机械装置控制的泵来控制喷射。

Other main components and systems are similar to designs well proven over a decade on Wartsila standard diesel engines, further underwriting high reliability of the dual-fuel engines.其它的主要部件和系统与过去十年间瓦锡兰经过广泛设计验证的柴油机相似,从而进一步保证双燃料发动机的可靠性。

## LESSON 13

# Exhaust Emissions And Control 废气排放和控制

Marine engine designers in recent years have had to address the challenge of tightening controls on noxious exhaust gas emissions imposed by regional, national and international authorities responding to concern over atmospheric pollution. 近些年船用柴油机设计者不得不集中精力应对严格控制有毒废气排放物的挑战，这些控制是各地区、国家和世界的权力机构为防止大气污染所提出的强制要求。

Exhaust gas emissions from marine diesel engines largely comprise nitrogen, oxygen, carbon dioxide and water vapor, with smaller quantities of carbon monoxide, oxides of sulphur and nitrogen, partially reacted and non-combusted hydrocarbons and particulate material 船用柴油机的废气排放物的组成主要有氮、氧、二氧化碳和水蒸气，少量的一氧化碳、硫氧化物和氮氧化物，部分反应但没有燃烧的碳氢化合物和颗粒物。

Nitrogen oxides (NOx)--generated thermally from nitrogen and oxygen at high combustion temperatures in the cylinder--are of special concern since they are believed to be carcinogenic and contribute to photochemical smog formation over cities and acid rain (and hence excess acidification of the soil). 氮氧化物是由氮和氧在汽缸中高温条件下热反应所生成的，由于它们被认为有致癌性、会导致城市上空光化学烟雾的形成和酸雨（使土壤过度酸化），所以被特别的关注。Internal combustion engines primarily generate nitrogen oxide but less than 10 per cent of that oxidizes to nitrogen dioxide the moment it escapes as exhaust gas. 内燃机主要产生一氧化氮，但是当废气被排出去的时候仅有不到10%的一氧化氮被氧化成二氧化氮。

Sulphur oxides (SOx)--produced by oxidation of the sulphur in the fuel--have an unpleasant odor, irritate the mucus membrane and are a major source of acid rain (reacting with water to form sulphurous acid). 硫氧化物由燃油中的硫氧化而来，有难闻的气味，刺激黏膜还是酸雨的主要来源（与水反应形成硫酸）Acid deposition is a trans-boundary pollution problem: once emitted, SOx can be carried over hundreds of miles in the atmosphere before being deposited in lakes and streams, reducing their alkalinity. 酸的沉降是一个跨地域的污染问题，一旦产生后，硫氧化物可以被空气携带几百英里，然后沉降到湖里河里，降低它们的碱度。

Sulphur deposition can also lead to increased sulphate levels in soils, fostering the formation of insoluble aluminum phosphates which can cause a phosphorous deficiency. 硫的沉积导致土壤中硫酸盐含量提高，促进了不溶性磷酸铝的形成，这样就导致土壤中磷酸盐的缺乏。Groundwater acidification has been observed in many areas of Europe; this can lead to corrosion of drinking water supply systems and health hazards due to dissolved metals in those systems. 在欧洲的许多地区已经发现地下水的酸化，导致饮用水供应系统的腐蚀，由于金属溶解在系统里又对健康造成伤害。Forest soils can also become contaminated with higher than normal levels of toxic metals, and historic buildings and monuments damaged. 有毒金属的含量超过正常水平，森林的土壤也会被污染。历史建筑和遗迹也会遭到破坏。

Hydrocarbons (HC)--created by the incomplete combustion of fuel and lube oil, and the evaporation of fuel--have an unpleasant odor, are partially carcinogenic, smog forming and irritate the mucus membrane (emissions, however, are typically low for modern diesel engines.) 燃油和润滑油的不完全燃烧以及燃油蒸汽生成碳氢化合物，它有难闻的气味、部分致癌性，能形成油

雾，刺激黏膜（现代柴油机的排放物低）

Carbon monoxide (CO)--resulting from incomplete combustion due to a local shortage of air and the dissociation of carbon dioxide--is highly toxic but only in high concentrations.局部缺少空气所造成的不完全燃烧和二氧化碳的分解都会产生一氧化碳，浓度较高时一氧化碳有高毒性。

Particulate matter (PM) is a complex mixture of inorganic and organic compounds resulting from incomplete combustion, partly unburned lube oil, thermal splitting of HC from the fuel and lube oil, ash in the fuel and lube oil, sulphates and water. 颗粒物是不完全燃烧的无机化合物和有机化合物的混合物，其中包括部分未燃烧的润滑油，燃油和润滑油碳氢化合物的热分裂，燃油和润滑油中的灰分，硫酸盐和水。More than half of the total particulate mass is soot (inorganic carbonaceous particles), whose visible evidence is smoke. 颗粒物一半以上是烟灰（无机碳颗粒），能够看见的证据是烟。Soot particles (unburned elemental carbon) are not themselves toxic but they can cause the build-up of aqueous hydrocarbons, and some of them are believed to be carcinogens. 灰颗粒（未燃烧的碳）本身没有毒性，但是它们能够形成水溶性的碳氢化合物，这多少被认为有致癌性。Particulates constitute no more than around 0.003 per cent of the engine exhaust gases.颗粒物组成大约不超过柴油机排气的0.003%。

Noxious emissions amount to 0.25-0.4 percent by volume of the exhaust gas, depending on the amount of sulphur in the fuel and its lower heat value, and the engine type, speed and efficiency. 有毒排放物的量是废气排放量的0.25-0.4%，主要取决于燃油里的含硫量、燃油的低热值，还有柴油机的类型、转速和效率。Some idea of the actual pollutants generated is provided by MAN B&W Diesel, which cites an 18 V 48/60 medium speed engine in NOx-optimized form running at full load on a typical heavy fuel oil with 4 per cent sulphur content. MAN B&W 柴油机厂提供了实际实际污染物的产量，数据来源于一台18 V 48/60型带有优化氮氧化物形成的中速柴油机，全负荷燃烧含硫量为4%的典型重油。A total of approximately 460 kg of harmful compounds are emitted per hour out of around 136 tones of exhaust gas mass per hour. 每小时排放接近460 kg 的有害化合物，大约136 t的废气。Of the 0.35 per cent of the exhaust gas formed by pollutants, NOx contributes 0.17 per cent, sulphur dioxide 0.15 per cent, hydrocarbons 0.02 percent, carbon monoxide 0.007 per cent and soot/ash 0.003 per cent.废气的0.35%由污染物组成，氮氧化物的量为0.17%，二氧化硫的量为0.15%，碳氢化合物的量为0.02%，一氧化碳的量为0.007%，烟灰/灰分的量为0.003%。

Carbon dioxide: some 6 per cent of the exhaust gas emissions from this engine are carbon dioxide. Although not itself toxic, carbon dioxide contributes to the greenhouse effect (global warming) and hence to changes in the Earth's atmosphere. 这种机型废气排放物中6%是二氧化碳，尽管它本身没有什么毒性但是二氧化碳会引起温室效应（全球变暖），也会改变在地球大气中的比例。The gas is an inevitable product of combustion of all fossil fuels, but emissions from diesel engines--thanks to their thermal efficiency--are the lowest of all heat engines. 二氧化碳是石油燃料不可避免的燃烧产物，但是由于柴油机热效率高，所以它的排放物是所有热机中最低的。A lower fuel consumption translates to reduced carbon dioxide emissions since the amount produced is directly proportional to the volume of fuel used, and therefore to the engine or plant efficiency. 低的燃油消耗就会降低二氧化碳的排放，因为产生二氧化碳的量正比于消耗燃油的量，柴油机或装置的效率 As a rough guide, burning one tone of diesel fuel produces approximately three tones of carbon dioxide.一个粗略的指导意思是，燃烧一吨的船用燃料油就会产约三吨的二氧化碳。

International concern over the atmospheric effect of carbon dioxide has stimulated measures

and plans to curb the growth of such emissions, and the marine industry must be prepared for future legislation.国际上关于二氧化碳对大气影响的关注已经激励出一些方法和计划来抑制二氧化碳排放的增长,船舶工业必须为将来的立法做好准备。

The scope for improvement by raising the already high efficiency level of modern diesel engines is limited and other routes have to be pursued: operating the engines at a fuel-saving service point; using marine diesel oil or gas oil instead of low sulphur heavy fuel oil; adopting diesel-electric propulsion (the engines can be run continuously at the highest efficiency); or exploiting a diesel combined cycle incorporating a steam turbine. The steam-injected diesel engine is also promising.提高效率已经很高的现代柴油机的空间是有限的,应该寻求其它方法,如以省油工况点运行柴油机,以船用柴油或者柴油代替低硫重油,采用柴油机发电---电力推进(柴油机以高效率连续运转),采用柴油机和蒸汽涡轮机混合循环。蒸汽喷射柴油的机器也是很有发展前途的。

Compared with land-based power installations, fuel burned by much of shipping has a very high sulphur content (up to 4.5 per cent and more) and contributes significantly to the overall amount of global sulphur oxide emissions at sea and in port areas. 与陆地用动力装置相比较,大多数船舶燃料油有非常高的含硫值(高达4.5%,甚至还高),在海上和港口区域对全球硫氧化物的排放量起到了重要的影响。Studies on sulphur pollution showed that in 1990 SOx emissions from ships contributed around 4 per cent to the total in Europe. 硫污染方面的研究显示,欧洲1990年船舶排放的硫氧化物大约占总排放的4%, In 2001 such emissions represented around 12 per cent of the total and could rise to as high as 18 per cent by 2010.2001年船舶排放大约占总排放的12%,到2010年能够升到18%。

SOx emissions in diesel engine exhaust gas--which mostly comprise sulphur dioxide with a small amount of sulphur trioxide--are a function of the amount of sulphur in the fuel and cannot be controlled by the combustion process. 柴油机废气中的硫氧化物最主要由二氧化硫和一小部分的三氧化硫组成,是燃油中硫含量的函数,不能通过燃烧过程控制其产量。If the fuel contains 3 per cent sulphur, for example, the volume of SOx generated is around 64 kg per ton of fuel burned; if fuel with 1 per cent sulphur content is used SOx emissions amount to around 21 kg per ton of fuel burned.举个例子,如果燃油中含有3%的硫,那么燃烧1吨的燃油大约会产生64公斤的硫氧化物,如果燃油中含有1%的硫,那么每吨燃油大约会产生21公斤的硫氧化物。

Chemical and washing/scrubbing desulphurization processes can remove SOx from the exhaust gases but are complex, bulky and expensive for shipboard applications, and increase overall maintenance costs.化学方法或水洗法的脱硫过程能够从排气中除去硫氧化物,但是设备比较复杂、体积庞大,对于船上应用来说比较昂贵,还增加维护保养费用。The most economical and simplest approach is thus to burn bunkers with a low sulphur content. (If a selective catalytic reduction system is installed to achieve the lowest NOx emission levels--see section below--then low sulphur fuels are dictated anyway to avoid premature fouling of the system's catalyst package.)最经济最简单的方法是燃烧含硫量低的燃油。(如果安装了催化还原系统来降低氮氧化物的排放,见下一章节,应该使用低硫燃油来避免系统的催化还原包提前脏污。)

A global heavy fuel oil sulphur content cap of 4.5 percent and a 1.5 per cent fuel sulphur limit in certain designated Sulphur Emissions Control Areas (SECAS)--such as the Baltic Sea, North Sea and English Channel is sought by the International Maritime Organization (IMO) to reduce SOx pollution at sea and in port. 全球重油硫的含量最高是4.5%,在指定的硫排放物控制区域内,硫的含量限定为1.5%,比如波罗的海、北海和英吉利海峡,国际海事组织要努力实现

硫含量的限定，在海上和港口降低硫氧化物的污染。The European Union strategy for controlling air pollution calls for all ships in EU ports to burn fuel with a maximum sulphur content of 0.2 per cent, which would force unit-fuel ships to carry low sulphur fuel specifically for this purpose. 欧盟控制空气污染的策略是要求所有在欧盟港口的船舶燃烧的燃油含硫值最大为0.2%，为了实现这个目的，特别强制要求所有用油的船携带低硫燃油。

### **Exhaust gas recirculation 废气再循环**

Exhaust gas recirculation (EGR) is a method of modifying the inlet air to reduce NOx emissions, an approach widely used in automotive applications. 废气再循环技术是一种调整进气来降低氮氧化物排放的方法，这种方法在汽车上广泛使用。Some of the exhaust gas is cooled and cleaned before recirculation to the scavenge air side. 一些废气再重新进入扫气侧之前要进行冷却和净化。Its effect on NOx formation is partly due to a reduction of the oxygen concentration in the combustion zone, and partly due to the content of water and carbon dioxide in the exhaust gas. 它对氮氧化物生成影响，一部分是因为在燃烧区域内氧气的浓度降低了，一部分是因为排气中含有水和二氧化碳。The higher molar heat capacities of water and carbon dioxide lower the peak combustion temperature which, in turn, curbs the formation of NOx. 水和二氧化碳较高的摩尔热值降低了燃烧温度的峰值，也就抑制了氮氧化物的形成。

EGR is a very efficient method of reducing NOx emissions (by 50-60 per cent) without affecting the power output of the engine but is considered more practical for engines burning cleaner bunkers such as low sulphur and low ash fuels, alcohol and gas. 废气再循环技术在降低氮氧化物排放方面是一种非常有效的方法，并且不影响柴油机的功率输出。对于燃烧清洁燃料比如低硫、低灰分的燃油，酒精和天然气等，这种方法会更有效。Engines operating on high sulphur fuel might invite corrosion of turbochargers, intercoolers and scavenging pipes. 柴油机燃烧高硫值的燃油会导致增压器、中冷器和扫气管的腐蚀。

Wartsila acknowledges that EGR leads to reductions in NOx emissions but suggests its practical application is limited by the fact that it quite soon starts to adversely affect combustion, leading to increased fuel consumption, particulates, unburned hydrocarbons and carbon monoxide. Wartsila公司确认废气再循环技术使得氮氧化物的排放降低了，但是提出它的实际应用受到了一些事实的限制，就是它在快速投入使用时，会对燃烧造成不利影响，会导致燃油消耗、颗粒物、未燃烧的碳氢化合物和一氧化碳的量都增加。A worse drawback is that, even with an insignificant sulphur content in the fuel, cooling down of the exhaust gas results in a sticky liquid of sulphur acid products, water and soot matter. This makes it difficult to maintain the functionality of the cooling device and, above all, results in a difficult residual product, says Wartsila, which abandoned EGR for diesel engine applications. 一个更坏的缺点是，即使是燃油中几乎不包含硫，当废气冷却下来后，也会形成一些由硫酸、水和烟灰物质所组成的粘稠液体。这就使得冷却器及上面所提到的其他设备正常维持它们的功能变得困难了，Wartsila公司认为产生了一个难于处理的剩余产物，他们放弃在柴油机上使用废气再循环技术。

For low speed engines, especially those with electronically-controlled exhaust valve timing, Wartsila suggests that the Water Cooled Rest Gas technique offers an opportunity for NOx reduction. 对于低速柴油机，尤其是使用电控排气阀正时的柴油机，Wartsila 公司建议使用剩余气体水冷技术，该技术提供了一个降低氮氧化物的机会。In this concept some of the exhaust gas is left in the cylinder, which in normal circumstances leads to increased thermal loading and inferior combustion. 在这个概念中，一些留在汽缸内的废气在正常的情况下，会导致热负荷的增加，使燃烧变差。These drawbacks are largely avoided, however, if the rest gas is cooled by an internal spray of water. 然而，如果这些剩余的气体通过内部喷水冷却，那么这

些缺点就会很大程度的避免。As the surrounding combustion space components are rather hot, there will be no condensation of acid products on the metal surfaces.由于燃烧室周围的部件温度相当高,就不会在金属表面有酸产物冷凝下来。

#### **Fuel nozzles 燃油喷嘴**

Different fuel nozzle types and designs have a significant impact on NO<sub>x</sub> formation, and the intensity of the fuel injection also has an influence.不同的燃油喷嘴型号和设计对氮氧化物的形成有着重要的影响,燃油喷射的强度也有着影响。

The increased mean effective pressure ratings of modern engines require increased flow areas throughout the fuel valve which, in turn, leads to increased sac volumes in the fuel nozzle itself and a higher risk of after-dripping. 现代柴油机平均有效压力等级的增加,需要燃油阀流通面积的增加,依次也就导致燃油喷嘴储液空间的增加,这样就会有后滴的高风险。Consequently, more fuel from the sac volume may enter the combustion chamber and contribute to the emission of smoke and unburned hydrocarbons as well as to increased deposits in the combustion chamber. 因此,更多的燃油可能从储液空间进入到燃烧室内部,导致排烟和未燃烧的碳氢化合物,燃烧空间的沉积物也增加了。The relatively large sac volume in a standard design fuel nozzle thus has a negative influence on the formation of soot particles and hydrocarbons.标准设计燃油喷嘴的储液空间相对较大对灰粒和碳氢化合物的形成有负面的影响。

The so-called 'mini-sac' fuel valve introduced by MAN B&W Diesel incorporates a conventional conical spindle seat as well as a slide inside the fuel nozzle. MAN B&W把所谓小储液空间的喷油阀应用到传统锥形轴座上,同样也在燃油阀内部滑动。The mini-sac leaves the flow conditions in the vicinity of the nozzle holes similar to the flow conditions in the conventional fuel nozzle. 小储液空间使得喷油孔附近油液的流动条件与传统燃油喷嘴相似。But it's much reduced sac volume--only about 15 per cent that of the conventional fuel valve--has demonstrated a positive influence on the cleanliness of the combustion chamber and exhaust gas outlet ducts. 但是进一步降低的储液空间(大约仅是传统喷油阀的15%)已经被证实燃烧室和排气出口管的清洁方面有积极的影响。Such valves also reduce the formation of NO<sub>x</sub> during combustion.这样的喷射阀也降低了燃烧过程中氮氧化物的生成。

A new type of fuel valve--essentially eliminating the sac volume--was subsequently developed and introduced by MAN B&W Diesel as standard to its larger low speed engines. 由MAN B&W公司发展和使用的新型燃油喷射阀完全消除了储液空间,并且作为大型低速机的一个标准。The main advantages of this slide-type fuel valve are reduced emissions of NO<sub>x</sub>, CO, smoke and unburned hydrocarbons as well as significantly fewer deposits inside the engine. 滑动性燃油阀的主要好处是降低了氮氧化物、一氧化碳、烟和未燃烧碳氢化合物的排放,柴油机内部的沉淀物也明显少。A positive effect on the cylinder condition in general is reported.也有报道说在汽缸整体状况方面也有积极地影响。

## **LESSON 14**

### **SEPARATOR DEVELOPMENT**

#### **分油机的发展**

The main aim of centrifugal separators is to remove fuel contaminants--notably water,

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catalyst fines, abrasive grit and sodium from sea water—that can cause excessive wear when burned in the engine. 离心式分油机的主要目的是为了除掉燃油里的杂质—明显的水分，催化剂粉末，以及来自于海水的沙粒和钠—当在柴油机内燃烧时，会引起过度磨损。Continuing development pursues even higher separation efficiencies to maximize engine protection, and more efficient discharge systems that reduce overall discharge volumes; decrease the amount of water used and hence cut the amount of material collected in the sludge tank. 不断的发展追求更高的分离效率，从而可以给柴油机提供最大的保护，以及更加有效的排放系统可以降低总体的排放体积；使用的水量减少可以削减聚集在油渣柜内的材料总量。

When partial discharge type separators replaced total discharge designs the actual oil consumed at each discharge fell dramatically. In the partial discharge process, however, larger volumes of water are needed for displacing the oil interface and for the operating system. 当部分排放式的分油机代替全部排放式的设计时，每次排放的实际耗油量大大降低。但是在部分排放的过程中，油液界面的替换和操作系统需要大量的水。This quantity of water is a major contributor to the overall sludge volume as it too must be processed. 这些水是全部油渣容积的主要贡献者，因为它们也需要被处理。Alfa Laval's Separation Unit exploits a new discharge process called CentriShoot, which combines several design improvements to help reduce the sludge consumption volumes associated with separators: by at least 30 percent and up to 50 percent compared with previous models. 阿法拉阀分离单元采用一种新的排放过程叫做离心射击，结合需要的设计改进来帮助降低和分油机相关的油渣消耗容积：和以前的模式相比，至少是30%，甚至达到50%。

First, the bowl volume and therefore its contents are much lower than equivalent separators, which means that at each discharge the contents discharged will be significantly less. 首先，与相同的分油机相比，分离筒的体积和它的含量更少，也就是说每次排渣时排出的容量会显著减少。Secondly, the frequency of discharge has been extended by around four times compared with partial discharging separators. 其次，与部分排放式的分油机相比，排渣的频率已经延长到大约4次。A new design of discharge slide replaces the traditional sliding bowl bottom; the new component is a form of flexible plate that is secured at the centre, the slide outer edge flexing approximately 1-2 mm at each discharge to allow the sludge to be evacuated through the sludge ports. 一种新设计排渣滑阀替换了传统的滑动底盘；新元件是用柔性板构成，固定在中心处，在每次排放时，滑阀的外边缘挠曲大约1-2毫米，通过排渣口让油渣排出。

Installed as standard in the Separation Unit is a REMIND software package which allows the operator to install the program discs on a laptop computer. Connected to the control cabinet, the system can then review and store the alarm history and processing parameters in the computer. The data can be used later to check processing conditions for trouble shooting. 在分离单元内作为标准安装的是一个记忆软件包，可以让操作者在一个便携式的电脑上安装程序盘。电脑被连接到控制柜，然后系统能够在电脑内回顾并存储历史报警和整理参数。这些数据以后能够用于检查处理过程进行故障诊断。

