Marine Technology Society

Dynamic Positioning Conference

21 - 22, October, 1997

Session 7:

Power Plant

Prime Movers for Power Generation of Dynamically Positioned Vessels

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Prime movers for power generation of dynamically positioned ships

1. Main features

The redundancy requirements imposed on dynamically positioned vessels largely dictate and define the configurations of various systems onboard. By this definition the power plant of these vessels has to be a multi engine installation. Further, stand-by units and components are necessary in the essential auxiliary systems. On the other hand the operating profile of a DP ship results in large variations in the required power and require flexibility and hence also multiple engines to be installed in the power plant. Combining the load variations imposed by the DP system when operating in heavy weather with the varying load demands of the operations performed, e.g. deep water drilling, a very wide loading range for the power generation is evident.

Therefore, good load acceptance characteristics as well as load rejection capabilities are essential features of the prime movers of the generators. Unpredicted, sudden and large load changes have to be accommodated as well as frequent starting and stopping of the engines. For economically feasible operation these capabilities have to be combined with high (electrical) efficiency and reliability of the machinery. Medium speed diesel driven generator sets provide these features in the power range required to match the needs of most DP vessels.

To further increase the flexibility of the power plant the ability to operate on different grades of fuel oil is important. Generally today’s medium speed diesel engines can operate, start and stop on heavy fuel oil (HFO) and can be switched over to run on lighter fuel, e.g. marine diesel oil (MDO) without any modifications.

Diesel engines installed onboard ships emit into the atmosphere exhaust gasses unfortunately containing small fractions of emissions which damage the environment. If the ship is stationed in one location for a considerable period of time, which normally is the case with DP vessels, the emissions might have to be controlled.

2. Load response

In DP vessels good load response capability of the prime movers is essential. A multiple diesel engine installation is very flexible and can cope with large and sudden deviations in power demand. Provided the engine is preheated close to the operating temperature it can be loaded immediately after start without restrictions except the maximum transient frequency deviation specified by the classification societies. It should be noted that for highly supercharged diesel engines 100% instant load can not be applied due to the air deficit until the turbocharger has accelerated. At instant loading the speed and hence frequency will drop.