Westfalia Separator's C-generation family of separators exploits Hydrostop and Softstream systems. 分油机家族中的韦斯伐利亚C代分油机采用流体截止和软流系统。Hydrostop features special discharge ports and a separator bowl architecture allowing more efficient sludge ejections at full operating speed; this, in turn, extends desludging intervals and reduces maintenance costs. 流体截止特点是采用特殊的排渣口和分离筒结构，可以在全部的工作速度下更加有效的排渣；这样会相应的延长清除油渣的间隔并降低维修费用。Softstream allows liquids to enter the bowl in a 'super calm' state, thus improving separator efficiency, increasing

flow rates and reducing component wear. 软流允许液体以一种“超静”状态进入到分离筒内，因此分油机效率提高，流速增加并且元件磨损降低。Typically, says Westfalia, a C-generation separator will reduce sludge volumes by up to 50 per cent during fuel and lube oil purification. The separators can also be specified with Unitrol, a self-thinking system for automatically handling fuel and lube oils of varying quality and density in an unmanned engine room. 韦斯伐利亚公司说，C代分油机最独特的地方是在对燃油和滑油净化的过程中，会降低50%的油渣容积。分油机也被指定装设Unitrol系统，一个自思考系统用来在无人机舱中，自动处理不同质量和密度的燃油和滑油。

Refinements introduced by Mitsubishi Kakoki Kaisha (MKK) in recent years have sought improved overall performance and capacity, easier operation and reduced maintenance from the Japanese designer's Selfjector Future (SJ-F) series of separators. More compact and lighter units have also been targeted.最近几年中，从日本设计的SJ-F系列分油机来看，MKK公司引进的细微改良试图改善总体性能和容量，使其更容易操作并且减少维修。更加紧凑和更轻的装置也是追求的目标。

MKK's Hidens system is offered for treating oils with densities of up to  $1.01 \text{ g/cm}^3$  at  $15^\circ\text{C}$ , the installation comprising the separator, an automatic control panel, water detector, water detector controller and discharge detector. 用MKK的Hidens系统可以处理在 $15^\circ\text{C}$ 时密度达到 $1.01 \text{ g/cm}^3$ 的油液，装置由分油机，自动控制面板，水分检测器，水分检测控制器和排渣检测器组成。The water content of the oil is continuously monitored and when a pre-set maximum level is reached a total discharge function is automatically actuated. 油液中的水分被持续监测，并且当达到预先设定的最高值时，一个全部排放程序自动开启。Among the options that can be specified is a sludge discharge control system that automatically sets the most suitable discharge interval based on feedback from an oil inlet sensor continually measuring sludge concentration in the dirty oil; differences in bunker quality can also be detected at the first stage. 众多功能中需要详述的是排渣控制系统，根据进油口传感器的反馈，可以自动设定最合适的排渣间隔，传感器可以不断的测量污油中油渣浓度；加油质量的差异也能在第一级中被检测出来。A monitoring and diagnostic system can supervise the operating conditions of up to six separators simultaneously. 一个监控和诊断系统能够同时地管理多达六个分油机工作情况。

A homogenizer may be installed to support the separators and filters of a fuel treatment system. 均质器的安装可以为燃油处理系统的分油机和滤器提供支持。The shearing action breaks down particles in the fuel oil to sub-micron sizes and finely distributes any water present as small droplets. 剪切作用会把燃油中的颗粒粉碎到亚微米尺寸并使任何水分呈小水滴分布。A considerable reduction in sludge amounts and improved combustion are claimed. Some homogenizer systems are designed to produce a stable fuel/water emulsion with water amounts up to 50 per cent and higher, contributing to a reduction of NOx emissions in the exhaust gas. 油渣量大量降低并且燃烧改善被证实。一些均质器系统被设计成能够产生稳定的油/水乳化液，含水量达到50%，甚至更高，导致排气中氮氧化物的排放下降。

There is some disagreement, however, over the positioning of a homogenizer in the fuel treatment system (before or after the separator). 但是在燃油处理系统中，对于均质器的位置也有一些不同意见（分油机之前或者之后）。Alfa Laval argues that installing such a unit prior to the separator reduces the ability of the treatment system to remove those particles that can cause damage to the fuel injection system and the main engine, and should therefore be avoided. 阿法拉发认为在分油机前安装这样一个装置会降低燃油处理系统除掉颗粒的能力，这样会对燃油喷

射系统和主机造成损坏，因此必须避免。

The role of filtration systems has been strengthened by higher fuel injection pressures and the wider use of common rail fuel systems. 过滤系统的作用在被高的燃油喷射压力和共轨燃油系统的广泛使用中得到加强。Solids remaining after previous treatment stages are removed from the fuel circuit by manual cleaning in a simplex filter or by an automatic backflushing filter. 先前处理阶段剩余的固体物在燃油回路中被除掉，通过单一滤器的手动清洁或者自动的反冲洗滤器。Common rail fuel systems call for stricter filtration regimes, typically dictating 5-micron filtration to protect injection components from extensive wear. 共轨燃油系统需要更严格的过滤要求，代表性地规定5微米的过滤精度，从而来保护喷射元件以避免过度磨损。Such fine filter elements either translate to a shorter lifetime or larger filter sizes, and this must be compensated by centrifugal separator equipment which is not dimensioned at the maximum flow rate to reach its best possible solid removal performance. 如此细小的过滤元件要么让其使用寿命变短，要么使其过滤尺寸变大，这个必须通过离心分离设备进行补偿。不要在最大流速下对离心分离设备进行设计，目的是为了尽可能的达到最佳的固体物移除性能。

## LESSON 15

# OPERATION

### COMMISSIONING 试车

When an engine is to be run for the first time in the ship or after an extensive overhaul, it is first of all essential to make sure that the various services providing sea water, fresh water, fuel, compressed air and lubricating oil have been checked for cleanliness, satisfactory operation and freedom from leaks. 当柴油机首次在船上运行或者是大修之后，首先最重要的是保证各种服务系统能够提供海水、淡水、压缩空气，检查润滑油洁净度，运行正常，没有漏泄。In the case of lubricating oil, it is prudent to circulate this system for 24 hours or longer with warm oil and with gauzes fitted in the joints of pipes, and with fittings to trap any dirt that may be within the system: 润滑油首次使用的时候，应将润滑油加热，并在管路连接处安装丝网除去系统中可能存在的脏污，然后再谨慎地运行润滑油系统24小时或者更长时间。Hammering the pipes from time to time whilst the circulation is being carried out is also beneficial in dislodging dirt of many kinds that would otherwise stay trapped in the system until released by vibration of the engine when starting to run. 当系统打循环的时候，不时地敲打系统的管路，这样有利于将多种脏污撞击出来，否则的话，脏污会沉积在系统当中，直到柴油机启动运行的时候才能将它们振动下来。The first run of the engine in the ship is the time when it is most vulnerable to damage by various kinds of foreign matter carried in by the lubricating oil. 在船上初次运行是柴油机最容易被润滑油中携带的各种外来物质损坏的时候。

### Preparing to Start the Engine for the First Time 柴油机初次启动的准备

Make sure that the control hand wheel or lever on the engine is in the "stop" position. 确认柴油机控制手轮或手柄处在“停止”位置。Open the outlet valve on the fuel daily service tank and open any valves on the engine necessary to permit the light diesel fuel to circulate. 打开燃油日用柜的出口阀，打开柴油机上的所有阀，有必要允许轻柴油打循环。Vent each element of the light fuel filter and ensure that the system is free from air. 给轻油滤器的每个单元放气，保证系

统里没有空气。

With all the pipes to the fuel pumps open. 打开所有通往燃油泵的管路。Proceed to prime each pump, injection pipe and injector. 进一步给每一个泵、喷射管和喷射器注满油, Any vent screws on the injectors should be unscrewed. 喷射器上的放气旋塞都应该拧开, The fuel pump rack should be pushed to the full position and the pump plunger operated with priming levers or equipment provided until air-free fuel issues from the leak-off Pipe. 燃油齿条应该推到满刻度位置, 用起动注液杆或起动设备操作油泵柱塞, 直到泵内没有空气, 油液从放油管流出来。Tighten the vent screw and again operate the pump until it is felt to go hard, thus indicating that fuel has reached the nozzle. 上紧放气旋塞, 再一次操作油泵直到感觉较硬, 这就意味着燃油已经到达喷嘴了。

The linkage between the governor and the fuel pumps should be checked for freedom of movement; any tendency for it to be stiff or sticky in operation should be rectified and the whole system lubricated before any attempt is made to start the engine. 确认调速器和燃油泵之间的连杆活动自由, 操作上任何不灵活或粘滞的倾向都应该调整, 打算要起动机之前要给整个系统润滑。Particular attention should be paid to the fuel racks to see that they are free. 应该特别注意燃油齿条, 看它是否活动自由。Each rack in turn should be pushed to the maximum fuel position and then released. 每一根齿条都应该推到最大油位然后松开。The spring in the linkage should promptly return the rack to the "no fuel" position. Any rack that is not free should be removed, cleaned and lubricated. 连杆上的弹簧应该迅速将齿条推到停油的位置, 任何活动不自由的齿条都应该拆下、清洁、上油。

Check that the lubricating oil tank is filled to the correct level. 检查润滑油柜的油位处于正确位置。The motor-driven lubricating oil priming pump should then be started and, when oil is seen to be circulating, the engine should be turned manually through two revolutions to make sure that nothing is fouling. 然后应该起动机驱动的润滑油注油泵, 当油液正在循环的时候, 柴油机应该手动转两圈, 确保没有卡阻。

The appropriate valves in the sea water and fresh water circulating system can then be opened. 然后能够打开海水和淡水循环系统中适当的阀门。If separately driven water pumps are used these should be started and a check made to see that circulation through the engine is taking place correctly. 如果使用独立驱动的水泵, 那么这些水泵应该起动机, 检查确认冷却水正确地通过柴油机循环。Any auxiliary systems such as exhaust valve or reject water-cooling systems should then be started up and their operation checked: 任何辅助系统比如排气阀或喷水冷却系统应该起动机, 进行操作检查, If there is a load limit on the governor for starting, this should be set at the appropriate position. 如果调速器有起动机符合限制, 应该把限制手柄放在合适的位置。The trip gear for over speed should be in the correct reset position. Having ensured that the starting air receiver is fully charged the stop valve admitting air to the engine can be opened. 超速跳闸机构也应该正确重新设定, 保证启动空气瓶充满空气, 允许空气通往柴油机的停气阀也应该打开。

### **STARTING 起动机**

The starting and maneuvering of engines is accomplished by the operation of either a hand wheel, or a lever, or a combination of levers according to the make of engine. 柴油机的起动机和机动操作都是由操纵手轮或手柄, 或者是具体柴油机生产商的联合手柄来完成的。The first movement of the hand wheel or lever should be to ensure that the sense of rotation is that which is desired. 手轮或者手柄的初次动作应该保证转动方向与想要的方向一致。The next movement

批注 [s12]: Hand??

of the hand wheel or lever is to a position that is marked "start". 手轮或者手柄的下一个动作是移到标记“开始”的位置。In this position compressed air is admitted to the starting air system and the engine will commence to rotate and then gather speed. 在这个位置压缩空气开始进入启动空气系统，柴油机开始旋转并开始逐渐加速。When the speed is sufficiently high for the engine to fire, the lever or hand wheel should be moved to the "run" position at which compressed air will be shut off and fuel admitted to the cylinders. 当转速足够高到柴油机发火的时候，手柄或手轮就应该推到“运行”的位置，这时切断压缩空气，燃油进入汽缸。When the engine is running on fuel the speed control lever or wheel may be operated to bring the engine up to the desired running speed. 当柴油机靠燃烧燃油运转时，可以操作控制手柄或手轮把柴油机转速提升到想要的转速。

Stopping is accomplished by moving the hand wheel or lever to the position marked "stop". 把手轮或手柄推到“停止”的位置就可以实现停止。This movement cuts off the fuel supply and, usually, automatically resets the mechanism which operates the starting air admission. 这个动作切断了燃油供应，通常自动重新安排机械机构，允许启动空气进入。With some designs it is necessary to move the hand wheel or lever to "stop" by a route which avoids the "start" position: the maker's instructions on this should always be followed carefully. 在一些设计中，有必要按一定的路线移动手轮或手柄到“停止”的位置，这样会避开“启动”的位置，这种设计中应该仔细遵守厂家的指导说明。

#### **FIRST RUN 首次运转**

The first run should be limited to a low speed and low load, preferably no load if the engine can be declutched from the propeller. 首次运转应该限制在低转速、低负荷，如果柴油机能够与螺旋桨分离的话，最好是没有负荷运转。The run should continue for only three to five minutes after which the engine should be shut down and all external surfaces checked for over-heating. 最好只连续运行3到5分钟，之后柴油机就应该停下来，检查所有外表面是否有过热。If there is no sign of overheating externally, the crankcase inspection doors should be removed and a check made on internal bearings and running gear to ensure that all temperatures are normal. 如果外表面没有过热迹象，应该打开曲轴箱检查道门，检查内部轴承和运转机构确保它们的温度是正常的。However, if there is evidence of over-heating from the external inspection the engine should be stopped immediately but no doors should be removed until at least fifteen minutes after the engine has stopped: this is to avoid the possibility of a crankcase explosion. 可是，如果外部检查明显过热，那么柴油机应该马上停止，但是至少要停机15分钟以后才可以打开道门，这是避免曲轴箱爆炸的可能。An abnormal hot spot inside the engine causes lubricating oil to vaporize and if a door is removed admitting air an explosive mixture can result. 柴油机内部过热点会导致润滑油蒸发，如果打开道门进入空气，就可以形成爆炸性混合气体。

If any bearing shows signs of over-heating it should be dismantled and the cause found. 如果任何轴承显示过热，应该拆解轴承找出造成过热的原因。

If the engine is found to be in order after inspection it may be restarted and run for a little longer. 如果检查后发现柴油机一切良好，可以重新启动柴油机并且运行稍长一点时间。During this run it is prudent to check the action of the low lubricating oil trip mechanism and the over speed shutdown. 在这一次运行期间小心检查润滑油低压跳闸机构和超速停车机构。The low lubricating oil trip mechanism can be checked by stopping the engine and noting the oil pressure at which the trip mechanism operates. 润滑油低压跳闸机构可以停止柴油机进行检查，在跳闸机构动作的时候记录润滑油压力。This should be adjusted, if necessary, to give the correct pressure. 如果必要的话，可以调整该机构达到正确的压力值。The trip must be re-set

批注 [s13]: Hand??

before restarting the engine. 再次起动柴油机之前跳闸机构应该重新设定。To check the over speed trip, the engine should be run up to its full speed and then by carefully forcing the fuel pump control racks to give more fuel the speed increased to approximately 115 percent; the over speed mechanism should then operate. 为了检查超速保护, 柴油机应该加到全速, 然后小心地推动燃油泵控制齿条, 给柴油机供入更多的燃油使其加速到将近全速的 115%, 这时超速保护机构应该动作。Immediately the mechanism operates release the fuel control rods. 马上, 控制机构放松燃油控制杆。When both mechanisms have been checked the trips should be reset and the engine restarted. 当两个机构都检查完后, 脱扣装置应该复位, 重新起动柴油机。The stop valve on the air receiver may now be closed and the motor-driven lubricating oil priming pump shut down. 现在可以关闭空气瓶上的截止阀和电机驱动的润滑油注油泵。When the engine is warmed through, after running for about half an hour, the lubricating oil pressure should be noted and compared with the test results for the same engine speed. 运行半小时后, 当柴油机完全热透时, 应该记录滑油压力与相同转速时的测试结果相对比。If the load limit on the governor is adjustable it can now be moved to the full load position. 如果调速器的负荷限制是可调的, 那么可以将它调到全负荷位置。

On a new engine, or one that is having its first run after an overhaul. 一台新柴油机, 或则是一台大修后初次运转的柴油机。It is necessary to check that on steady full load the readings of maximum cylinder pressure and exhaust temperature are in reasonable agreement with the test figures. 有必要在稳定全负荷时检查最大汽缸压力和排气温度的读数跟测试数据相对比是否合理。The engine should be brought up to load gradually on sea trials so that full load can be obtained at full revolutions. 在海上实验时, 柴油机应该逐渐加载, 所以在全速旋转时能够达到全负荷。Checks on maximum cylinder pressure and exhaust temperature are made mainly to see that the engine is balanced between cylinders and any discrepancy should be rectified by adjustment to the timing or rack setting of the fuel pumps. 检查最大汽缸压力和最高排气温度, 主要看一下柴油机各缸之间负荷是否均匀, 如果有差异的话应该调整正时或燃油泵的齿条设定进行修定。

When the engine has been balanced during the first run it should then only be necessary to note the exhaust temperature every watch there-after, and to take maximum pressures about once a month. 如果第一次运行期间柴油机各缸负荷均匀, 那么仅需要在以后每次值班时记录排气温度, 一个月测取一次最高温度。

If it is possible to do so it is recommended that before stopping the engine the load is gradually reduced to cover a period of about 20 minutes. 如果有可能做到的话, 建议每次停止柴油机之前负荷逐渐降低, 这个过程大约持续20分钟。If the engine has been running on heavy fuel, changes to light fuel before stopping. 如果柴油机燃烧重油, 停机之前要换成轻油。When the fuel is cut off the motor-driven lubricating oil priming pump should be started up and run for fifteen to twenty minutes in order to allow the pistons to cool slowly and evenly. 当燃油切断后, 电机驱动的滑油注油泵应该起动起来, 继续运转15到20分钟使活塞缓慢、均匀地冷却。The circulating water pumps, if separately driven, should be run for a similar time to avoid hot spots in the cylinder heads, valve cages and injectors, etc. 循环水泵如果是独立驱动的, 应该运行相同的时间, 避免汽缸盖、阀箱和喷油器等出现过热点。

If the engine is to be shut down for a fairly long period it is prudent to close all fuel valves and cocks on the fuel supply systems. 如果柴油机停止相当长的一段时间, 应该小心关闭所有燃油阀和燃油供应系统上的考克。

批注 [s14]: Every??

### **AFTER AN OVERHAUL 大修后**

Before running the engine for the first time after an overhaul carry out checks. 大修后首次运行柴油机之前应该进行检查, These should include the pipe systems, if any of them have been disturbed. Pay particular attention to the cleanliness of the lubricating oil system.如果管路动过的话, 也应该包括管路系统。应该特别注意润滑系统的清洁。

The engine should be primed, started, run for three or four minutes and then shut down and examined.应该给柴油机灌满油水, 起动运转三到四分钟后停车, 再进行检查。 If everything is satisfactory the engine should be restarted and the speed and load gradually increased. 如果各方面令人满意, 应该再次起动柴油机, 逐渐增加速度和负荷。 If major components such as piston rings and liners have been renewed during the overhaul, the speed and load should be advanced in small steps, taking about six hours or more to reach the full speed full load condition. 如果主要部件比如活塞环和缸套在大修中换新的话, 速度和负荷应该小幅度提升, 应花费六小时或者更长时间达到全速全负荷的工况。 As this condition is approached, adjustments must be made to the fuel injection pumps in order that the loads may be shared equally amongst all the cylinders.达到这种工况后, 应该调整燃油喷射泵使各缸的负荷平均分配。

## **LESSON 16**

### **Alternating Current Generator**

### **交流发电机**

Over the last 20 years, the use of direct current (D.C) generators has declined in favor of alternating current (A.C.) generators, almost to the exclusion of D.C systems. The voltage of systems has changed from 110 V D.C. and 220 V D.C. to voltages in the range of 380V to 440 V A.C. and even to voltages as high as 3300 V A.C.在过去的20年间, 直流发电机的使用在下降而被交流发电机取代, 几乎拒绝了直流系统。系统的电压从110 V D.C和220 V D.C变化到380 V A.C.到440 V A.C.的范围之内, 甚至最高达到3300 V A.C.。

The adoption of A.C. generators has resulted in a general reduction in the size of copper required in machines, switchgear, and cables, giving savings in weight, size and cost of equipment. 交流发电机的采用已经导致在机器, 开关装置和电缆上铜的使用量减少, 在设备的重量, 尺寸和成本上节省很多。 In addition, maintenance costs are reduced by the elimination of commutators, and squirrel cage motors can be used with simplified control systems. The development of rectifiers of the silicon and germanium type enables D.C. supplies to be made available for excitation systems and at other points in the distribution network as required. 另外由于换向器被除掉降低了维修成本, 并且鼠笼式电动机可以使用简单的控制系统。硅锗式整流器的发展可以在励磁系统中和在分配网络中需要的地点使用直流供给。

#### **SELECTION OF ALTERNATORS交流发电机的选择**

In view of the now almost universal use of A.C. generators for shipboard electrical supply requirements, the following description refers only to this class of machine. Outstanding considerations in choice, of machine are: 由于目前在船上广泛使用交流发电机来满足电力供给的要求, 下面的描述就是关于这一类型的机器。对机器的选择有以下显而易见的考虑:

- a) Reliability and freedom from breakdown; 可靠并且不受断电限制;
- b) Ability to meet the load requirements; 能够满足负载的要求;
- c) Minimum fire risks.最低的起火危险。

Modern alternators of the brushless type are designed to meet all these requirements. 现代无刷式发电机的设计能够满足所有这些要求。Removal of the brushes and commutators reduces the maintenance required and eliminates sparking, a potential cause of fires or explosions. 电刷和换向器的移除降低了需要的维修并且会消除火灾或爆炸潜在的火花原因。Sets having static excitation do, of course, require slip ring brushes, but in this case sparking hazards are minimal as the slip rings do not require performing the switching duty present with commutators.当然, 装置里有静态励磁确实需要滑环电刷, 但是在这种情况下火花的风险是最小的, 因为滑环不需要履行换向器的转换责任。

Electrical load sheets listing the various loads on board ship are usually made available to the set supplier. 电力负载表列出的船上各种负载对于固定的供电设备来说通常是有用的。These give details of the number, rating and starting conditions of various motors with diversity factors under working conditions at sea (entering or leaving harbor, harbor working ship, or idle ship), enabling alternators to be designed to meet the specific load and voltage requirements. 这些表格给出了不同功率因素的所有电动机的数量, 等级和启动情况, 包括海上各种工作情况(进港或离岗, 船舶港口情况或者闲置船舶), 从而使交流发电机的设计能够满足特定的负载和电压要求。

The use of flame retardant materials for insulation, together with correct specifications of materials to meet the temperature rise of the generators with relevant ambient air conditions; combine to give minimum fire risks.对于正常的周围空气环境来说, 用于绝缘的阻燃材料和材料规格的正确使用可以满足发电机温升的要求; 两者的结合可以降低发生火灾的危险。

#### **CONSTRUCTION结构**

Alternators used for auxiliary supplies are usually of the rotating field, silent pole type, having screen protection and an end shield bearing.用于辅助供电的交流发电机通常是旋转磁场, 静止磁极式, 有屏蔽保护和一个端面保护轴承。With two bearing machines, where a flexible coupling is interposed between the engine and alternator, a thrust bearing is fitted to take part or most of the thrust when the ship pitches. 对于双轴承机器来说, 有一个弹性联轴器安装在柴油机和交流发电机之间, 当船舶颠簸时, 配备的推力轴承可以承受部分或者大部分的推力。The stator windings are normally arranged to give a 3-phase output connected in star or Y formation with the common point of the three windings brought out as a neutral into the terminal box.定子绕组正常布置成能够连接成星形或三角形的三相输出, 三个绕组的共用点引线出来到接线盒作为中性点。

#### **Stator Core and Frame定子铁芯和壳体**

The core is built up from laminations of low loss silicon steel, each lamination coated with varnish or other insulant to reduce eddy current losses. 铁芯由低损耗的硅钢片叠加而成, 每一层涂有绝缘漆或者其它绝缘截止来降低涡流损失。The laminations have slots stamped out to take the stator windings and to enable a firm fixture to be made to the stator frame.叠层开有冲压成型的槽口来接受定子绕组并有一个固定装置来安装定子壳体。

The laminations are pressed between end flanges during assembly to a pressure which ensures a tight core and then locked when under pressure by, say, spot welding or wedges.在组装过程中叠层要在端面法兰之间被压紧到一定压力, 保证铁芯紧固, 然后在这个压力下用点焊或楔子锁定。

The stator frame carries the core and windings and is fitted with terminal connection boxes and feet for mounting on the underbed.定子壳体用来支撑铁芯和绕组并装配有接线盒和用来固定底座的地脚。

### **Rotor Shaft and Field Poles** 转子轴和磁场磁极

The shaft is manufactured as a carbon steel forging proportioned so that bending and torsional stresses are kept within safe limits. The half coupling for bolting to the flywheel is usually forged as an integral part of the shaft. 传动轴有碳钢成比例锻造制成，这样可以让弯曲和扭转应力保持在安全范围之内。和飞轮用螺栓连接的那一半联轴器通常与轴系锻造成一个整体。

After forging, the shaft is rough machined and finally heat treated ready for final machining. 锻造之后，轴系被粗略的车削，最后进行热处理并准备好最好的车削。

The field poles, built of thin steel laminations to reduce losses and shaped to minimize harmonics in the voltage wave form, are either bolted or keyed to a spider which is shrunk and keyed to the rotor shaft. 磁场磁极由薄钢片组成从而降低损耗并且做成减少电压波同相的形状，再用螺栓或者键连接到三脚架上，而三脚架被红套并键合到转子轴上。

### **EXCITATION SYSTEMS** 励磁系统

There are two basic Forms of excitation associated with alternators--rotating and static. 交流发电机有两种基本的励磁形式—旋转励磁和静态励磁。

The rotating exciter armature is usually mounted on a hollow shaft extension of the main generator rotor, with the poles stationary on the frame. 旋转励磁电枢通常安装在主发电机转子的空心轴外伸处，而在外壳上有静止的磁极。 The A.C. current generated in the exciter armature is rectified by solid state rectifiers mounted on the armature and the resultant D.C. output fed through conductors in the hollow shaft to the main alternator field. 在励磁电枢中产生的交流电被安装在电枢上的固态整流器整流，最终得到的直流电经过空心轴里的导体输出到主交流磁场中。

Static excitation systems attain the same objective by diverting part of the alternator output via rectifiers and brushes on to slip rings on the alternator rotor shaft. 静态励磁系统可以获得相同的目标，通过把交流电输出的一部分经过整流器和电刷转移到交流发电机转轴上的滑环。

Both systems normally rely on residual magnetism on the alternator producing a small voltage at the terminals when the set is rotating. This voltage is applied to the field system after rectification causing rapid build up of output voltage to its normal level. 当装置旋转时，两个系统在正常情况下依赖于交流发电机上的剩余磁场在终端产生一个小的电压。在整流之后，这个电压可以应用到磁场系统中，促使输出电压快速的建立到一个正常的水平上。

A variation which overcomes this reliance on residual magnetism employs a permanent magnet generator which supplies the excitation current. 为了改变对剩余磁场的依赖，可以采用永久磁铁的发电机来供给励磁电流。

### **VOLTAGE REGULATORS** 电压调节器

In addition to the excitation system, all machines require a device to maintain the output voltage of the machine in a suitable condition at the required level. 除了励磁系统之外，所有的机器都需要一个设备来维持机器的输出电压按照要求在一个合理的状态下。 This can be achieved automatically by adjusting the level of excitation applied to the alternator field and devices for this function are generally categorized under the generic term *automatic voltage regulators*. Usually, a facility for manual control of voltage level also exists. 可以通过自动调整应用到交流磁场的励磁水平来实现，具有这个功能的设备通常按照自动电压调节器这个专业术语来分类。通常也存在一个手动控制电压装置。

Various systems have been adopted by manufacturers and no two schemes are necessarily alike. 各种各样的系统被制造商采用并且没有两个电路是必然相似的。 The main differences are in the methods used to give necessary voltage trimming to allow corrections to be applied for

load conditions, variations in Power Factor, and differences between hot and cold resistances of the generator and field systems. These corrections are needed in order to maintain the voltage within the required limits.主要的区别是所用的方法不同, 这些方法是给出必要的电压调整以允许对负载情况, 功率因素的变化, 以及发电机的热冷负载和磁场系统之间做出一些校正。这些校正正是为了维持电压在设定的范围内。

An automatic voltage regulator is normally used, in addition to emergency hand control, to control the excitation applied to the field of the rotating exciter, a typical example being that of GEC type FV65 thyristor regulator.除了应急手动控制, 正常情况下一个自动电压调节器需要用来控制旋转励磁器的磁场励磁, 一个典型的例子是GEC式FV65半导体闸流管调节器。

In this unit, the excitation power is obtained from the alternator output using two separate sources operating in parallel, the principal source being a thyristor and silicon rectifier giving half-wave rectification.在这个装置里, 励磁功率是通过交流发电机的输出获得的, 采用两台独立电源并联工作, 主要的电源是半导体闸流管和硅整流器, 从而可以进行半波整流。The output is dependent on the period of time in each half cycle for which the thyristor conducts and is fed to the exciter field. 输出依赖于每半个循环的持续时间, 因为半导体闸流管会传输并反馈回励磁磁场。In addition, to ensure that the excitation is maintained under short circuit conditions, it is usual to incorporate current transformers in the generator output. This current transformer output is rectified and also fed to the exciter field.另外, 为了保证在短路状态下维持励磁, 通常在发电机的输出里加入交流变压器。这个交流变压器的输出被整流并反馈到励磁磁场。

The excitation power taken from the generator is through thyristor. The output depends on the time for each half cycle. This point is controlled via the blocking oscillator and the amplifier.来自于发电机的励磁电源是通过半导体闸流管传输的。输出依赖于每半个循环需要的时间。这一点经由间歇振荡器和放大器进行控制。

When the generator voltage falls due to a sudden application of load, the amplifier output to the blocking oscillator causes it to advance the firing angle of the thyristor, thus providing more excitation.当发电机由于负载的突然使用而导致电压下降时, 放大器到间歇振荡器的输出会促使它提前半导体闸流管的点弧角, 因此产生更多的励磁。

## LESSON 17

### Electric Propulsion 电力推进

Electrical installations are present in any ship, from powering of communication and navigation equipment, alarm and monitoring system, running of motors for pumps, fans or winches, to high power installation for electric propulsion. 在任何船舶上都有发电设备, 它们为通讯设备、航行设备、报警和监控系统提供电力, 驱动泵、风扇或绞缆机的电机, 以及为电力推进的大功率设备供电。

The concept of electric propulsion is not new, the idea originated more than 100 years ago.电力推进不是一个新的概念, 这个想法起源于100年以前。After the rather experimental applications of battery driven electric propulsion at the end of the 19<sup>th</sup> century took place in Russia and Germany, the first generation electric propulsion was taken into use in the 1920's as a result of the strong competence of reducing transatlantic crossing times for passenger liners. 在19世纪末, 俄国和德国应用电池驱动的电力推

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进试验之后，第一代电力推进在 20 实际 20 年代投入使用，它具有强大的能力，降低了定期客轮横渡大西洋的时间。At that time, the high propulsion power demand could only be achieved by turbo-electric machinery. 在那时，高推进动力的需求只能由涡轮发电机来实现。“S/S Normandie” was one of the most renowned. “S/S Normandie” 是当时最有名的。Steam turbine generators provided electric power that was used to drive the 29MW synchronous electrical motors on each of the four screw shafts. 蒸汽涡轮发电机提供的电力被用来驱动四个螺旋桨轴上每个 29 MW 的同步电动机。The rotational speed was given by the electrical frequency of the generators. 转动的速度是由发电机频率决定的。The generators would normally run one propulsion motor each, but there were also possibility for feeding two propulsion motors from each generator for cruising at lower speeds. 每台发电机通常驱动一台推进电机，在低速巡航的时候，也有可能驱动两台推进电机 With the introduction of high efficient and economically favorable diesel engines in the middle of the 20<sup>th</sup> century, steam turbine technology and electric propulsion more or less disappeared from merchant marine vessels until the 1980's. 随着 20 世纪中叶高效率，经济上受欢迎的柴油机的引入，蒸汽涡轮技术和电力推进在 20 实际 80 年代或多或少从商船上消失了。

The development of variable speed electric drives, first by the AC/DC rectifier (Silicon Controlled Rectifier – SCR) in the 1970's and the AC/AC converters in the early 1980's enabled the power plant based electric propulsion system, which is typical for the second generation electric propulsion. 变速电力驱动的发展，首先是 20 世纪 70 年代交流/直流整流器（可控硅整流器）的发展，接下来是 20 世纪 80 年代变频器的发展，这样就产生了基于电力推进系统的动力装置，那是典型的第二代电力推进。A fixed voltage and frequency power plant consisting of a number of generator-sets feeding to the same network was supplying the propulsion as well as the hotel and auxiliary power. 一个固定电压和频率的发电站由一些给同一电网供电的发电机组成，电网为推进系统供电的同时也给房间和辅助动力设备供电。The propulsion control was done by speed control of the fixed pitch propellers (FPP). 推进系统的控制是通过对定距桨的转速控制来完成的。These solutions were firstly used in special vessels like survey ships and icebreakers, but also in cruise vessels. 这些解决方案首先用在一些特种船上，如测量船和破冰船还有巡洋舰。“S/S Queen Elizabeth II” was converted to electric propulsion in the mid 1980's, and later followed the Fantasy and Princess class cruise vessels, several DP vessels, and shuttle tankers. “S/S Queen Elizabeth II”号在 20 世纪 80 年代转换为电力推进，后来 Fantasy 和 Princess 级巡洋舰、几个动态定位船和往返油轮也跟着改成电力推进船。Notice that in direct driven diesel propulsion the thrust is normally controlled by a hydraulic system varying the propeller pitch angle. This is denoted as controllable pitch propellers (CPP). 值得注意的是在柴油机直接驱动的推动装置中，通常通过液压系统变化螺旋桨的螺距角来控制推进力，这叫做变距桨。

Podded propulsion was introduced in early 1990's where the electric motor is installed directly on the fixed pitch propeller shaft in a submerged, rotateable pod. 吊舱式推进系统在 20 世纪 90 年代的早期引入使用，在这种情况下电机安装在潜在水中的、旋转的吊舱中，直接与定距桨相连。While this concept was originally developed to enhance the performance of icebreakers, it was early found to have additional benefits on hydrodynamic efficiency and maneuverability. 这种设计概念本来是用来提高破冰船的性能，但人们很早发现它对水力效率和机动性方面有些益处。After the fist

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application in a cruise liner, “M/S Elation”, the advantages were so convincing that podded propulsion almost over night became a standard on new cruise liners.初次在“M/S Elation”号巡洋舰上使用后，这种设计的优点是如此的令人信服，吊舱式推进一夜之间变成新巡洋舰的标准。

With the possibility to control electrical motors with variable speed in a large power range with compact, reliable and cost-competitive solutions, the use of electrical propulsion has emerged in new application areas during the 80's and 90's. 这种解决方案，在大功率变化时可以变速控制电动机，并且结构紧凑、工作可靠而且花费方面也具有竞争性，在 80-90 年代，电力推进已经在新的应用领域显现出来。Electric propulsion with gas turbine or diesel engine driven power generation is used in hundreds of ships of various types and in a large variety of configurations. 利用燃气涡轮或柴油发电机的电力推进系统已经应用在上百艘不同类型的船舶上，但推进的结构形式多种多样。Installed electric propulsion power in merchant marine vessels was in 2002 in the range of 6-7 GW (Gigawatt), in addition to a substantial installation in both submarine and surface war ship applications. 在 2002 年电力推进动力系统开始安装在 6-7 GW 的商用海船上，除此之外，在潜艇和水面舰艇上也大量安装使用。

At present, electric propulsion is applied mainly in following type of ships: Cruise vessels, ferries, DP drilling vessels, thruster assisted moored floating production facilities, shuttle tankers, cable layers, pipe layers, icebreakers and other ice going vessels, supply vessels, and war ships. 目前，电力推进主要应用在下列船型上：巡洋舰、渡轮、动态定位钻探船、浮式生产设备系泊的辅助推进、定期往返油轮、布缆船、管道铺设船、破冰船、其它冰区船、供给船和舰艇。There is also a significant on-going research and evaluation of using electric propulsion in new vessel designs for existing and new application areas.对新设计的电力推进在现有和新的使用领域的使用情况继续研究和评估也是很重要的。

The following characteristics summarize the main advantages of electric propulsion in these types of vessels: 下面是在这些船上电力推进的主要优点的总结：

- ◆ Improved life cycle cost by reduced fuel consumption and maintenance, especially where there is a large variation in load demand. E.g. for many DP vessels a typically operational profile is equally divided between transit and station keeping/maneuvering operations. 通过降低燃油消耗和维护保养，改善了日常花费，特别是负荷需求方面有较大变化的场合。例如，很多动态定位船的典型操作姿态在中转和保持位置/机动操作之间平均分配。
- ◆ Reduced vulnerability to single failure in the system and possibility to optimize loading of prime movers (diesel engine or gas turbine). 克服了系统中由于单个设备的故障所造成的整体失效的弱点，并让原动机的负载优化变为可能（柴油机或燃气涡轮机）
- ◆ Light high/medium speed diesel engines. 较轻的高/中速柴油机。
- ◆ Less space consuming and more flexible utilization of the on-board space increase the payload of the vessel 降低了空间消耗，提供了更多灵活可用的船上空间，增加了船舶的有效载荷。
- ◆ Flexibility in location of thruster devices because the thruster is supplied with electric power through cables, and can be located very independent on the location of the

prime mover. 因为推进器是通过电线由电力推进的，布置位置针对原动机的位置来说可以非常自由，所以推进装置的安装位置也变得灵活了。

- ◆ Improved maneuverability by utilizing azimuthing thrusters or podded propulsion. 利用全方位推进器或吊舱式推进增加了船舶的机动性。
- ◆ Less propulsion noise and vibrations since rotating shaft lines are shorter, prime movers are running on fixed speed, and using pulling type propellers gives less cavitation due to more uniform water flow. 由于旋转轴短，原动机以固定速度运转，使用拖挂性螺旋桨后，由于水流均匀所以穴蚀也轻。

These advantages should be weighted up against the present penalties, such as: 这些优点应该加强克服目前存在的缺点，比如：

- ◆ Increased investment costs. However, this is continuously subject for revisions, as the cost tends to decrease with increasing number of units manufactured. 增加了投资成本，但是这会不断地改善，随着设备生产的越来越多费用也越来越少。
- ◆ Additional components (electrical equipment – generators, transformers, drives and motors/machines) between prime mover and propeller increase the transmission losses at full load. 原动机和螺旋桨之间增加的设备增加了在全负荷时的传递损失。
- ◆ For newcomers a higher number and new type of equipment requires different operation, manning, and maintenance strategy. 作为一种新的装置，大量的、新型的设备需要不同的操作、人员配备和维护保养方法。 High availability of power, propulsion and thruster installations, as well as safety and automation systems, are the key factors in obtaining maximum operation time for the vessel. 动力的高可靠性，推进系统和推进器的安装，还有安全和自动化设备等都是获得装置最大运转时间的关键因素。 The safety and automation system required to monitor, protect, and control the power plant, propulsion and thruster system, becomes of increasing importance for a reliable and optimum use of the installation. 安全和自动化系统需要起到监控和保护的作用，还要控制动力装置、推进系统和推进器，对于装置的可靠性和优化使用变得越来越重要。

## LESSON 18

### Boiler Management 锅炉管理

General management principles and operating procedures are well known and must be always followed to avoid boiler mishaps. 应该熟知全部的管理原则和程序，必须按原则和程序操作，避免锅炉事故。

With many small package boilers, the automatic control sequence usually ensures that the boiler fire is initially ignited from a diesel oil supply, and changed over to the usual source when ignition is completed. 对于大多数小型锅炉，自动控制程序保证锅炉使用柴油点火，当点火完成时在转换成常用的燃料。 With good management, to facilitate subsequent starting from cold, the fuel system of large boilers will have been flushed through with diesel oil when the boiler was

on light duty immediately prior to being secured. 管理良好的锅炉，为了方便下一次的起动，当大型锅炉在轻负荷马上要停止之前，会用柴油冲洗燃油系统。When burning such diesel fuel it is essential for safety that only the correct (small) burner tip should be used. 当燃烧这样的柴油时，要注意安全，只能使用正确的（小型的）喷油器。It should be kept in mind that if fire does not light, immediately shut off fuel and vent furnace. 要注意一旦点火不成功，应马上停止供油，给锅炉扫风。

Complete ignition of fuel in the furnace is essential. 完全点燃炉膛内的燃油是重要的。The burner flame, the smoke indicator and the funnel should be frequently observed. 应该经常观察燃烧的火焰、烟雾指示器和烟囱。With satisfactory combustion, the flame should appear incandescent with an orange shade at the flame tip, and a faint brownish haze should show at the funnel. 燃烧良好，火焰就会呈现出明亮色，火焰端部呈橙色，烟囱排烟呈淡褐色。If on first ignition the flame is uncertain, badly shaped and separates from the primary swirler, momentary opening or closing of air register may correct. 如果初次点火后火焰不稳定，形状不良并与旋流配风器分开，瞬间开闭风门会改善这种效果。

The pH value of the boiler feed water should be kept between 8 and 9 and the boiler density less than 300 ppm, but, if water samples show a heavy concentration of suspended matter, short blow-downs of 20 seconds duration should be given until the sludge content is seen to be reduced. 锅炉给水的PH值应该在8-9之间，且浓度小于300ppm，但是如果水样显示悬浮物浓度过高，应进行20秒的下排污，直到看到脏物减少。The boiler should be blown down when the oil burner is operating, the water level lowered and then restored to prove the functioning of the low water cut-out and the oil burner start-up equipment. 下排污应该在燃烧器工作时进行，锅炉水位应降低然后恢复，以证明低水位切断功能和锅炉燃烧器启动装置正常。The boiler scum valve should also be operated at this time to keep the water level clear floating scum. 这时锅炉上排污阀也应该进行操作以保持水面没有浮渣。

批注 [s17]: .

Fuel burner components and igniter electrodes should be cleaned weekly and the furnace examined to ensure that there are no excess carbon deposits. 燃烧器部件和点火电极应该每周清洁，炉膛每周检查以确定没有过量积碳。

Tubes in the exhaust gas section of the boiler should be brushed through at about six-monthly intervals, and those in the oil-burning section periodically examined and cleaned as necessary with a wire bristle brush. 锅炉废气区域的管子间隔六个月左彻底涮洗一次，使用燃油区域的管路应定期检查，必要的时候可以用钢丝刷清洗。With correct feed water treatment, blow-down procedures and sludge contents in water samples at a stable level, it should not be necessary to wash out the water side of the boiler more than once every three or four months. 锅炉给水处理良好，排污操作正确，且水样中泥渣的含量稳定，则锅炉水侧每三四个月清洗一次就可以了。

Boiler fires may be out for long periods when a ship is at sea and the boiler steaming maintained by heat input from waste heat recovery plant. 当船舶在海上航行的时候，锅炉可长时间停火，可以由废热回收装置保持锅炉供气。This operation is free from hazard, but feed water and boiler water treatment must be maintained to prevent internal deterioration or scale formation. 这时运行锅炉没有危险，但是必须要处理给水和炉水，防止内部腐蚀或形成水垢。Water level controllers must be kept operable to protect external steam-using plant from water "carry-over" danger. 必须保持水位控制器正常工作，以防止外部用气装置受到蒸汽带水的危害。

If a boiler is isolated from the steam-using system it must be kept either in closed dry storage with a suitable internal desiccant, or completely full of treated water, or under a low steam

pressure preferably maintained by a steam-heated coil. 如果要将锅炉从蒸汽系统隔开，或者在锅炉内部放适量的干燥剂使锅炉干燥密闭保养，或者是装满处理过的水，或者是用蒸汽盘管加热让锅炉维持在低气压下。

Regular testing of boiler protective devices must be implemented. 锅炉保护装置必须定时实验。

Frequent comparison of drum-mounted and remote-reading water level indicators: discrepancies between these have contributed to failures because of overheating through shortage of water, when a boiler was being oil-fired. 要经常比较锅炉上的水位计和远程水位计的读书，当锅炉处于着火工作状态的时候，它们之间的差异曾经导致过因缺水而过热的故障。If in doubt as to the true boiler water level, i.e. whether a water level indicator sightglass is completely full or empty, when a unit is being oil-fired the fire should be immediately extinguished until the true level is resolved. 如果对锅炉的真实水位有所怀疑，也就是说，无论水位计观察镜显示是全满的还是全空的，当锅炉处于燃油工作状态时应立即熄火，直到恢复真实水位。

Procedures should be predetermined and followed in the event of shortage of water, bulging or fracture of plates or furnace, or bursting of water tubes. 应该预先制定一些程序，并在管板或炉膛变形、裂纹，锅炉缺水或者水管爆裂的时候执行这些程序。In general, fires should be immediately extinguished by remote tripping of fuel supply valves; forced draught air pressure maintained if there is any risk of escaping steam entering the boiler room; stem pressure relieved if metallic fractures seem possible; and boiler water level maintained, where practicable, until the boiler begins to cool down. 通常情况下，应立即通过燃油远控速闭阀使锅炉熄火；如果蒸汽可能逸出进入锅炉间，应该保持强制通风压力；如果有可能发生金属破裂，应释放蒸汽压力；如果可能的话，在锅炉冷却之前应保持锅炉的水位。

批注 [s18]: Steam

Regular operation of soot blowers, if there are fitted, when the boiler is on oil-fired operation. 如果装有吹灰器，应在锅炉处于燃油工作时定期吹灰。The steam supply line must be thoroughly warmed and drained before the blowers are used, the air/fuel ratio increased throughout the action, and blowers greased after use. 使用吹灰器之前，供气管路应完全预热、放残。使用期间应加大风油比，使用之后应涂油脂。

Immediate investigation of any high salinity alarms in condensate system, and elimination of any salt water or oil contamination of boiler feed water system. 如果冷凝系统有高盐度报警应立即进行调查，并清除给水系统的海水和油污。

Safety precautions taken before entering a boiler connected to another boiler under steam. 进入一个与工作锅炉相连的锅炉之前，应采取安全预防措施。

The main engine may be kept in operation with the boiler dry and the gases passing through the exhaust gas section. 当锅炉无水时，主机仍可以保持运转，而使排烟通过锅炉的废气区域。If this is to be done for a prolonged period it is advisable to allow a current of air to flow through the boiler by removing manhole, sight hole and mudhole covers. 如果这种操作将在长时间内进行，那么打开人孔、观察窗和泥渣孔盖板使空气流过锅炉是明智的。If refilling a hot boiler the main engine speed should be reduced to slow for half an hour and the feed water supplied be as hot as possible; thereafter the main engine may be brought up to power over a similar period. 如果要向热的锅炉内加水，主机的转速应降低运行半小时，给水应尽可能的热，然后，主机可在相同时间内恢复功率。

## LESSON 19

# Refrigeration System 制冷系统

## Fundamentals 基本原理

Refrigeration is the process of removing heat, and the practical application is to produce or maintain temperatures below the ambient. The basic principles are those of thermodynamics. 制冷是移除热的过程, 实际应用就是产生或保持低于环境的温度。基本原理是热力学的一些知识。

Heat is one of the many forms of energy and mainly arises from chemical sources. 热是能量的一种形式, 主要来自于化学能。The heat of a body is its thermal or internal energy, and a change in this energy may show as a change of temperature or a change between the solid, liquid and gaseous states. 热是物体的热能或内能, 热能的改变可能会带来温度的改变或固态、液态和气态之间的变化。Matter may also have other forms of energy, potential or kinetic, depending on pressure, position and movement. 物质可能有其它形式的能量, 比如势能或动能, 这些主要取决于物质的压力、位置和运动。Enthalpy is the sum of its internal energy and flow work and is given by:  $H = u + Pv$ . 焓是物质的内能和流动功的总和, 可表达为  $H = u + Pv$ 。In the process where there is steady flow, the factor  $Pv$  will not change appreciably and the difference in enthalpy will be the quantity of heat gained or lost. 在稳定流动的过程中,  $Pv$ 项不会改变, 焓的变化就是得到或失去的热量。

If a change of enthalpy can be sensed as a change of temperature, it is called *sensible heat*. 如果焓的变化, 就能感觉到温度的变化, 就叫做显热。This is expressed as specific heat capacity, i.e. the change in enthalpy per degree of temperature change, in  $\text{kJ}/(\text{kg K})$ . 这表示为比热, 也就是温度每度的变化焓的变化量, 单位是  $\text{kJ}/(\text{kg K})$ 。If there is no change of temperature but a change of state (solid to liquid, liquid to gas, or vice versa) it is called *latent heat*. 如果没有温度的变化, 但是有物质状态的改变 (固体变成液体, 液体变成气体, 反过来也一样。), 这就叫做潜热。This is expressed as  $\text{kJ}/\text{kg}$ , but it varies with the boiling temperature, and so is usually qualified by this condition. 潜热表达为  $\text{kJ}/\text{kg}$ , 但是它随着沸腾温度变化, 所以它通常也就限定在沸腾条件下。

The temperature at which a liquid boils is not constant, but varies with the pressure. 液体沸腾的温度不固定, 它随着压力变化。Thus, while the boiling point of water is commonly taken as  $100^\circ\text{C}$ , this is only true at a pressure of one standard atmosphere (1.013 bar) and, by varying the pressure, the boiling point can be changed. 因此, 当一般认为水的沸点是  $100^\circ\text{C}$ , 这只是水在一个标准大气压 (1.013 bar) 下的沸点, 当压力改变时, 沸点也改变。

The boiling point is limited by the *critical temperature* at the upper end, beyond which it cannot exist as a liquid, and by the triple point at the lower end, which is at the freezing temperature. 沸点限定在临界温度以上, 临界温度以下不存在液体, 临界点以下的三相点是凝固点。Between these two limits, if the liquid is at a pressure higher than its boiling pressure, it will remain a liquid and will be subcooled below the saturation condition, while if the temperature is higher than saturation, it will be a gas and superheated. 在这两个界限之间, 如果液体的压力比它的饱和压力高, 那么它保持液体状态, 在饱和状态以下有一定过冷, 如果温度比饱和温度高, 那么它就变成气体, 有一定过热。If both liquid and vapour are at rest in the same enclosure, and no other volatile substance is present, the condition must lie on the saturation line. 如果液体和气体同时存在于一个密闭容器如果没有其它不稳定物质存在, 这时必定是处于饱和状态。

## Basic vapour compression cycle 基本蒸发压力循环

A liquid boils and condenses—the change between the liquid and gaseous states—at a

批注 [s19]: ?? 缺少单位质量, 是不是不应该用千焦

temperature which depends on its pressure, within the limits of its freezing point and critical temperature. 液体的蒸发和冷凝—在液体状态和气体状态之间变化—依赖于其压力，并且要处于凝固点和临界温度之间。In boiling it must obtain the latent heat of evaporation and in condensing the latent heat must be given up again. 在沸腾时，液体必须获得蒸发潜热，在冷凝时，潜热必须再释放出去。The basic refrigeration cycle makes use of the boiling and condensing of a working fluid at different temperatures and, therefore, at different pressures.基本的制冷循环利用工作流体在不同温度和不同压力下的蒸发和冷凝。

Heat is put into the fluid in the evaporator at the lower temperature and pressure and provides the latent heat to make it boil and change to a vapour. 在蒸发器中，压力比较低，饱和温度也比较低，这时热量传递给流体，也就是向流体提供潜热，使流体沸腾变成蒸汽。This vapour is then mechanically compressed by the compressor to a higher pressure and a corresponding saturation temperature at which its latent heat can be rejected in the condenser so that it changes back to a liquid.这些蒸汽被压缩机机械压缩成高压蒸汽，在冷凝器中，在对应的饱和温度下它的潜热被释放出来，所以蒸汽又变回液体。

A working system will require a connection between the condenser and the inlet to the evaporator to complete the circuit. 一个工作系统需要在冷凝器和蒸发器入口之间建立连接以完整整个回路。Since these are at different pressures this connection will require a pressure reducing and metering valve.由于它们的压力不同，所以这个连接环节需要一个具有降压和调整功能的阀。 Since the reduction in pressure at this valve must cause a corresponding drop in temperature, some of the fluid will flash off into vapour to remove the energy for this cooling. 由于在该阀处有压降，必定会引起相应的温度降，一些流体闪发成蒸汽带走热量实现制冷。The volume of the working fluid therefore increases at the valve by this amount of flash gas, and gives rise to its name, the expansion valve.工作流体在该阀后由于闪发成气体所以体积增大，这也就得到它的名字，膨胀阀。

### **Refrigerants 制冷剂**

#### **Ideal properties for a refrigerant 制冷剂的理想性能**

It will be useful to remind ourselves of the requirements for a fluid used as a refrigerant.这将帮助我们记住用来作为制冷剂的流体所应具备的条件。

- A high latent heat of vaporization 高的蒸发潜热
- A high density of suction gas 高的吸气密度
- Non-corrosive, non-toxic and non-flammable 无腐蚀性、无毒性、不易燃烧
- Critical temperature and triple point outside the working range 临界温度和三相点在工作温度范围以外。
- Compatibility with component materials and lubricating oil 与原件材料及润滑油相兼容
- Reasonable working pressures (not too high, or below atmospheric pressure) 合适的工作压力（不太高，也不低于大气压力）
- High dielectric strength (for compressors with integral motors) 高绝缘强度（压缩机和电机做成一体）
- Low cost 低成本
- Ease of leak detection 漏泄检查容易
- Environmentally friendly 环境友好

#### **Ozone depletion potential (ODP) 臭氧消耗潜能值**

The ozone layer in our upper atmosphere provides a filter for ultraviolet radiation, which can be harmful to our health. 臭氧层位于大气层的外面，提供了一个防止紫外线辐射的滤光器，

紫外线对人们的健康有害。Research has found that the ozone layer is thinning, due to emissions into the atmosphere of chlorofluorocarbons (CFCs), halons and bromides. 研究发现由于向大气中排放氯氟烃(CFCs), 哈龙以及溴化物, 臭氧层正在变薄。The Montreal Protocol in 1987 agreed that the production of these chemicals would be phased out by 1995 and alternative fluids developed.1987年的蒙特利尔协议同意这些化学产品到1995之前逐渐淘汰, 开发替代产品。

- R22 is an HCFC and now regarded as a transitional refrigerant, in that it will be completely phased out of production by 2030, as agreed under the Montreal Protocol. R22是一种氢代氯氟烃, 现在被认为是一种过渡制冷剂, 根据蒙特利尔协议, 它到2030年之前要完全被淘汰,

### **Global warming potential (GWP) 全球变暖潜能**

Global warming is the increasing of the world's temperatures, which results in melting of the polar ice caps and rising sea levels. 全球变暖就是世界温度是升高, 它导致两极冰帽融化, 海平面升高。It is caused by the release into the atmosphere of so-called 'greenhouse' gases, which form a blanket and reflect heat back to the earth's surface, or hold heat in the atmosphere. 这时由于所谓“温室气体”释放到大气中所引起的, 温室气体就像毯子一样包在地球外层, 把热反射回地球表面或把热保留在大气层里。The most infamous greenhouse gas is carbon dioxide (CO<sub>2</sub>), which once released remains in the atmosphere for 500 years, so there is a constant build-up as time progresses.最声名狼藉的温室气体是二氧化碳(CO<sub>2</sub>), 它一旦释放到空气中, 会在大气中存在500年, 所以随着时间的发展, 它的含量会不断升高。

The main cause of CO<sub>2</sub> emission is in the generation of electricity at power stations. 二氧化碳主要是由发电厂发电所释放的。Each kWh of electricity used in the UK produces about 0.53 kg of CO<sub>2</sub> and it is estimated that refrigeration compressors in the UK consume 12.5 billion kWh per year. 在英国每用一度电就会产生大约0.53 kg 的二氧化碳, 据估计在英国制冷压缩机每年会消耗12.5亿度电。The newly developed refrigerant gases also have a global warming potential if released into the atmosphere. 新开发的制冷剂气体如果释放到大气中, 也有全球变暖的潜能, For example, R134a has a GWP of 1300, which means that the emission of 1 kg of R134a is equivalent to 1300 kg of CO<sub>2</sub>.例如R134a的全球变暖潜能值为1300, 也就意味着释放1kg的R134a就相当于释放1300kg的CO<sub>2</sub>。

### **Ammonia and the hydrocarbons 氨和碳氢化合物**

These fluids have virtually zero ODP and zero GWP when released into the atmosphere. 这些液体释放到大气中, 实际上没有臭氧消耗潜能值和全球变暖潜能值。Ammonia has long been used as a refrigerant for industrial applications. 氨已经作为工业用制冷剂很长时间。The engineering and servicing requirements are well established to deal with its high toxicity and flammability. 已经很好地满足了工程上和服务上的要求来处理它的高毒性和可燃性。Ammonia cannot be used with copper or copper alloys, so refrigerant piping and components have to be steel or aluminium. 氨不能和铜及铜合金一起使用, 所以制冷管系和部件必须是钢或铝。One property that is unique to ammonia compared to all other refrigerants is that it is less dense than air, so a leakage of ammonia results in it rising above the plant room and into the atmosphere. 氨独有的一个特性是与其它所有的制冷剂相比, 它的密度比空气轻, 所以氨的漏泄会导致氨上升到机械处所的上部, 最后飘散到大气中。If the plant room is outside or on the roof of a building, the escaping ammonia will drift away from the refrigeration plant. 如果机械处所在外面或在整个建筑物的顶部, 从制冷系统中漏泄出来的氨会慢慢散去。The safety aspects of ammonia plants are well documented and there is reason to expect an increase in the use of ammonia as a refrigerant.如果能证明氨制冷装置安全方面没有问题的话, 那么就有理由相信

以氨作为制冷剂就会增多。

Hydrocarbons such as propane and butane are being successfully used as replacement and new refrigerants for R12 systems. 碳氢化合物比如丙烷和丁烷成功的替代并作为R12系统的新制冷剂。They obviously have flammable characteristics which have to be taken into account by health and safety requirements. 它们明显的具有可燃性，必须考虑健康与安全方面的一些要求。However, there is a market for their use in sealed refrigerant systems such as domestic refrigeration and unitary air-conditioners.然而，在密封式制冷系统中（比如家用制冷设备和单体式空调）具有应用市场。

#### **Refrigerant blends 混合制冷剂**

Many of the new, alternative refrigerants are 'blends', which have two or three components, developed for existing and new plants as comparable alternatives to the refrigerants being replaced. 一些新的、可供选择的制冷剂混合在一起，它具有两种或三种成分，作为被替代冷剂的相似制冷剂，可供现有的和新的装置使用，They are 'zeotropes' with varying evaporating or condensing temperatures in the latent heat of vaporization phase, referred to as the 'temperature glide'. 它们是非共沸混合物，在蒸发阶段发生潜热时，具有不同的蒸发或冷凝温度，就叫做“温度滑移”。

The temperature glide can be used to advantage in improving plant performance, by correct design of the heat exchangers. 通过合理设计热交换器，可以有效利用温度滑移来提高装置性能。A problem associated with blends is that refrigerant leakage results in a change in the component concentration of the refrigerant. 一个和混合冷剂相关的问题是如果制冷剂漏泄会导致制冷剂成分浓度的变化。However, tests indicate that small changes in concentration (say less than 10%) have a negligible effect on plant performance.可是，测试显示浓度的变化不大时（变化小于10%），对装置的性能的影响可以忽略不计。

The following recommendations apply to the use of blends:下面是使用混合冷剂的建议：

- The plant must always be charged with liquid refrigerant, or the component concentrations will shift.装置必须加装液体冷剂，否则冷剂成分浓度会发生改变。
- Since most blends contain at least one flammable component, the entry of air into the system must be avoided.由于大多数混合冷剂至少有一种可燃成分，所以必须避免空气进入系统。
- Blends which have a large temperature glide, greater than 5K, should not be used for flooded-type evaporators.混合冷剂有大的温度滑移，甚至超过5K，所以不应在液流式蒸发器中使用。

## **LESSON 20**

### **Air Conditioning System**

### **空调系统**

Air conditioning systems fall into two main classes: individual unit system, in which each room contains its own small refrigeration plant and fan and air cooler; and central systems, where larger refrigeration machinery unit are installed and their out put distributed about the ship by a variety of means.空调系统主要分成两类：单独空调系统，每个房间包含它自己的小型制冷装置和风机以及空气冷却器；集中空调系统，安装有大型的制冷装置，它们的输出通过各种方式分配到船舶周围。

Self-contained units are noisier than central systems, require more maintenance and have been found to have a relatively short life (about 7 years).独立空调装置要比中央系统噪音大，需

要更多的维护并且已经发现相对短的使用寿命（大约7年）。

The single duct system only allows for adjustment of temperature in each room by the occupant manually controlling the air volume admitted. It is thus less flexible than any of the other systems. Which allow individual temperature control, at least of sections of the ship if not individual rooms.单风管系统只允许在每个房间内的温度调整，通过居住者手动控制进入的空气容积。因此与其它任何一个系统相比，缺少灵活性。其它的系统假如不是单独的房间，至少允许对船舶区域进行单独的温度控制。

With ducted systems, the modern tendency is to use “high velocity” in the air ducts with fans generating up to 2550 mbar pressure compared to “low velocity” systems with fans generating about 520 mbar. 对于风管系统来说，现代的趋势是使用“高速”空气管道，与“低速”系统的风机能产生大约520mbar的压力相比，高速系统的风机能产生高达2550mbar压力。This tendency helps installation as the size of ducts is reduced and prefabricated standard ducts can be used, but it incurs the heavier running costs of more powerful fans. 这一趋势有助于装置的管道尺寸变小，并且可以使用预先制作的标准管道，但是更大功率的风机会产生更沉重的运行成本。Air terminals lined with sound insulation material are necessary to reduce the noise passing into the room with high velocity systems.为了降低采用高速系统进入房间的噪音，空气末端管路必须衬有隔音材料。

In a typical marine pattern self-contained unit, air circulation is usually effected by means of a centrifugal fan, for quiet running, and a direct expansion cooler served by a hermetic compressor. 在一个典型的船用独立装置中，空气循环通常会受到离心式风机的影响，并且为了安静运转，一个直接膨胀冷却器提供给封闭式压缩机使用。Water cooled condensers are used. As these contain small water passages, choking develops rapidly with direct sea water circulation and a better method is to circulate with fresh water, itself cooled in a sea water/fresh water heat exchanger.水冷式的冷凝器被采用。因为冷凝器含有的水管小，由于是海水循环，堵塞会迅速发生，最好的办法是用淡水循环，淡水本身在海水/淡水的热交换器里冷却。

Control is on/off by a thermostat sensing the temperature of air returning to the unit.通过一个调温器感受返回到装置内的空气温度，实现开/关控制。

The cooling coil of the central unit may be of the direct expansion, brine or chilled water cooled type.中央空调的冷却盘管可能是直接膨胀式，盐水式或者冷水式。

When cooling is by direct expansion, a separate steam heater coil is fitted in the unit for winter heating. 当通过直接膨胀冷却，在装置里安装一个独立的蒸汽加热盘管用于冬天加热。With brine or water coolers, a central heater is used so that the same coil serves for summer or winter. 对于盐水或者水冷却器来说，中央加热器得到使用，这样在夏天或者冬天可以使用相同的盘管。Thermostatic control is provided sensing air delivery temperature itself, the temperature of the room, or the return air temperature.调温控制用来感受传送空气本身的温度，房间的温度，或者回风温度。

All types of thermostats are found in air conditioning systems, direct acting, pneumatic and electrical. 在空调系统中，可以发现所有类型的自动调温器，直接作用式，气动式和电动式。In themselves, they are all satisfactory instruments, but the results they achieve are dependent on the correct siting of their sensing elements.对于它们本身来说，它们都是令人满意的设备，但是它们能够达到的效果依赖于传感元件的正确位置。Even the site for a direct acting thermostat to control one single berth cabin must be chosen with care - if it is masked behind curtains, or too far away from the air inlet control will be too sluggish.甚至对于控制单独房间的直接膨胀式调温器的位置来说，也必须慎重选择—假如放置在窗帘后面被遮住，或者离空气

进气口位置太远控制也会变得迟滞。

The correct location for a thermostat to control a block of cabins is more difficult to find. 一个调温器控制一组房间温度的正确位置是很难寻找的。One can pick on a “typical” cabin, but if the occupant opens his porthole he can upset the whole block. 可以挑选一个“典型”房间，但是假如居住者打开他的舷窗，就会扰乱全部的房间。Another possibility is to site the thermostat in the alleyway of the block of cabin. 另一种可能是把调温器放置在一组房间的走廊上。This position may be affected more by an open door or draught in the alleyway than by the temperature of the cabins. 与用房间的温度调整相比，这个位置可能更多的受到走廊里开门或者通风的影响。Yet another possibility is to site the thermostat in the recirculation air trunk, carrying air back from the accommodation to the unit. 然而另外一种可能性是把调温器放置在空气重新循环管道里，在管道里可以将居住室的空气返回到装置里。If the recirculation grill is close to an outside door, this position too can be affected by outside air temperature when the door is open, rather than by cabin temperature. 当门打开的时候，假如重新循环格栅与外面门的距离太近，这个位置也会受到外面空气温度影响，而不是房间温度。

The first essential in operating the air cooling appliances through out the ship is to have all thermostats correctly set and correctly functioning. 操作整条船舶的空气冷却装置最为关键的是让所有的调温器位置正确和功能正常。In extreme weather conditions, either hot or cold, control of the plant usually presents few difficulties. 在极端天气条件下，炎热或者寒冷，装置的控制通常会呈现出少许困难。The capacity of many installations is such that under tropical conditions nearly all control valves move to the fully open position. 在酷热的情况下，许多装置的排量要使所有的控制阀移动到全开位置。Although automated control has been lost, internal conditions are by and large acceptable. 虽然自动控制已经失灵，但是内部情况总的来说可以接受。Control difficulties arise in intermediate weather conditions when there is a call for only a small amount of cooling. 当在中间天气情况下需要少量的冷却，就会产生控制困难。The worst case is when part of the ship, say inboard cabins against the engine room, require cooling and other parts, say exposed upper cabins, require warming. 最坏的情况是当船舶的一部分，比如说船舶内部房间而不是机舱，需要冷却而其它部分，比如暴露于上部的房间，需要加热。For this intermediate condition, thermostats must be correctly set by trial and error. 对于中间天气来说，调温阀必须通过反复试验进行正确设定。It is found that a uniform setting of say 21°C throughout the ship is not satisfactory, but slight variations of a few degrees up or down are needed to suit particular regions of the ship. 研究发现对整个船舶统一设定，比如 21°C 是不会令人满意的，但是几度上下的略微变化来适应船舶的特殊区域是需要的。Unfortunately, these variations in thermostat setting are not always the same for the cooling and heating condition and frequent resetting may be needed for a ship repeatedly passing from cold to warm weather. 不幸的是，调温器设定的这些变化对于冷却和加热的情况是不相同的，对于一个从寒冷到温暖的天气重复穿行的船舶来说，需要频繁的重新设定。

The control problem is eased if the chilled brine (or water) of systems using chilled liquid circulation is held at about 13°C in the intermediate weather conditions and lowered progressively to about 5°C as tropical weather conditions are approached. 假如在中间天气情况下，冷冻盐水（或水）系统中的冰冷液体循环保持在大约 13°C，而在接近于酷热的天气条件下，不断降低到大约 5°C，那么控制问题就被解决。

When air cooling is in use it is good practice to keep all portholes, windows and doors shut. On passenger ships, some public announcement requesting that this be done is worthwhile. 当使用空气冷却时，保持所有的舷窗，窗户和门关闭是一个良好的习惯做法。在客船上，一些公共

告示里要求这样做是有价值的。

A wise precaution for an engineer to take is to go through accommodation and public rooms periodically recording wet and dry bulb temperatures. Keeping a log of these readings then serves to identify any malfunctioning of the installation as soon as it arises. 对于一个轮机员来说，采取明智的预防措施是定期检查居住室和公共房间，记录干湿球温度。对这些读数保持记录，然后用于确认装置一旦出现任何故障。

The quantity of cooled air delivered by an air conditioning unit should balance the sum of the quantity of air recirculated to the unit and the quantity mechanically exhausted. 通过空调单元传输的冷风量必须与重新进入装置循环和机械排出空气数量的总和相平衡。The correct balance between supply and exhaust fans should be checked periodically. Even with filters fitted ducts can become partially blocked and fan performance can fall off to upset the balance. 供给和排出风机之间的正确平衡必须定期检查。甚至是风管里安装滤器的部分堵塞和风机性能下降都会扰乱平衡。

On older ships, temperature maintenance can be made easier by increasing the ratio of recirculated to fresh air. 在老船上，通过增加回风和新风比，温度维护会变得容易。Most air conditioning units have dampers for adjusting this ratio and the effect of these can be extended after they have reached full travel by partially blocking fresh air inlets. Care must be taken not to reduce the fresh air so that stuffiness or smells arise. 大多数的空调装置使用挡板对这个比率进行调整，并且在空气全部传输之后，通过部分堵塞新气进口，调整的效果会被延迟。必须注意不能降低新风量这样会引起闷热和臭味。

Cleaning or renewal of filters is necessary at about 3-monthly intervals, the time varying according to location on the ship. Disposable filters can be vacuum-cleaned so that in fact two or three “lives” are obtained before they need to be thrown away. 大约每三个月清洁或者更换滤器是必须的，间隔时间根据船上滤器的位置而变化。一次性滤器可以真空清洁，这样滤器被丢弃之前，在实际中还可以使用两到三次。

In addition to normal mechanical attentions, such as lubrication of bearings, and adjustment of fan belts and cleaning of motors, careful greasing of linkages of automatic controls is necessary. 除了留意正常的机械机构，比如轴承润滑，风机皮带调整以及电动机清洁，对自动控制连接处用油脂仔细润滑是必须的。

Cooled air ducts should be examined to see that the insulation vapour seal remains in good order. If a plastic film vapour seal becomes damaged, condensation forms within the film. 必须检查冷风管来判断绝缘蒸汽密封仍然工作正常。假如一个塑料膜蒸汽密封损坏，会在膜内形成凝水。As well as making the insulation wet and ineffective, the condensation may become serious enough to cause drips and damp patches on ceilings. 还有绝缘变湿和失效，可能会让凝水变得严重以至于在顶棚上形成滴水和水渍。

## LESSON 21

### Some Typical Applications Of Hydraulic Transmission

## 液压传动的一些典型应用

The applications of hydraulic drive on board different types of ships are too various to be covered in detail: it is hoped that the previous sections will have provided both interesting and useful information which can be related to differing circumstances and requirements. Finally, therefore, consideration will be given to a few particular areas where hydraulics is utilized. 在不同类型船上应用的液压驱动种类繁多,以至于很难详细覆盖:最希望前面的部分能够提供不同情况和要求下有趣和有用的信息。因此最后要考虑一些液压系统使用的特殊的区域。

### **DECK CRANES AND WINCHES甲板起货机和绞车**

The use of hydrostatic drives in cranes, winches and similar equipment has grown considerably over the years until it is now accepted as a conventional method of drive in many cases. 在过去几年中流体静力驱动在起货机,绞车和相似设备上的使用已经显著增加,直到现在在许多情况下被公认为一种常规的驱动方法。

The makers of ships' deck machinery were probably the pioneers in using low speed, low pressure equipment. 船舶甲板机械制造商可能是使用低速,低压设备的先驱者。The impetus for this is the freedom of installation resulting from the lack of mechanical connections between prime mover and the machinery, as well as the important safety feature of the high pressure relief valve limiting the maximum motor output torque--thus safeguarding the winch mechanism and cable from overloading. 这方面的推动力产生于设备的广泛安装,原因在于在原动机和机械设备之间缺少机械连接,以及高压安全阀重要的安全特点即可以限制最高的马达输出扭矩—因此保护绞车机械装置和缆绳过载。

These fundamental advantages are equally applicable today. However, great progress, has been made in the use of low cost equipment used at higher speeds and pressures, and a wide range of valve gear has made possible the use of reliable, highly sophisticated systems, e.g. with integrated override controls, remote controls and horsepower limiting controls. 这些基本的优点在今天同样适用。但是,在低成本设备中使用高速高压已经产生巨大的进步,阀件机构宽泛的范围使可靠,高度复杂的系统成为可能,比如综合优先控制,远程控制以及马力限制控制。It is in the field of control that the greatest strides have been made in recent years, and this, coupled with the continuing evolution and detailed development of the basic pumps and motors, has improved both the performance measured in absolute terms, and the all important response to the operator's hand or foot movements. 在最近几年中,控制领域取得了巨大的进步,与基本元件泵和马达的不断创新和细节发展相结合,改善了绩效衡量的绝对值以及操作者手或脚运动的所有重要响应。

### **Performance Requirements性能要求**

#### *Hoist 起升*

In any winching system, the hoist winch motor probably has the most exacting duty to perform: apart from covering the speed range up to the maximum light hook speed, the low speed performance is extremely critical. 在任何绞车系统中,起升绞车马达可能有最苛求的职责去履行:除了要覆盖的速度范围要达到最大的轻钩速度以外,低速性能也是极为关键的。The motor must start from rest smoothly and accelerate in a controllable manner, the most demanding case being when restarting to lift the maximum suspended load. 马达必须从静止开始平稳启动并以可控的方式加速,最为费力的情形是当需要重新开始起升最大的悬吊负载。Here, the motor must develop the maximum output torque when at rest, possibly with metal to metal contact between the dynamic elements, giving higher friction established hydrodynamic oil films, than

when rotating with established hydrodynamic oil films.这时，马达必须在静止时发出最大的输出扭矩，可能动力元件之间需要金属与金属接触，流体动力薄膜建立的摩擦力要比旋转时建立流体动力薄膜的摩擦力要大得多。

Since leakage normally reduces as speed increases, the minimum stable speed is governed by the ratio between maximum and minimum leakage within the cycle of one rotation; motors with a high static leakage tend to start suddenly and have a high minimum speed.因为泄漏通常会随着速度增加而降低，最低的稳定速度受到在一转循环中最大与最低泄漏之比控制；具有最大静态泄漏的马达容易迅速启动并有一个较高的最低转速。This minimum speed plays a major part in determining the extent of any dead band in control response around the neutral position, and is a critical factor governing the all-important inching and general control response of any hydrostatic transmission.这个最低转速对决定中位附近死区范围的控制响应有重要的影响，并且是任何流体静力传输中，控制所有重要微速和通常控制效应的一个关键因素。

The wide range of high torque, low speed motors described earlier are available for driving winch drums directly so dispensing with the need to fit reduction gearing. 早期描述的一系列范围内的大扭矩，低速马达可以用于直接驱动绞缆筒，取消安装减速机构的需要。Motors of this type are more common on larger cranes where reduction gearboxes would be expensive. The saving in gearbox cost is to some extent offset by the fact that the brake must withstand full drum torque plus a safety over load, and must therefore be relatively large.这种类型的马达在那种减速齿轮昂贵的大型吊车上更为广泛。节省下来的齿轮箱成本在一定程度上被刹车片所抵消，因为刹车片必须承受全部的绞缆筒扭矩加上安全负载的，所以要相对大一些。

All fixed capacity motors, whether high or low speed, require a high flow at low pressure to obtain high light hook speeds and consequent short cycle times. 所有固定排量的马达，不管是高速还是低速，需要大流量低压力来获得高的轻钩速度并相应的缩短循环时间。With large cranes this can become an embarrassment and one solution with low speed motors is to use the two speed type where half the cylinders can be isolated hydraulically from an auxiliary circuit, so doubling the speed and halving the output torque from a given flow and pressure.对于大型吊车来说将会变得尴尬，低速马达的一个解决办法是使用两种速度类型，一半的柱塞可以从辅助回路中液压隔离，所以在给定的流量和压力下获得双速和一半的输出扭矩。

With a radial piston motor of this type it is also possible to utilize a rotating outer casing as the inner member of a band brake to give an attractive solution. 对于这种型号的径向柱塞马达来说，也可以使用一个旋转的外壳作为带闸的内部构件，从而成为一个有吸引力的解决方案。

High speed motors with reduction gearing have the advantage that the brake can be mounted on the high speed shaft and so be much smaller and cheaper. Because of the availability of standard low cost gearboxes this arrangement is popular on lighter cranes.带有减速装置的高速马达的优点就是刹车可以安装在高速旋转的轴系上并且更小更便宜。由于可以使用标准的低成本齿轮箱，所以这种布置在小型吊车上更受欢迎。

Variable capacity axial piston motors have the important advantage that light hook speeds can be increased up to four times from a given oil flow by reducing the motor capacity to 25 percent of the maximum.变量轴向柱塞马达非常重要的优点是在给定油液流量下，通过降低马达排量到最大值的25%将轻钩速度提高到四倍

#### *Luff变幅*

If a luffing winch is used, the requirements are similar to those of the hoist winch. The maximum load position is determined by the geometrical layout of the crane.假如使用变幅绞车，它的要求类似于起升绞车。最大的负载位置由吊车的几何形状决定。

Alternatively, hydraulic cylinders can be used for luffing and in this case it is necessary to fit two-way-acting, counterbalance valves to prevent untoward movement of the jib which may occur by either creeping under load or rapid movement caused by tension in the hoisting ropes. 作为选择, 液压缸能够用于变幅, 在这种情况下, 有必要安装两位作用背压阀来阻止吊臂的意外运动, 可能是由于在负载下蠕动或者由于起升绳索张力引起的快速移动。

*Slew* 回转

The slewing duty is particularly arduous as the mass of the superstructure has to be accelerated, and brought back to rest at each cycle. 回转的职责是特别费劲的, 因为上部构造的质量必须被加速并且在每次循环后返回原位静止。 Unless the motor is operated by a variable capacity pump with a damped response, it will normally be necessary to operate on the relief valve during both acceleration and deceleration. 假如马达没有在有阻尼响应的变量柱塞泵下工作, 那么在加速和减速过程中有必要在安全阀下工作。

Adequate torque is required to slew on a cross slope caused by an unbalanced cargo during loading or unloading of a ship. 在船舶装卸货过程中, 需要额外的扭矩让吊车在不平衡货物引起的横倾下回转。

A by pass across the slew motor is also needed to act as an anti-swing device; the low polar moment of inertia of the rotating parts of a hydraulic motor allowing the mass of the superstructure to oscillate out of phase with the load--damping the swing. In this case, the bypass valve would normally be foot operated and spring loaded to the closed position. 同样需要一个经过回转马达的旁通作为一个防止摆动设备; 液压马达旋转部件的低惯性极矩引起上部构造与负载不同相的摆动, 而负载阻尼这种摆动。在这种情况下, 旁通阀正常时将用脚操作并用弹簧加载到关闭位置。

## LESSON 24

# CENTRIFUGAL PUMPS

### 离心泵

A typical centrifugal pump has one or more shaft-mounted vane impellers that rotate within a stationary casing and transfer energy to the fluid flowing between their vanes. 一个典型的离心泵有一个或者多个在轴上安装的叶片叶轮在静止的涡壳里旋转并把能量传输给叶片之间的流动的流体。 Liquid entering a centrifugal pump impeller generally flows primarily in the axial direction. 进入离心泵叶轮的液体一般以沿着轴向流动为主。 Any tangential component to the inlet flow is often referred to as prewhirl or prerotation. 任何输入流量的切向部分通常被认为是预旋。 Liquid enters a double-suction impeller through two inlets, or entrance eyes. A single-suction impeller, however, has only one entrance eye. 液体通过两个吸入口或者入口进入一个双吸叶轮。 但是一个单吸式叶轮只有一个入口。

A centrifugal pump impeller can be designed for radial-flow, mixed flow, or axial-flow operation, where these classifications refer to the primary orientation with respect to the shaft axis of flow at the impeller's discharge. 离心泵叶轮能够设计成在径流, 混流, 或者轴流下工作, 这些分类涉及到关于叶轮排出端流体与轴线的基本定向。 The impeller-flow orientation required or used in a centrifugal pump can often be determined from the specific speed, which is a characteristic number that can be calculated using the relative equation. 在离心泵里需要的叶轮流向通常由比转数决定, 而比转数是使用相对方程计算出的一个特征数值。

A low specific speed represents a relatively low capacity and a relatively high total head; consequently, low-specific-speed impellers tend to have large outside diameters with respect to their waterway widths. 低比转数代表一个相对低的排量和一个相对高的总压头；因此，低比转数叶轮与它们的流道宽度相比趋向于大的出口直径。Conversely, a high-specific-speed impeller often has relatively wide waterways with respect to its outside diameter.与之相反，高比转数叶轮与它的出口直径相比通常有相对较宽的流道。Centrifugal-pump impellers can also be classified based on shroud configuration: a closed impeller's vanes are located between both a front and a rear shroud; a semi-open impeller's vanes are attached to a single rear shroud; and an open impeller consists of vanes that are attached to the periphery of a hub and, in some cases, a partial rear shroud.离心泵叶轮也可以根据盖板结构进行分类：闭式叶轮的叶片位于前盖板和后盖板之间；半开式叶轮的叶片被固定在一个单独的后盖板上；而开式叶轮由固定在轴毂周围的叶片组成，在有些情况下有部分的前盖板。The impellers in high specific-speed axial-flow pumps have no shrouds and frequently are referred to as propellers.高比转数轴流式离心泵的叶轮没有盖板并且经常被认为是螺旋桨。

A centrifugal pump casing can be arranged so that the pump's shaft is oriented either horizontally or vertically.对离心泵蜗壳进行布置可以让泵轴水平或者垂直导向。In addition, the casing can be split in a plane that is parallel to the shaft's axis (referred to as an axially split casing), or, the casing split can be in a plane that is perpendicular to the shaft (referred to as a radially split casing).并且，蜗壳可以水平切成与轴线平行的平面（叫做轴向蜗壳），或者，蜗壳分面可以是与轴向垂直的平面（叫做径向蜗壳）。When an axially split design is used, the pump's suction and discharge connections are both generally in the stationary half of the casing.当使用轴向分面设计，泵的吸入和排出连接通常都在静止的半面泵壳上。This enables the casing to be opened for inspection or maintenance without disconnecting the suction and discharge piping.这样可以打开泵壳进行检查或者维护而不需要断开吸入和排出管的连接。In the case of a radially split casing, this same feature can be incorporated into the pump design by utilizing a back-pull-out configuration.对于径向分面泵壳来说，通过使用背向拉出结构相同的特点可以包含到泵的设计当中。With this arrangement, both the suction and discharge connections are in a common portion of the casing.对于这种布置来说，吸入和排出连接在泵壳一个共同部分里。The name back-pull-out is derived from the ability to back the pump's rotating assembly out of the casing without disconnecting the suction and discharge piping.背向拉出这个名字来自于将泵的旋转组件从泵壳后部拉出而不需要断开吸入和排出管的能力。Because the removable section of the casing typically contains the pump's shaft seal, this configuration is also sometimes referred to as a seal-head design.因为泵壳的移出部分一般含有泵的轴密封，这种结构有时也被称为封头设计。Alternatively, some radially split casings have a suction head that is separate from the discharge portion of the casing.另一种情况是，一些径向分面蜗壳有一个与蜗壳排出端分离开来的吸入头。With this latter configuration, either the suction or the discharge piping must be disconnected from the pump before the casing can be disassembled.对于后一种结构来说，在分解泵壳之前，吸入或者排出管必须与泵断开连接。Radially split casings can also be classified based on the relative orientation of the pump's suction and discharge connections.径向分面蜗壳也可以基于泵的吸入和排出接头相对导向进行分类。For example, a vertical in-line (VIL) pump has suction and discharge connections that are 180° apart.举个例子来说，一个垂直直列式泵的吸入和排出接头相隔 180°。In an end-suction pump, however, the casing's suction port, which leads directly into the eye of the first-stage impeller (the only impeller in a single-stage pump), is usually perpendicular to the discharge connection.但是在端面吸入泵

中，直接与第一级叶轮（在单级泵里只有一个叶轮）入口相连的泵壳吸入口，通常与排出接头相垂直。

The suction portion of a casing guides fluid entering the pump from the suction connection to the eye of the first-stage impeller. 泵壳的吸入口引导流体从吸入接头到一级叶轮的吸入口进入到泵中。Stationary guide vanes are sometimes added to the inner wall of a casing's suction nozzle to straighten the flow path at the entrance to the impeller and to break up vortices that may form if a portion of the fluid that enters the impeller is recirculated back out of the impeller's eye. 有时静止的导向叶片加在泵壳吸入喷嘴的内壁上使进入到叶轮的流体流动轨迹变直并破坏可能形成的漩涡，假如进入到叶轮的部分流体重新循环返回到叶轮的入口。The discharge portion of a casing includes a collector to catch the fluid discharged from the impeller and a channel to guide this fluid either to the pump's discharge connection or, in the case of a multistage pump, to the inlet of the next stage. 泵壳的排出部分包括一个汇集器来汇集从叶轮排出的流体并且一个管道用来引导流体到泵的排出接头或者假如在多级泵里，被引导到下一级的入口。Additionally, the casing ordinarily has some type of diffuser in which a portion of the velocity head of the fluid being discharged from the impeller is converted to static pressure head. 另外，泵壳通常有一些类型的扩压管，用来把从叶轮排出流体速度头的一部分转换为静压头。Referred to as pressure recovery, this conversion is necessary due to the relatively high absolute velocity of fluid leaving the typical centrifugal pump impeller. 这也叫作压力回收，由于流体离开典型离心泵叶轮相对较高的绝对速度，这种转化是必须的。

One of the most common types of casing collectors used in single-stage radial- and mixed-flow centrifugal pumps is the volute, which is a scroll-shaped channel with a gradually increasing radius and cross-sectional area that surrounds the periphery of the impeller. 在单级径向和混流式离心泵中，最为常见一种的泵壳汇集器是涡壳，具有半径和横截面积不断增加的螺旋形流道并围绕在叶轮的外缘。To increase pressure recovery, the fluid leaving the volute is generally decelerated in the casing's discharge nozzle, which forms the transition from the volute's throat to the pump's discharge connection. 为了增加压力回收，离开涡壳的流体通常会在泵壳的排出喷嘴减速，从而形成从涡壳喉部到泵的排出接头的能量转变。As an alternative to a spiral volute, some centrifugal pumps are furnished with a circular or concentric collector having a constant radius and cross-sectional area. 作为螺旋形涡壳的一种替代方法，一些离心泵安装有一个环形或者同心的汇集器，它们具有恒定的半径和横截面积区域。In addition, a modified or semi concentric casing design, in which the radius and cross-sectional area of the collector remain constant over only a portion of the circumference, is sometimes used. 另外，有时使用一种改正的或者半同心泵壳设计，在设计中汇集器的半径和横截面积区域仍然在圆周的一部分中保持不变。

Volutes are also used in some multistage centrifugal pumps. 涡壳也在一些多级离心泵中使用。When a multistage-volute pump has an axially split casing, the flow passages that connect successive stages may be integrally cast with or welded onto the casing. 当多级涡壳泵有一个轴向分面的涡壳，连接相邻级之间的流动管道可以整体铸造或者焊接在泵壳上。Alternatively, a multistage pump may be fitted with multivaned diffusers instead of volutes. 另外一种方法是，一个多级泵可以安装多级叶片式扩压器取代涡壳。A multivaned diffuser, which is also used in some single-stage radial-flow pumps, contains a number of diverging vanes mounted in a ring that surrounds the periphery of the impeller. Diffuser-type multistage pumps frequently have radially split casings. 同样在一些单级径向泵中使用的多级叶片式扩压器，包含许多安装在环里的相邻叶片并围绕在叶片的边缘。扩压式多级离心泵经常会有径向分面泵壳。With this

configuration, the flow channels that join adjacent stages are generally formed by vanes that either are on the back side of the diffusers or are part of separate diaphragms, or stage pieces, used to separate adjoining stages.对于这种结构来说, 连接相连级之间的流道通常由叶片形成, 叶片位于扩压器背面或者是独立膜片的一部分, 或者是级片, 用来分离临近的两级。 In addition, the pump's rotor, together with the stationary diffusers and stage pieces, can often be inserted into the casing as an assembled cartridge.另外, 泵的转子, 与静止的扩压器和级片一起, 可以经常被插入到泵壳中作为组合式的夹头。

## LESSON 25

# AQUA-SEP Seawater Desalinator System

## 海水淡化系统

### THEORY OF REVERSE OSMOSIS 反渗透原理

Reverse Osmosis is based upon the biological process of osmosis, which allows fluids to pass through a semi-permeable membrane.反渗透基于渗透作用的生物过程, 该过程允许液体穿过半透膜。 Plants use osmosis to transport water and nutrients through their roots to branches and leaves; the human body uses osmosis to transfer fluids internally.植物利用渗透作用通过它们的根系向分支及叶传送水分和营养; 人体利用渗透向体内传送液体。 Osmosis is when two solutions of different concentrations are separated by a semi-permeable membrane; the less concentrated (purer) solution will naturally flow through the membrane toward the more concentrated solution there by diluting the more concentrated solution. 渗透作用是当两种浓度不同的溶液用半透膜隔开时发生的; 低浓度的溶液(或较纯的溶液)会自发的穿过膜流向浓度较高的溶液, 稀释高浓度的溶液。 In reverse osmosis this process is reversed, where as the concentrated solution is force through a synthetic semi-permeable membrane leaving its dissolved solids behind producing a less concentrated (purer) solution.反渗透是这个过程反过来, 浓度高的溶液被迫通过一个合成半透膜, 被溶解的固体留下来, 产生浓度低的溶液(或较纯的溶液)。

The desalination of water by reverse osmosis is a membrane separation process in which the water from a pressurized saline solution (seawater) is forced through a synthetic semi-permeable membrane leaving its salts behind (dissolved solids). 利用反渗透实现海水的淡化是一个膜分离过程, 加压的盐溶液(海水)的水被迫通过合成半透膜, 把盐留下(溶解的固体)。 The liquid flowing through the membrane known as permeate or product emerges near atmospheric pressure has a reduction in salt content greater than 98.6%. 液体从膜流出来称作渗透, 或者是接近大气压力的渗出, 这时盐的含量已经降低了98.6%以上。 The feed solution, which is pressurized on the other side of the membrane, increases in salt content, and is returned to its original source (sea, ocean, etc.) as the concentrate or reject.供给的溶液在膜的另一边被加压, 盐的含量增加了, 又被当作浓缩物或剩下的废水(盐水)重新排回到原来的地方(海、洋等)。

As no heating or phase change takes place, the major energy usage in the process is that required to pressurize the feed water. 由于没有热量或相的改变, 过程中主要使用的能量是需要给供应来的水加压。 For seawater, the operating pressure generally ranges from 700 to 1000 PSI, (4800-6900 kPa). 对于海水来说, 操作压力一般从700到1000 PSI(4800-6900 kPa).

#### **PROCESS FLOW DESCRIPTION 过程描述**

The AQUA-SEP REVERSE OSMOSIS SEAWATER DESALINATOR is a complete packaged plant designed for simple installation and operation. AQUA-SEP 型反渗透海水淡化装置是一个成套装置, 良好的设计使得安装和操作都很简单。 All components are of high quality, reliable, low maintenance, and marine duty. 所有的部件质量高、可靠、低保养并适合海上使用。 The Booster Pump, controls and prefilters are mounted onto a rugged coated steel frame. 增压泵、控制和预过滤装置都安装在结实的镀钢架上。 The controls, valves and displays are all located for ease of operation and are plainly labeled for operator convenience. 控制、阀和显示都位于容易操作的位置, 为了操作者使用方便都有简单的标签。 A membrane cleaning and preserving system is incorporated as standard equipment, thus permitting cleaning or preserving without requiring additional equipment. 膜清洁和维护系统作为标准装备也集成在系统内, 这样清洁和维护就不需要额外的设备。 The Membranes are installed on the same coated steel frame. 膜也安装在相同的镀钢框架上。 The Pretreatment Unit, which contains the Feed Pump and a Multi-Media Filter, is also included on the system. 包含给水泵和多介质滤器的预处理单元也包含在这个系统中, The Feed pump is required for proper operation of the system and the Multi-Media filter will aid in overall system performance and give longer Cartridge Filter life. 给水泵保证系统合适的操作, 多介质滤器保证整个系统的性能, 使筒型滤器的使用寿命延长。

The process starts with a raw seawater source. 处理过程从天然海水开始。 The raw seawater source should supply the system Feed Pump with a flooded suction. 海水用淹没充液法供应到给水泵。 A user supplied basket strainer (optional) should be installed on the Feed Pump's suction line to prevent any damage or premature plugging by removing all solids particles larger than 1/8" (3mm). 篮式粗滤器应该安装在给水泵的吸入管线上, 防止损害或过早堵塞, 用滤器除去所有大于1/8英寸(3mm)的固体颗粒。

The Feed Pump pumps the raw seawater through the Multi-Media Filter to the AQUA-SEP inlet for processing. 给水泵通过多介质滤器把海水供应到AQUA-SEP海水淡化装置整个处理的入口。 The flow is then directed to the "Multi-Media Filter", which contains layers of various permanent materials, which serve as the filtering media. 水流直接流向多介质滤器, 滤器包含有多层各种永久过滤材料, 它们起到过滤媒介的作用。 As the feed water flows very slowly through the media (from top to bottom), suspended particles are retained in the upper portion of the Multi-Media Filter. 由于给水非常慢的从上往下流过滤介质, 一些悬浮颗粒就留在了多介质滤器的上部。 The Multi-Media Filter also functions to remove small amounts of dispersed oil, which may be present in feed water of certain locations. 多介质滤器也用来除去少量的分散油, 这些油可能存在于某些地区的给水中。 The suspended particles and dispersed oils are discharged from the Multi-Media Filter per a backwash valve provided with the Multi-Media Filter. 多介质滤器上的悬浮物和分散油由滤器上配备的反冲阀来清除。

The feed water exits the Multi-Media Filter and enters the AQUA-SEP and its two Cartridge Filters in parallel, which functions as the final polishing filter for the feed water and as a safety filter in the feed water system. 给水离开滤器进入AQUA-SEP海水淡化装置, 然后进入两个并联的筒型滤器, 它的功能是作为给水的最后一级精滤器, 是给水系统中的保障性过滤器。 Each cartridge filter vessel contains one 5 micron high surface area cartridge. 每一个筒型滤器的

壳体内包含有一个5微米高的表面过滤筒。The dual 5 micron filters provide an extremely high surface area and dirt holding ability. 两个5微米高的滤器提供了一个非常大的流通面积和容纳脏物的能力。The polished feed water exits the Cartridge Filters and enters the suction of the system Booster Pump, where the pressure is increased to 700-1000 PSI (4800-6900 kpa). 精确过滤的给水离开筒型滤器后, 进入到系统的增压泵, 压力被加到700-1000 PSI (4800-6900 kpa). The pressurized feed water exits the Booster Pump and flows through high pressure hose at a velocity high enough to prevent crevice corrosion to the membrane feed port. 加压后的给水离开增压泵, 高速通过高压管防止在膜入口出造成腐蚀。

The system utilizes membrane housing. There are a total of two, 8" diameter, 40" long membranes. 系统采用壳体罩住膜, 内部有两个膜, 它直径为8英寸, 长为40英寸。As the feed water flows into the reverse osmosis membranes, the membranes yield reject water and product water. 当给水水流到反渗透膜时, 膜产生盐水和淡水。The reject water flows to the pressure control valve, which is set by the operator to maintain pressure on the membranes. 盐水流到压力控制阀, 控制阀由操作者设定, 保持在膜上有一定的压力。The reject water is returned to the sea via the reject water outlet line. 盐水经由盐水出水管返回到大海里。The product water flows from the membrane through the Product Water Flow Meter, to a pair of Diverter Valves that are controlled by a water quality monitor. 产出的水从膜流出来到产水流量计, 然后流到一副由产水质量监控器控制的换向阀。Depending on the product water quality, it is either directed to the Product Water Outlet for use as potable water, or diverted to the reject line and returned back to the sea. 依据产水的质量, 决定产水是流到产水口作为饮用水, 还是转到盐水管路流回大海。

The AQUA-SEP System utilizes the thin film composite, spiral wound membranes that are less susceptible to plugging and easier to clean than other types of membrane. AQUA-SEP型海水淡化系统利用薄膜复合材料、螺旋式薄膜, 降低了脏堵的影响, 并且比其它形式的膜更容易清洁。Reverse Osmosis membranes will require periodic cleaning to maintain the rated output of product water. 反渗透膜应该定期清洁, 保持它的额定产水量。A Cleaning system and the necessary valves and piping are provided to permit easy cleaning of the membranes. 已经配备了清洁系统和必要的阀和管路可容易的清洗膜。For instructions on cleaning, refer to the "Membrane Cleaning" section. 关于清洁的说明请参考膜清洗章节。

## LESSON 27

### MARPOL 73/78 73/78 防污公约

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto. MARPOL 73/78 系指经 1978 年议定书修订的 1973 年国际防止船舶造成污染公约。

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL 公约是防止船舶因操作或事故而对海洋造成污染的主要公约。It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. 它是由 1973 年和 1978 年两个相对独立的条约联合而成的, 多年来经过多次修改。

The International Convention for the Prevention of Pollution from Ships (MARPOL) was adopted

on 2 November 1973 at IMO and covered pollution by oil, chemicals, and harmful substances in packaged form, sewage and garbage. 《国际防止船舶造成污染公约》是 1973 年 11 月 2 日在国际海事组织通过的，涵盖了油污染、化学品污染、包装有害物质污染、生活污水污染和垃圾污染。The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976-1977. (Measures relating to tanker design and operation were also incorporated into a Protocol of 1978 relating to the 1974 Convention on the Safety of Life at Sea, 1974)。《关于 1973 年国际防止船舶造成污染公约 1978 年议定书》是在 1978 年 2 月针对 1976-1977 年发生的大量油轮事故，所召开的油轮安全和防污染大会上通过的。（关于油轮设计及操作的措施也包括在《关于 1974 年海上人命安全公约 1978 年议定书中》）。

As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. 鉴于 1973 MARPOL 公约当时没有生效，1978 年的 MARPOL 议定书吸收了 73 公约的内容。The combined instrument is referred to as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), and it entered into force on 2 October 1983 (Annexes I and II). 这个联合文件是指《经 1978 年议定书修订的 1973 年国际防止船舶造成污染公约》，该公约从 1983 年 10 月 2 日生效（附则 I 和 II）。

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes: 该公约包括多个条款，目的在于防止和减少船舶污染—包括事故性污染和常规操作污染。目前公约包括六个技术附则：

**Annex 附则 I Regulations for the Prevention of Pollution by Oil**  
**防止油类污染规则**

**Annex 附则 II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk**  
**控制散装有毒液体物质污染规则**

**Annex 附则 III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form**  
**防止海运包装有害物质污染规则**

**Annex 附则 IV Prevention of Pollution by Sewage from Ships**  
**防止船舶生活污水污染规则**

**Annex 附则 V Prevention of Pollution by Garbage from Ships**  
**防止船舶垃圾污染规则**

**Annex 附则 VI Prevention of Air Pollution from Ships (entry into force 19 May 2005)**  
**防止船舶造成大气污染规则（2005 年 5 月 19 日生效）**

States Parties must accept Annexes I and II, but the other Annexes are voluntary. I 和 II 为必选附则，其它为可选附则。

**Revised MARPOL Annex I (oil) 修订附则 I**

The revised MARPOL Annex I *Regulations for the prevention of pollution by oil* incorporates the various amendments adopted since MARPOL entered into force in 1983, including the amended regulation 13G (regulation 20 in the revised annex) and regulation 13H (regulation 21 in the revised annex) on the phasing-in of double hull requirements for oil tankers.

MARPOL 修订附则 I 为防止油污规则，包含了从 1983 年强制实行以来的各种修正案，包括已修改的 13G 条（修订附则的规则 20）和 13H 条（修订附则的规则 21），这两个规则要求油船逐步采用双层船体。 It also separates, in different chapters, the construction and equipment provisions from the operational requirements and makes clear the distinctions between the requirements for new ships and those for existing ships. 在不同章节中，区分操作需要的结构和设备，清楚地区分了新船和现有船的不同要求。The revision provides a more user-friendly, simplified Annex I. 修订附则 I 对使用者来说更友好、简便。

New requirements in the revised Annex I include the following: 修订附则 I 中新的要求如下：

- Regulation 22 Pump-room bottom protection: on oil tankers of 5,000 tones deadweight and above constructed on or after 1 January 2007, the pump-room shall be provided with a double bottom. 第 22 条泵房底部保护规则：凡 5000 吨及其以上，2007 年 1 月 1 日以后建造的船舶，泵房应该建有双层底。
- Regulation 23 Accidental oil outflow performance - applicable to oil tankers delivered on or after [date of entry into force of revised Annex I plus 36 months] 1 January 2010; construction requirements to provide adequate protection against oil pollution in the event of stranding or collision. 第 23 条事故溢油执行规则：适用于 2010 年 1 月 1 日（修订附则 I 强制实行 36 个月）或该日期以后交付使用的船舶，需要对船体结构提供足够的保护，防止在触礁或碰撞是造成油污。

#### Revised MARPOL Annex II (noxious liquid substances carried in bulk) 修订附则 II (散装有毒液体物质)

The revised Annex II *Regulations for the control of pollution by noxious liquid substances in bulk* include a new four-category categorization system for noxious and liquid substances. 修订附则 II 控制散装有毒液体物质污染规则，包括一个新的四大类针对有毒的液体物质的的分类系统 The revised annex is expected to enter into force on 1 January 2007. 修订附则计划于 2007 年 1 月 1 日起开始实行。

The new categories are: 新的分类是：

- **Category X:** Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of the discharge into the marine environment; X 类：这类有毒液体物质，如随洗舱水或压载水排放入海，将对海洋资源或人类健康产生重大危害，禁止排放入海；
- **Category Y:** Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment; Y 类：这类有毒液体物质，如随洗舱水或压载水排放入海，将对海洋资源或人类健康产生危害，或对舒适性或海洋的合理使用有危害，将限制排放入海的质量和总量。
- **Category Z:** Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a minor hazard to either marine resources or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment; and Z 类：这类有毒液体物质，如随洗舱水或压载水排放入海，将对海洋资源或人类健康产生较小危害，将较低程度限制排放入海的质量和总量。

- **Other Substances:** substances which have been evaluated and found to fall outside Category X, Y or Z because they are considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning of deballasting operations. The discharge of bilge or ballast water or other residues or mixtures containing these substances are not subject to any requirements of MARPOL Annex II. 其它物质：一些物质评估后发现它们不属于 X、Y、Z 类物质，因为它们随洗舱水或压载水排放入海后，对海洋资源、人类健康、舒适性或海洋合理利用等没有危害。如所排放的舱底水、压载水或者是其它残余物质或混合物中包含这些物质，就不受 MARPOL 附则 II 的限制。

The revised annex includes a number of other significant changes. 修订附则包括一些其它重要改变。Improvements in ship technology, such as efficient stripping techniques, has made possible significantly lower permitted discharge levels of certain products which have been incorporated into Annex II. 在船舶技术方面也有修改，比如有效的脱模技术，这些修改使得某些产物的允许排放水平特别地低，这些修改也添加到附则 II 当中。For ships constructed on or after 1 January 2007 the maximum permitted residue in the tank and its associated piping left after discharge will be set at a maximum of 75 liters for products in categories X, Y and Z - compared with previous limits which set a maximum of 100 or 300 liters, depending on the product category. 对于 2007 年 1 月 1 日及其以后建造的船舶，根据 X、Y、Z 类要求，排放后，船舶及其管路中允许最大残留量为 75 升，根据货物类型的不同，以前的最大限度是 100 或 300 升。

Alongside the revision of Annex II, the marine pollution hazards of thousands of chemicals have been evaluated by the Evaluation of Hazardous Substances Working Group, giving a resultant GESAMP2 Hazard Profile which indexes the substance according to its bio-accumulation; bio-degradation; acute toxicity; chronic toxicity; long-term health effects; and effects on marine wildlife and on benthic habitats. 与修订附则 II 相比较，上千种化学品对海洋污染危害已经由有害物质评估工作组评定完毕，并得出 GESAMP2 危害简介，它根据物质的生物积累、生物降解、急性毒性、慢性毒性、对健康的长期影响和对海洋生物及海底环境的影响来度量该物质的危害性。

As a result of the hazard evaluation process and the new categorization system, vegetable oils which were previously categorized as being unrestricted will now be required to be carried in chemical tankers. 作为危害评估过程和新分类系统的结果，植物油以前分类时没有限制，现在必需要用化学品船运输。The revised Annex includes, under regulation 4 Exemptions, provision for the Administration to exempt ships certified to carry individually identified vegetable oils, subject to certain provisions relating to the location of the cargo tanks carrying the identified vegetable oil. 修订的附则包括一些条款（第 4 条免责条款），使得管理部门豁免已证明是单独运送已认定的植物油的船舶，但要遵守运送已认定的植物油的船舶所属国的某些条款。

## LESSON 28

### Port State Control

#### 港口国检查

#### **The international framework 国际框架**

The United Nations Convention on the Law of the Sea, 1982 (UNCLOS) establishes the general rights and obligations of the flag State. 联合国海洋法会议，1982 (UNCLOS) 建立船旗

国的一般权利和责任。Within the United Nations two specialized agencies deal with maritime affairs, the International Maritime Organization (IMO) and the International Labor Organization (ILO), and they have a responsibility for devising and developing conventions and guidelines under which ships can be regulated.在联合国内部两个专门机构处理海事事务，国际海事组织（IMO）和国际劳工组织（ILO），而且它们负责策划和发展控制船舶的公约和指导方针。In general, matters concerning safety at sea, pollution prevention and the training of seafarers are dealt with by IMO, whereas the ILO deals with matters concerning working and living conditions at sea. 总的来说，与海上安全，污染防治和海员培训相关事宜由IMO进行处理，而ILO处理与海上工作和生活情况相关的事宜。While IMO and ILO set the international regulatory framework for ships, each Member State bears the responsibility for enforcing the international conventions it has ratified on the ships flying its flag.尽管IMO和ILO设定船舶的国际管理框架，但是每个成员国对于所批准的悬挂本国旗帜船舶的国际公约履行要负有责任。

### **The role of the flag state 船旗国的作用**

The international conventions developed by IMO form the main framework of safety, training and pollution prevention regulation, with SOLAS, MARPOL, STCW, Tonnage Measurement and Load Line conventions being the key regulations. 由IMO发展的国际公约形成了船舶安全，培训和污染防治控制的主要框架，而《1974年国际海上人命安全公约》，《经1978年议定书修订的1973年国际防止船舶造成污染公约》，《1995年经缔约国大会决议修订的1978年培训、发证和值班标准国际公约》，《1969年国际船舶吨位丈量公约》以及《1966国际载重线公约》是主要的规章制度。These are supported by classification rules that largely focus on the structure of the ship, including the materials used in its construction, the size of scantlings and essential engineering systems like the main engine. 这些公约受到船级社制度的支持，而船级社制度主要聚焦船舶的结构，包括建造中所使用的材料，船材尺寸和关键的轮机系统比如主机。Classification and Convention requirements can be inter-related. The issuing of Load Line and Cargo Ship Safety Construction certificates would require, for example, the ship to be built and maintained to class rules.船级社和公约的要求是相互关联的。举个例子来说，载重线和货船结构安全证书都需要船舶在船级社规则下进行建造和维护。

Evidence that convention standards and classification rules have been met is generally provided by the presence on board of valid certificates. 通常满足公约标准和船级社规则的证据就是需要在船上存在有效证书。To ensure that a ship meets and then subsequently maintains convention standards, a flag State needs to have in place arrangements for ensuring that its ships are periodically surveyed and re-certified. 为了保证船舶满足以及接下来需要保持的公约标准，船旗国需要进行合理的安排保证本国船舶被定期检验和重新发证。This responsibility applies regardless of whether a flag state carries out its own surveys using its own surveyors or authorizes a Recognized Organization (RO) to conduct surveys and issue international certificates on its behalf. 不管船旗国是否使用自己的验船师执行检验或者授权认可组织来执行，这个职责是致力于引导检验和以船旗国名义签发国际证书。

The member societies of the International Association of Classification Societies (IACS) meet the minimum standards required of an RO. 国际船级社协会的成员要满足认可组织的最低标准要求。In many cases therefore, it would be a class surveyor who undertakes all the certification work on board ship. 因此在许多情况下，船级验船师将承担船上的所有认证工作。

Port States have had the right to check that visiting foreign ships met the required international safety and pollution prevention standards for many years. 在许多年中，港口国已经有权去检查到访的外国船舶来满足必须的国际安全和防污标准。Over the last twenty years

or so, rather than approaching the task individually, port States have developed regional agreements and now much of the world is covered. 在过去的大约二十年中, 港口国已经发展出来成熟的区域协议并且现在世界大部分已经覆盖, 而不是单独的处理任务。

Port State control and the impact it is having on ships is growing. 港口国检查和对船舶的影响正在上升。Port States in their regional groupings are becoming more organized and professional in their approach to ship investigations, and when detentions occur, ships are 'named and shamed' in public. 在他们的区域组织里, 港口国以他们的方式对船舶的检查正在变得更加有条理和专业。Ships and shipping companies with a history of detentions will begin to find it difficult to trade unhindered船舶和有扣船历史的公司开始发现不受妨碍的交易将变得困难。

INTERCARGO would like to see more consistency in the way inspections are carried out, improvements in the targeting of ships, better regional co-operation and exchange of information and the implementation of common deficiency coding system for all port State control regions to use. 干散货船东协会将会看到所用检查方式更多的连续性, 目标船舶的改进, 更好的区域合作和信息交换以及执行所有港口国检查区域使用的共同缺陷代码系统。Ships with a 'clean' record should be able to move freely between port State control regions without the threat of undue repeat inspections. 拥有干净记录的船舶应该在港口国控制区域内自由航行而不应该受到过度频繁检查的威胁。Ships that have cleared outstanding deficiencies should have their records immediately cleared. 已经清除突出缺陷的船舶必须立即清理它们的记录。The main aim of port State control should be to eliminate substandard shipping and to then end port state control as a means to achieve that, can be supported.港口国检查的主要目的是清除不达标的船舶并最终通过得到支持的港口国检查这个手段来实现这个目标。

#### **The right of a port state港口国权利**

In practice, many ships do not regularly call at flag state ports and this can restrict the ability of the flag State to effectively police and enforce convention standards on its ships. 在实际当中, 许多船舶不是经常在港口国港口停靠, 而这样限制了船旗国对本国船舶的有效管理和公约标准的执行。This encourages some ships to sail in a substandard condition, endangering other ships, the lives of seafarers as well as the environment. 这样会鼓励一些船舶在标准以下航行, 使其它船舶, 海员生命以及环境遭受危险。

Coastal States have certain rights to exercise authority over ships in their waters. 沿岸国家对经过它们水域的船舶肯定拥有行使职权的权利。In addition, a port State has the authority to check that foreign ships visiting its ports meet all the appropriate convention standards.另外, 港口国拥有权利去检查到它们港口来访的外来船舶从而来满足合适的公约标准。Indeed, the origins of Port State Control can be traced back to the 1929 SOLAS Convention. Convention control provisions can now also be found in MARPOL, the Load Line Convention, STCW and the ILO Convention No. 147.实际上, 港口国检查的来源可以追溯到1929年的SOLAS公约。公约控制条款现在可以在国际防污染公约, 载重线公约, 培训、发证和值班标准国际公约以及国际劳工组织公约147号中找到。

A port State can, however, only apply those conventions which have entered into force, and which it has implemented for its own ships. 但是, 一个港口国只能应用那些已经生效的公约, 并对于它们拥有的船舶已经执行。Ships that fly the flag of a State that has not ratified a convention, or are below convention size would not, however, be exempt from inspection because the principle of no more favorable treatment would be applied.然而, 那些悬挂没有批准公约国家旗帜的船舶, 或者低于公约要求的尺寸将不会免除检查, 因为优惠待遇的原则将不再适用。

A State may also enact its own domestic laws and impose additional national rules and

regulations on foreign ships entering its waters. 一个国家也可能制定自己的内部法规并强加额外的国家规则和制度到进入它们水域的外来船只。The United States, for example, has enacted the Oil Pollution Act, 1990 (OPA 90). 举个例子来说, 美国已经制定油污法案, 1990。The existence of convention control provisions and national rules, coupled with the general desire of port States to ensure that visiting ships are safe and unlikely to pollute their waters, forms the background to port State control. 公约控制条款和国家规则的存在, 外加港口国的常规需要来保证来访船舶是安全的并不会污染它们的水域, 从而形成港口国检查的背景资料。

#### **The rules that govern port state control activities 控制港口国检查活动的规则**

In November 1995, IMO adopted resolution A.787 (19) – Procedures for port State control. 在1995年11月, 世界海事组织采纳A.787 (19)决议—港口国检查程序。The resolution was amended in 1999 by resolution A.882 (21) and will no doubt be further amended in the future. 决议通过A.882 (21)号决议在1999年被修订并且毫无疑问将来还会被进一步修订。The procedures are intended to provide basic guidance on how port State control inspections should be conducted and how to identify deficiencies in a ship, its equipment, or its crew, with the purpose of ensuring that convention control provisions are consistently applied across the world from port to port. 检查程序用来提供基本的指导, 它是关于如何让港口国检查被正确引导并且如何确认船舶, 设备, 或者船员的缺陷, 主要的目的是保证公约控制条款在全世界范围内从一个港口到另一个港口得到始终如一的执行。

The procedures are not mandatory and only offer guidance to port states, albeit guidance that has been developed and agreed internationally. 这个程序不是强制的, 只是给港口国提供指导, 虽然指导意见已经发展成熟并被国际承认。While port State regions should use the procedures when exercising port State control, in practice variations in the way the procedures are interpreted exist. 当进行港口国检查时, 尽管港口国区域必须使用这套程序, 但是在实际中对检查方式解释而引起的变化是存在的。

For example, if convention control provisions were strictly interpreted, a routine or general inspection would be limited to a check on the validity of the ship's certificates, except in cases where the condition of the ship was in doubt. 举个例子来说, 假如对公约控制条款进行严格的解释, 一个常规的检查将会限制在对船舶证书有效性的检查, 除了对船舶状况有所怀疑的情况之外。It is, nevertheless, often argued that the presence of certificates is only evidence of, and not conformation of convention standards being met. 尽管如此, 争辩者常常认为证书的存在只是符合公约标准的证据, 而不能确认它满足公约标准。For this reason, some Port State Control Officers (PSCO) are likely to want to inspect more than just the ship's certificates while undertaking routine port State control inspections. 由于这个原因, 当承担常规的港口国检查的时候, 一些港口国官员可能想要进行更多的检查, 而不只是船舶的证书。

#### **Dealing with the PSCO 与港口国官员的交涉**

It is probably best assumed that the PSCO is fully qualified, well-trained and familiar with ships although of course this may not always be the case. 最好假设是港口国官员完全称职, 受到良好的训练并熟悉船舶, 虽然事实很难如此。The master should select a room for the initial meeting that is quiet, comfortable and have all the certificates and documentation readily available. 船长必须选择一个安静舒适的房间用来最初的会面并准备好所有的证书和文件。The reports of previous port state inspections should also be at hand. 以前的港口国检查报告也必须准备在手边。All questions asked by the PSCO should be responded to in an honest and straightforward manner. 港口国官员提问的所有问题必须以一种诚实和坦率方式进行回应。

When the PSCO is ready to make an inspection of the ship, a senior and knowledgeable

officer should be assigned to accompany him. 当港口国官员准备对船舶进行检查时, 应该指派一个高级并且博学的高级船员陪同他。That person should be familiar with the ship and have the necessary keys with him so ensuring that ready access to all spaces is possible. 这个人必须熟悉船舶并随身携带必需的钥匙来确保可以进入所有的房间。If a spare crew member or a cadet is available, his attendance is also recommended. 假如一个空闲的船员或者实习生是可以交谈的, 那么他也应该被推荐陪同。If things need immediate attention or assistance needs to be called, that person can attend to such matters and the flow of the inspection can remain unaffected.假如事情需要立即注意或者需要进行协助, 那么这个人可以参与这种事务而检查的流程仍然不能受到影响。

The officer should be vigilant and not afraid to point out and immediately rectify discrepancies that appear during the inspection, rather than risk the PSCO identifying the discrepancies himself.高级船员必须警觉并且不要害怕指出和立即矫正在检查过程中出现的问题, 而不要冒着被港口国官员亲自确认问题的风险。Being able to fix things on the spot is an indication of being well organized. 能够在现场解决问题表明船舶管理有序。Even if something does not work or needs adjusting but can not be fixed immediately, move on and let the PSCO return later. This could save a second visit to the ship.即使存在某些问题或者需要调整但是无法立即处理, 继续进行检查并让港口国官员过会儿再来。这样能够为船舶争取到第二次检查机会。

Finally, it must be remembered that the master always has the right to query the direction that an inspection is taking should he believe that the inspection could interfere with the safety of the crew or indeed cause crew fatigue. Unreasonable requests for drills while the ship is cargo handling or bunkering should always be questioned.最后, 必须记住船长永远有权利质疑正在进行的检查命令, 假如他相信检查会干扰到船员的安全或者的确会引起船员的疲劳。当船舶正在装卸货或者加油, 必须对演习的不合理请求进行质疑。

## LESSON 29

### **International Ship and Port Facility Security Code 国际船舶和港口设施保安规则**

A new, comprehensive security regime for international shipping is set to enter into force in July 2004 following the adoption by a week-long Diplomatic Conference of a series of measures to strengthen maritime security and prevent and suppress acts of terrorism against shipping. 随着为期一周的外交大会通过了旨在加强海运安全, 防治和抑制针对船舶的恐怖活动的一系列措施, 一个为国际航运制定的新综合安全法规与 2004 年 7 月 1 日生效。The Conference, held at the London headquarters of the International Maritime Organization (IMO) from 9 to 13 December 2002, was of crucial significance not only to the international maritime community but the world community as a whole, given the pivotal role shipping plays in the conduct of world trade. 2002 年 12 月 9 日至 13 日在国际海事组织总部伦敦召开大会, 这次会议不仅对国际海事界而且对整个国际社会来说都是非常重要的, 因为海运在世界贸易方面扮演着重要的角色。The measures represent the culmination of just over a year's intense work by IMO's Maritime Safety Committee and its Intercessional Working Group since the terrorist atrocities in the United States in September 2001. 自从 2001 年 9 月恐怖分子在美国实施暴力活动以来, 国际海事组织的安全委员会和协调小组成年紧张的工作, 各种措施的出台一直处于高点。

The Conference adopted a number of amendments to the 1974 Safety of Life at Sea Convention (SOLAS), the most far-reaching of which enshrines the new International Ship and

Port Facility Security Code (ISPS Code). 大会通过了对 1974SOLAS 的数项修正案, 其中影响最大的是《国际船舶和港口设施保安规则》(ISPS 规则)。The Code contains detailed security-related requirements for Governments, port authorities and shipping companies in a mandatory section (Part A), together with a series of guidelines about how to meet these requirements in a second, non-mandatory section (Part B). 该规则强制要求部分(A 部分)包括对政府、港口当局和航运公司关于保安的详细要求, 第二部分, 即非强制要求部分(B 部分)包括如何满足这些要求的一系列指导原则。The Conference also adopted a series of resolutions designed to add weight to the amendments, encourage the application of the measures to ships and port facilities not covered by the Code and pave the way for future work on the subject.大会也通过了一系列决议, 计划增加修正案的比重, 鼓励各种措施能够实际应用到船舶和港口设施上, 而不是仅限于制定规则, 为以后在这方面的开展铺平道路。

### **The International Ship and Port Facility Security Code 国际船舶和港口设施保安规则**

In essence, the Code takes the approach that ensuring the security of ships and port facilities is basically a risk management activity and that to determine what security measures are appropriate, an assessment of the risks must be made in each particular case.总体来说, 保安规则是采取方法保证船舶和港口设施的安全, 基本上就是风险管理, 决定哪种安全措施是合适的, 必须制定每一种特殊情况下的风险评估。

The purpose of the Code is to provide a standardized, consistent framework for evaluating risk, enabling governments to offset changes in threat with changes in vulnerability for ships and port facilities.保安规则的目的是提供一个标准的、始终如一的风险评估框架, 保证政府能够应对危险变化导致船舶和港口设施的易损性的变化。

To begin the process, each Contracting Government will conduct port facility security assessments. 为了开始这个过程, 每一个缔约国政府都要做港口设备的安全评定。Security assessments will have three essential components.安全评定有三个主要因素。First, they must identify and evaluate important assets and infrastructures that are critical to the port facility as well as those areas or structures that, if damaged, could cause significant loss of life or damage to the port facility's economy or environment.首先, 必须确定并评价对港口设施来说的重要资产和基础设施。以及一些区域和结构, 这些区域和结构如果受到损坏, 会引起重大的生命损失或对港口设施的有效使用或环境造成重大损失。Then, the assessment must identify the actual threats to those critical assets and infrastructure in order to prioritize security measures. 其次, 为了对安全方法进行优先排序, 评价必须指出对重要资产和基础设施的实际威胁。Finally, the assessment must address vulnerability of the port facility by identifying its weaknesses in physical security, structural integrity, protection systems, procedural policies, communications systems, transportation infrastructure, utilities, and other areas within a port facility that may be a likely target. 最后, 评价必须确定港口设施的弱点在哪里, 指出它在实际安全性、整体结构性、保护系统、程序方针、通信系统、运输设施、公共设施和港口内其他领域一些可能成为攻击目标的设施所存在的弱点。Once this assessment has been completed, Contracting Government can accurately evaluate risk.一旦完成这些评价, 缔约国政府就可以正确进行风险评估。

This risk management concept will be embodied in the code through a number of minimum functional security requirements for ships and port facilities. 通过对船舶和港口一系列最低保安功能要求, 风险管理的概念被引入保安规则。For ships, these requirements will include:对于船舶的要求包括:

- Ship security plans 船舶保安计划
- Ship security officers 船舶保安员

- Company security officers 公司保安员
- Certain onboard equipment 一定的船上设备

For port facilities, the requirements will include:对于港口设施的要求包括:

- Port facility security plans 港口设施保安计划
- Port facility security officers 港口设施保安员
- Certain security equipment 一定的保安设备

In addition the requirements for ships and for port facilities include:此外, 对船舶和港口设施的要求还包括:

- Monitoring and controlling access 监控手段
- Monitoring the activities of people and cargo 对人和货物状态的监控
- Ensuring security communications are readily available 保证安全通信方便有效

Because each ship (or class of ship) and each port facility present different risks, the method in which they will meet the specific requirements of this Code will be determined and eventually be approved by the Administration or Contracting Government, as the case may be.因为每艘船(或每种类型的船舶)以及各港口设施存在不同风险, 所以为了满足该规则具体要求而采取的方法由主管机关或缔约国政府确定并最终认可, 正如事实上可能的情况那样。

In order to communicate the threat at a port facility or for a ship, the Contracting Government will set the appropriate security level. 为了沟通港口设施或对船舶威胁信息, 缔约国政府应设定恰当的保安等级。Security levels 1, 2, and 3 correspond to normal, medium, and high threat situations, respectively. 保安等级 1、2、3 分别对应正常、中等和高级威胁状态。The security level creates a link between the ship and the port facility, since it triggers the implementation of appropriate security measures for the ship and for the port facility. 由于保安等级会引发对船舶和港口设施执行合适的保安措施, 所以保安等级建立了港口和船舶之间的联系。

The preamble to the Code states that, as threat increases, the only logical counteraction is to reduce vulnerability. 保安规则的前言中陈述到, 随着威胁的增加, 唯一符合逻辑的应对方法是减少各种漏洞。The Code provides several ways to reduce vulnerabilities. 规则给出几种降低漏洞的途径。Ships will be subject to a system of survey, verification, certification, and control to ensure that their security measures are implemented. 船舶将接受系统的检查、核实、验证和控制保证安全措施得以执行。This system will be based on a considerably expanded control system as stipulated in the 1974 Convention for Safety of Life at Sea (SOLAS). 这个系统基于一个广泛延伸的控制系统, 比如 1974 年签订的《海上人命公约》(SOLAS 公约)。Port facilities will also be required to report certain security related information to the Contracting Government concerned, which in turn will submit a list of approved port facility security plans, including location and contact details to IMO.港口设施被要求要向缔约国政府汇报某些相关的安全信息, 也要依次递交一份被认可的港口设施安全计划, 包括设施的位置以及和国际海事组织的详细联系。

### **The Company and the Ship**

Under the terms of the Code, shipping companies will be required to designate a Company Security Officer for the Company and a Ship Security Officer for each of its ships. 根据规则的条款, 船舶公司被要求为公司指派一名安全员, 为公司的每一艘船指派一名船舶安全员。The Company Security Officer's responsibilities include ensuring that a Ship Security Assessment is properly carried out, that Ship Security Plans are prepared and submitted for approval by (or on behalf of) the Administration and thereafter is placed on board each ship.公司安全员的责任包

括，保证船舶安全评价实实在地开展，船舶安全计划提前准备并上交（或代表）公司主管部门批准，然后保存于每艘船上。

The Ship Security Plan should indicate the operational and physical security measures the ship itself should take to ensure it always operates at security level 1. 船舶保安计划应该确认本船应该采取的实际的、可操作的保安措施，保证船舶始终处于保安等级 1. The plan should also indicate the additional, or intensified, security measures the ship itself can take to move to and operate at security level 2 when instructed to do so. 该计划还应该指出当被命令升级到保安等级 2，船舶应该采取的额外或加强保安措施。 Furthermore, the plan should indicate the possible preparatory actions the ship could take to allow prompt response to instructions that may be issued to the ship at security level 3. 另外，计划还应指出船舶可能的准备工作，以便船舶对可能发出指令在保安等级 3 时作出迅速的反映。

Ships will have to carry an International Ship Security Certificate indicating that they comply with the requirements of SOLAS chapter XI-2 and part A of the ISPS Code. 船舶必须持有《国际船舶保安证书》，确认符合 SOLAS 第 XI-2 章和 ISPS 规则 A 部分的规定。 When a ship is at a port or is proceeding to a port of Contracting Government, the Contracting Government has the right, under the provisions of regulation XI-2/9, to exercise various control and compliance measures with respect to that ship. 当船舶在港或要前往缔约国的港口，缔约国政府有权根据 XI-2/9 章规则要求，针对该船执行各种控制和符合措施。 The ship is subject to port State control inspections but such inspections will not normally extend to examination of the Ship Security Plan itself except in specific circumstances. 船舶要接受港口国控制检查，除非在特殊情况下，否则这样的检查通常不会延伸到船舶安全计划本身。

The ship may, also, be subject to additional control measures if the Contracting Government exercising the control and compliance measures has reason to believe that the security of the ship has, or the port facilities it has served have, been compromised. 如果缔约国政府在执行控制和符合措施时，有理由相信船舶保安或港口设施有危害，那么船舶可能要接受额外的控制措施。

#### **The Port Facility 港口设施**

Each Contracting Government has to ensure completion of a Port Facility Security Assessment for each port facility within its territory that serves ships engaged on international voyages. 各缔约国政府必须完成其领土范围内的每个港口设施的保安评价，这些设施是为了船舶从事国际航运服务的。 The Port Facility Security Assessment is fundamentally a risk analysis of all aspects of a port facility's operation in order to determine which parts of it are more susceptible, and/or more likely, to be the subject of attack. 港口设施保安评估是港口设施操作的各个方面的一个基本风险分析，是为了确定哪些方面是更敏感的，或者是更像是容易遭到攻击。 Security risk is seen a function of the threat of an attack coupled with the vulnerability of the target and the consequences of an attack. 保安风险像是一个由攻击威胁和目标脆弱性及攻击结果的函数。

On completion of the analysis, it will be possible to produce an overall assessment of the level of risk. 分析完成后，将会产生风险等级的一个整体评估。 The Port Facility Security Assessment will help determine which port facilities are required to appoint a Port Facility Security Officer and prepare a Port Facility Security Plan. 港口设施保安评估将会帮助确定哪些港口设施需要指派港口保安员，并准备港口保安计划。 This plan should indicate the operational and physical security measures the port facility should take to ensure that it always operates at security level 1. 该保安计划应该确认港口设施采取的实际的、可操作的保安措施，保证港口设施始终处于保安等级 1. The plan should also indicate the additional, or intensified,

security measures the port facility can take to move to and operate at security level 2 when instructed to do so. 该计划还应该指出当被命令升级到保安等级 2, 港口设施应该采取的额外或加强保安措施。It should also indicate the possible preparatory actions the port facility could take to allow prompt response to the instructions that may be issued at security level 3. 另外, 计划还应指出港口设施可能的准备工作, 以便对可能发出指令在保安等级 3 时作出迅速的反映。

Ships using port facilities may be subject to port State control inspections and additional control measures. 船舶使用港口设施可能要接受港口国控制检查和额外的控制措施。The relevant authorities may request the provision of information regarding the ship, its cargo, passengers and ship's personnel prior to the ship's entry into port. 有关当局也可能要求在船舶进入港口之前提供关于船舶、货物、乘客和船舶人员的信息。There may be circumstances in which entry into port could be denied. 可能有被拒绝入港的情况。

#### **Responsibilities of Contracting Governments 缔约国政府的责任**

Contracting Governments have various responsibilities, including setting the applicable security level, approving the Ship Security Plan and relevant amendments to a previously approved plan, verifying the compliance of ships with the provisions of SOLAS chapter XI-2 and part A of the ISPS Code and issuing the International Ship Security Certificate, determining which port facilities located within their territory are required to designate a Port Facility Security Officer, ensuring completion and approval of the Port Facility Security Assessment and the Port Facility Security Plan and any subsequent amendments; and exercising control and compliance measures. It is also responsible for communicating information to the International Maritime Organization and to the shipping and port industries. 缔约国政府有各种责任, 包括设定合适的保安等级、批复船舶保安计划、批复计划之前的相关评估、核实船舶是否符合 SOLAS 公约第 XI-2 章和 ISPS 规则 A 部分的要求以及颁发《国际船舶保安证书》, 决定其领域内哪些港口设施需要指派港口设施保安员, 保证完成和批准港口设施保安评估和港口设施保安计划以及后续的评估; 执行控制和符合措施。也要负责与国际海事组织、船舶和港口工业交流信息。

Contracting Governments can designate, or establish, Designated Authorities within Government to undertake their security duties and allow Recognized Security Organizations to carry out certain work with respect to port facilities, but the final decision on the acceptance and approval of this work should be given by the Contracting Government or the Designated Authority. 缔约国政府可以在政府内部指派、建立授权机构, 来承担保安职责, 允许公认的保安组织对港口设施开展一定的工作, 但是关于是否接受和批准这些工作的是由缔约国政府或授权机构来最终决定的。

## **LESSON30**

### **MANAGEMENT AND SAFETY OF MARINE ENGINEERING OPERATIONS**

#### **轮机操作的管理和安全**

Maintenance embraces routine services such as adding or changing lubricants and coolants, cleaning, etc., performed at frequent intervals(every watch, daily, or weekly), and planned

maintenance procedures including inspections, tests, adjustments, and replacement of non-basic parts like filters, packing, belts, some bearings, and valves. 维护包括常规的检修比如添加或者更换润滑介质和冷却介质, 清洁剂等, 定期操作 (每次值班, 每天或者每周), 而计划维修程序包括检查, 测试, 调整, 以及更换非基本元件比如滤器, 填料, 皮带, 一些轴承和阀件。Planned maintenance procedures are normally based on the manufacturer's recommendations regarding required services, time intervals (running hours, elapsed time, etc.) and certain operational parameters like pressure, temperature, vibration, material loss, etc. 计划维修程序正常情况下是基于制造商的推荐, 涉及到需要的服务, 时间间隔 (运行时间, 实耗时间等等) 以及某些工作参数比如压力, 温度, 振动, 材料损耗, 等等。

Shipboard maintenance is traditionally divided between deck and engine departments according to function. The following is the scope of involvement of the ship's administration in maintenance activities. 根据功能不同, 船舶维修在 traditionally 是在甲板部和轮机部之间分配。下面的是在维修活动中船舶主管要参与的维修范围。

#### **MASTER 船长**

In coordination with the chief engineer, the master ensures that the ship's planned maintenance program is carried out properly and sustains a safe and efficient ship operation with minimum cost and minimum downtime. 为了配合轮机长, 船长要保证船舶维修计划程序被合理的执行并维持一个安全和有效的船舶运转, 达到最低的花费和最短的停船期。

#### **CHIEF ENGINEER 轮机长**

The chief engineer coordinates and supervises the performance of the maintenance program for all machinery and equipment assigned to the engineering department. The engineer also provides assistance to the deck department team when certain maintenance actions and repairs are beyond their capability. 轮机长要协调和监督分配给轮机部门所有机械和设备维修项目的执行情况。当某些维修行为和修理超出了甲板部门的能力, 轮机员也需要协助他们。

#### **FIRST ASSISTANT ENGINEER 大管轮**

The first assistant engineer carries out the maintenance work according to the schedule, reports the completion and the related data to the chief engineer, and holds responsibility for the spare parts inventory management. 大管轮根据日程表执行维修工作, 向轮机长报告完成情况和相关材料, 并对备件清单的管理负有责任。

#### **CHIEF MATE 大副**

The chief mate coordinates and supervises the performance of the maintenance program for all machinery and equipment assigned to the deck department except major actions that are beyond the capability of the department. 大副协调和监督分配给甲板部门所有机械和设备维修项目的执行情况, 除了超过甲板部门能力的主要任务。

The scope of the shipboard maintenance activities performed by the engineering crew includes the following: 由轮机员执行的船舶维修工作包括如下范围:

- creating a list of servicing routines related to ship's structures, machinery, and equipment for every watch, day, and week, in compliance with planned maintenance procedures set by the company and the manufacturer's recommendations 建立一系列与船舶结构, 机器, 和设备相关的的维修程序, 该程序在每次值班, 每天, 和每周使用, 并与公司和制造商推荐的计划维修程序相一致;
- planning and scheduling maintenance actions and assigning responsibilities 计划并安排维修活动以及指派任务;

- monitoring performance of the maintenance procedures 监督维修程序的执行;
- keeping logs and records of maintenance actions 对维修活动保持记录;
- reporting maintenance scheduling data and accomplished maintenance actions to the shore management 报告维修计划资料并根据岸上管理完成维修活动;
- keeping a machinery history 保存机器维修历史;

A preventive maintenance and repair system is the prevailing approach in modern ship operations. 预防性维护和修理系统是现代船舶管理的流行方法。It means that maintenance and repairs are carried out before failures occur, so that running costs do not become excessive. 这就意味着在故障发生前开始维护和修理, 这样经营管理费用不会太高。There are two preventive maintenance methods: periodic and conditional, or predictive in naval terminology. 有两种预防性维修方法: 定期维修和视情维修, 或者用海军的术语来说叫预先维修。The periodic method requires that maintenance and repair procedures are performed at fixed calendar intervals or upon achieving certain accumulated running hours. 定期维修方法需要维护和修理程序在固定时间间隔内执行或者当达到某个累积运行时间的时候。Conditional or predictive maintenance is based on the actual condition of the ship components, maintenance and repairs are carried out when the condition reaches a certain level. 视情或者预先维修是基于船舶元件的实际情况, 当情况达到某个水平时, 就开始维护和修理。Most ship owners employ a combination of both methods. 大多数的船东采用两种方法的结合。The periodic method is applied to ship components where actual operational conditions cannot be determined at any given moment by visual inspection or by other nondestructive methods. 定期维修方法适用于这样的船舶部件, 即实际操作情况不能在什么时候通过目视检查或者其它非破坏性的方法决定。It is also used when machinery or equipment must be opened and inspected on a periodic basis according to classification requirements. 定期维修方法也可以用于当机器或者设备必须根据船级社的要求定期打开并检查。

Where the condition of other ship components might be determined by employing the known nondestructive diagnostic procedures, these components are routinely maintained on a periodic basis, but special maintenance and repair actions are performed depending on the results of the inspections. 其它船舶元件的情况可以通过采用大家都知道的无损诊断方法来确定, 这些元件通常被定期维护, 但是特殊维护和修理工作的执行是依赖于检测结果的。

Shipping companies use a wide variety of nondestructive methods and instruments to evaluate the condition of ship components. 船公司使用很多无损方法和仪器来评估船舶元件的情况。These methods and instruments fall into two groups: direct measurement and indirect diagnostic. 这些方法和仪器可以分成两类: 直接检测和间接诊断。For instance, evaluation of the condition of a cylinder liner might be performed in accordance with the diagram shown. 举个例子来说, 气缸套的评估情况可以按照显示的图表进行。In addition to fixed or mounted thermometers, different types of portable gauges have been developed, both contact and non-contact, primarily of infrared type. 除了固定或者安装温度计之外, 不同类型的手提式仪表已经发展成为接触式和非接触式, 主要是红外线。

Vibration tests might be used to evaluate the status of practically any rotational mechanism on board a ship. 振动测试可以用来评估船上实际使用的任何旋转机械的地位。The results of the test analyses provide valuable data on the operational condition of the rotating and load bearing elements. 测试分析的结果给旋转元件和负载承受元件的运行情况提供极为有用的数据。This data is used to determine the required maintenance and repairs without relying on the time-based maintenance schedule. A detailed description of vibration analysis methods may be

found in of volume 2 of this manual.这个数据可以用来决定需要的维护和修理而不需要依靠基于时间的维修日程。振动分析方法的详细描述可以在手册中的第二部分找到。

Other widely used methods of indirect monitoring of the condition of the ship's machinery and equipment include the following:其它广泛使用的间接监控船舶机械和设备情况的方法包括如下:

- analysis and monitoring of lubricating and hydraulic oil 润滑油和液压油的分析和监控
- thermo-graphic analysis of machinery performance 机器性能的热力图分析
- testing, analysis, and treatment of boiler and feed water, and also diesel engine cooling water 锅炉和供给水, 以及柴油机冷却水的测试, 分析和处理。

Oil monitoring and analysis include taking samples of oil from different units of equipment and performing onboard tests.油液监控和分析包括从不同设备单元里取油样并在船上测试。More comprehensive oil analyses may be performed by a shipping company's laboratory or by specialized engineering companies.更加综合的油液分析可以通过船公司的实验室或者专门的工程公司来进行。Test results are evaluated and necessary corrective actions are undertaken. 测试结果被评估并采取必要的矫正措施。It may be found necessary to change the oil or to use a better brand.可能发现有必要进行换油或者使用更好牌号的油液。In the case of excessive contamination, the storage and sump tanks and piping should be flushed, cleaned, and dried before refilling is done.假如有过度胀污, 储存柜和污油柜以及管路在被重新装油之前, 必须被冲洗, 清洁和干燥。

Shipboard electrical machinery is subjected to heat, humidity, corrosive effects of seawater, and possible physical damages. 船舶的电力设备容易遭受高温, 潮湿, 海水腐蚀作用以及可能的自然损害。The combined impact of these factors might compromise the integrity of the insulation and lead to a failure of the equipment.这些因素的综合作用可能损害完整的绝缘并导致设备的失效。Therefore, the engineering crew should determine the necessary preventive actions by conducting regular testing of the insulation. 因此, 轮机人员必须通过实施常规的绝缘检查以决定必要的预防措施 The testing is normally performed in accordance with the manufacturer's recommendations and the approved company procedures. 这些测试通常根据制造商的建议和经过认可的公司程序进行。It is a responsibility of the shore management to ensure that all licensed engineering officers are familiar with the methods and procedures of insulation testing, and that the proper equipment for taking readings is available on board.这是岸上管理的责任来保证所有得到认可的轮机员熟悉绝缘测试的方法和程序, 以及那些用来测读取数的适当设备在船上可用。

Testing and treating boiler and feed water is essential for the safe and efficient operation of boilers and heat exchangers on board.锅炉和供给水的测试和处理对于船上锅炉和热交换器的安全和有效运行是非常重要的。Chemical testing of water provides the data for evaluation of the conditions inside boilers, other steam system equipment, and pipelines. 水样化学测试可以提供数据用来评估锅炉, 其它蒸汽系统设备以及管路内部的情况。Chemical treatment of water decreases the concentration of dissolved solids and oxygen. 锅炉水的化学处理可以降低溶解固体物和溶解氧的浓度。Combined with periodic bottom blow down, the chemical treatment prevents sludge accumulation and equipment failures. 与定期底部排污相结合, 化学处理可以避免杂质堆积和设备失效。The engineering department should test water daily, periodically check system equipment for the absence of water contamination, and inspect boilers to evaluate the effectiveness of the water treatment program.轮机部门需要每天测试水样, 定期检查没有水污染的系统设备, 并检查锅炉以评估锅炉水处理程序的有效性。

Modern diesel engines operate at high temperatures and heat transfer rates, causing increased accumulation of mineral deposits on the water cooled surfaces. 现代柴油机在高温和高的热传导率下运行, 从而引起无机物在冷却水表面沉积不断增加。Distilled water used for cooling contains dissolved oxygen, which makes it even more corrosive than regular water, especially at higher temperatures. 用来冷却的蒸馏水包含溶解氧, 从而导致与常规冷却水相比更强的腐蚀性, 特别是在高温下。Therefore, it is necessary to chemically treat the cooling water by adding corrosion inhibitors to provide a thin protective film on metal surfaces. 因此, 对冷却水进行化学处理是必须的, 通过添加腐蚀抑制剂可以在金属表面上形成一层薄的保护膜。

Both periodic and conditional methods allow for planning and scheduling of maintenance and repair activities, so most ship owners employ a planned preventive maintenance and repair system. 定期维修和视情维修方法允许对维护和修理活动进行计划和安排, 所以大多数的船东采用预防性的计划维护和修理系统。The difference between the periodic and conditional methods is in the actions that are planned. 定期维修和视情维修的区别在于计划采取的行动。In the first case, the scope of the planned maintenance and repairs is identified in advance, while in the case of the conditional method, the nondestructive inspection is planned, but the maintenance actions are based on the inspection results. 在第一种情况中, 计划维护和修理的范围应该在事先确认, 而在视情维修情况下, 需要用到计划中的无损检测, 但是维护活动是基于检查结果的。

The principal responsibilities of the port engineer (operation superintendent, etc.), who plays the key role in managing ship maintenance, include the following: 在对船舶维护扮演重要作用的港口工程师 (操作监督人等) 的主要职责包括如下:

- maintaining a current database for each ship under command 按照要求对每艘船舶的当前数据库进行维护
- developing maintenance requirements and monitoring ship crew compliance 完善维护要求并监督船员的服从性。
- planning and reviewing maintenance plans developed by crews, and monitoring their accomplishment 规划并检阅由船员提出的维护计划, 并监督他们的完成情况
- assisting the ship's crew in carrying out condition monitoring activities including vibration measurement, liquid analysis, and also machinery performance monitoring, and arranging for outside companies participation. 协助船员执行状态监测活动包括振动测量, 液体化验和机器性能监控, 以及为外来公司的参与做安排。

A planned preventive maintenance and repair system provides definite economic benefits when applied to those ship components that, if failed, would affect the safety of the ship or that might cause delays, damage to the cargo, and other serious losses such as fines for pollution, legal costs, etc. 一个计划预防维护和修理系统当应用到那些船舶部件时可以提供明确的经济效益, 假如不成功, 将会影响船舶的安全或者可能引起滞船, 货物损坏, 以及其他严重的损失比如因为污染而罚款, 诉讼费, 等等。If these losses when weighted by the estimated probability of their occurrence exceed the average cost of the required maintenance and repair actions, the preventive maintenance system is justified. 假如对估计发生的概率进行加权得出的这些损失超过必需的维护和修理行动的平均成本, 那么预防性维护系统会被认为是合理的。On the other side, the most efficient way of performing maintenance and repairs of some internal structures and non-vital auxiliary machinery is to wait until the excessive wear or failure occurs. 从另一方面来说, 对一些内部结构和非重要的辅助机械执行维护和修理的最有效方式是等待直到发生过度磨损或者失效。

# LESSON 31

## Conversations dealing with engine room tasks

### 机舱日常工作会话

The engine room is the store of technical knowledge and skill aboard the ship and the areas of maintenance and repair that are the responsibility of the engineers are almost endless. 在船上机舱是技术知识和技能的宝库, 轮机员负责的维修保养和修理的工作几乎是无止境的。 In this chapter we will be discussing helpful terms and phrases covering a small number of situations that a new engine room crewmember might find themselves in. 在这一章节我们将讨论一些有帮助的术语和短语, 这些术语和短语涉及到机舱中一个新的船员会发现的一些情况。 The emphasis will be placed on the interaction occurring at a typical engineers meeting before the start of the days work. 重点将放在一个典型的白班工作开始之前轮机员会议的相互交流。 It should be clear that not all situations can be covered, or anticipated. 应该清楚不是所有的情况都能涵盖, 或者是预先想到的。 I suggest that, as a new engineer, you should place some emphasis on becoming familiar with the machinery and systems you are most responsible for. 我建议作为一名新轮机员, 应该把重点放在熟悉你最应负责的机械和系统。 Exactly which equipment this involves will again depend upon the ship you are in and also your level of experience with the ship and equipment. 要涉及的准确设备又要取决于你所在的船舶和你对船舶和设备的经验水平。 The new crewmember will have particular responsibility for equipment such as purifiers, boiler, air compressors and incinerator etc. 新船员特别要对一些诸如分油机、锅炉、空气压缩机和焚烧炉等设备负责。

#### Sources of work for engineers

In some shipping companies the chief engineer is ultimately responsible for all maintenance done on the ship, whether in the engine room or outside, whether for the engineering department or for other departments on the ship. 在一些船公司轮机长要对船上的各种维护保养工作最终负责, 不管这些维护保养是在机舱内还是机舱外, 也不管是轮机部的还是船上的其它部门。 Within the engineering department of a merchant ship the everyday management of the operation, maintenance and repair tasks being undertaken is performed by the first engineer, the first engineer coordinates, manages and controls the maintenance being done and the personnel doing it. 在商船的轮机部, 大管轮承担每天操作、维护保养和维修任务的管理, 还要协调、管理和控制维护保养工作及做这些工作的人。 Many of the tasks, especially in the engine room, are routine and any consultation with the first engineer is primarily to keep him informed of what work each of the engine room staff is occupied with during the course of any particular day. 尤其是在机舱里的许多任务是常规性工作, 但是要首先让大管轮知道机舱人员在任何一天要从事的工作。 There are, however, many other non-planned or non-routine maintenance and repair tasks continually requiring the attention of an engineer and the oversight of the first engineer. 然而, 也有很多其它没有计划的或非常规性的维护保养和维修任务, 需要轮机员不断地关注也需要大管轮小心应对。

There are several sources of this work to be performed by the engineering staff and to be coordinated and managed by the first engineer, these sources include:有一些这样由轮机员完成并由大管轮协调、管理的工作，这些工作包括：

(1) Tasks arising from the routine role and duties of duty engineer. 工作任务来源于常规任务和值班轮机员的职责。One of the engineers will be the duty engineer, which means that a significant proportion of this engineer's already planned with the tasks inherent in being on duty. These tasks include such things as 一个值班轮机员，他大部分的任务已经计划好了，这些任务包括：

- Conducting an engine room inspection 进行机舱检查
- Recording machinery parameters in the engine room log 在轮机日志中记录机器参数
- Responding to engine room alarms 解决机舱内的警报
- Routine procedures such as topping up tasks, pumping bilges and machinery operations etc 一些例如加油、加水任务，打舱底水和机械操纵等的常规程序
- Responding to requests for maintenance or repair items throughout the ship 解决全船维护保养和修理项目的要求
- Routine engine and machinery adjustments as requested from the chief engineer of bridge etc. and so on 依照轮机长和驾驶台的要求对主机和其它机械的常规调整等诸如此类的工作。

(2) Maintenance arising from the preventive, of planned, maintenance system. 维护保养工作要依据预防性的计划性的维护保养系统进行，This will consist of regular and routine maintenance tasks to be performed on all equipment whose maintenance is managed by the planned maintenance system. 这包括对所有的设备实施定期的和日常的保养任务，这些维护保养工作是由计划维修系统来管理的。As a minimum, this will involve machinery and systems identified under the ISM code provisions as that whose failure could result in a hazardous situation, this will include major engine room machinery such as the main and auxiliary engines, air compressors, purifiers, steering gear, pumps and piping systems and so on. 小范围的保养工作，也将要包括 ISM 规则条款中所提及到的机械和系统，由于这些机械和系统的失效会导致其处于危险状态，主要包括机舱的设备比如主机、副机、空气压缩机、分油机、舵机、泵和管路系统等。The amount of machinery and systems covered by this system and the depth and detail of the tasks to be done will depend upon the type of planned maintenance system in use and the experience gained over the time the system has been used. 维护保养系统所涉及的机械和系统的量、深度和要做任务的详细程度，取决于所使用的计划维修系统的类型和该系统的过去使用经验。

The tasks arising from the planned maintenance system will extend from the basic operate and deck to regular services, to major services with strip downs and parts overhaul or inspections. 计划维修系统规定的工作任务范围从基本操作检查到正常服务和主要设备的拆解以及部分大修、检查。The coordination of the tasks will be under the chief engineer's control with the first engineer, the level and extent of documentation and reports etc required from maintenance staff, such as the second and third engineers, will vary from ship to ship and be very much dependent upon the shipping company and the chief engineer. 这些任务需要在轮机长和大管轮协调控制，维护保养人员（比如二管轮和三管轮）的说明和回报文件的等级和程度等，各个船之间有差别，主要跟船公司和轮机长有重要关系。

(3) Maintenance of repair requests from other departments in the ship. 船上其他部门的维护保养或修理需求。The engine room and the ship's engineers are responsible for the majority of all maintenance performed on the ship, and certainly for any mechanical, electrical or machinery

批注 [dlmut20]: Check???

批注 [dlmut21]: Or???

maintenance and repairs. 船上的轮机员负责船上的大多数维护保养工作，当然也包括任何机械的、电的维护保养和维修。As such the other departments within the ship, the deck and catering etc, forward requests for maintenance to the engine room these should be managed by the first engineer who will then coordinate and prioritize the manpower to ensure the work is done in the most efficient and timely manner, these requests flow in daily to the first engineer and he will issue the work during the daily engineers meeting. 由于船上的其它部门比如甲板部和厨房等，向机舱请求维修保养也应该由大管轮管理，他会协调并区分人力的优先次序保证工作以最高效和最时效的方式完成这些工作。大管轮每天都会遇到这些要求，他将会在每天的轮机会上分配这些工作。

批注 [dlmut22]: First? ? ?

(4) Outstanding repairs and maintenance including tasks identified as being necessary but not urgent enough to be done immediately, including tasks: 一些突出的修理和维护保养工作，包括一些必要的但不是非常紧急到马上要做的工作，主要有：

- Recently identified or 最近验证的或
- Identified whilst performing other duties of maintenance, of even 执行其它维护保养工作的同时验证的，甚至
- Outstanding from previous maintenance and inspections such as machinery of equipment surveys, dry-dock of safety inspections etc. 从以前维护保养和检查中突出出来的，比如机械或设备的检查，进坞或安全检查等。

批注 [dlmut23]: OR??

批注 [dlmut24]: OR??

For example, a cooling water pump may have been noted some days earlier as running noisily indicating the need for a closer inspection and possibly some repairs. 例如，可能几天前通知冷却水泵运转时有噪音，需要进一步的检查甚至可能需要修理。These items should be kept in a file of work pending which is a document maintained by the first engineer as part of his maintenance administrative load. 这些项目可能保存在待完成工作文件夹里，这是由大管轮保管的文件，是他管理工作的一部分。The jobs may even have been included in the planned maintenance system and thus would be included in the scheduled maintenance documentation. 这些工作甚至可能已经包含在计划维护保养系统中，因此可能包含在预定维护保养文件里。In this way the jobs would continue to appear on an outstanding work list until they are completed. 这样的话，这个工作会继续在突出工作表中出现直到它们被完成。This list then identifies areas needing work and is used to keep track of work as it arises, as an aid in planning and managing manpower and as record of work to be done. 这个表格指示出哪些区域需要工作，并且在工作出现后，可以用来了解工作的进展，帮助计划和管理人力，作为工作完成的记录。

(5) Any work that has become apparent to the engineers but is not yet within the documentation system of the engine room such as repairs or matters requiring attention that have arisen during the last few hours or as result of recent alarms etc. 一些已经显现在轮机员面前的工作，但是可能还没有体现在机舱记录系统中，比如近几个小时或最近一个警报等所引起的需要注意的修理或问题。

(6) Any other work arising from direct requests from other crewmembers, shore personnel etc. 任何其它直接由其他人员或岸上人员等提出的要求。

### Toolbox meeting

With the increasing emphasis being placed upon safety and the environment the procedures and documentation involved with all shipboard tasks has gained in importance. 随着在安全和环境方面重点的增加，所涉及船舶工作任务的程序和文件就变得重要了。This is of particular relevance to the engineers and the administration of their maintenance workload. 这尤其关系到轮

机员和他们维护保养工作量。 One means of improving communication and feedback has been to organize regular small meetings of relevant personnel to discuss and organize the work. 一个提高交流和反馈的方法是，相关人员组织小型例会讨论和组织工作， Further, one of the particular administrative tasks of the first engineer is to keep a record of the work being done by the engine room staff. 更进一步的是，大管轮的一个特殊的管理任务是记录机舱人员已经完成了哪些工作。 To do this he must be kept informed of the work being performed by the engineers and other engine room staff. 为了完成记录他必须了解轮机员和其他机舱人员完成的工作。 Once again, the exact nature and arrangement of the management of the engine room depends on the shipping company and the personnel previously working in the ship. 同样，准确性和机舱管理的安排依赖于船舶公司和人员以前在船上的工作。

To meet these needs of improved documentation and administration it is not uncommon for the engine room staff, particularly the engineers, to meet each morning before the start of the working day to discuss the coming days work. 对于机舱人员，尤其是轮机员，满足提高记录和管理需要是一件普通的事情，他们每天早晨工作开始之前，都会讨论第二天的工作。 These meetings will likely occur in the machinery control room or some other similarly convenient location such as the workshop or change room etc, and include discussion of any work including any problems. 这些会议可能会发生在集控室或其他相似的方便地场所，比如工作间或交班室等，谈论的内容包括工作及包含的问题。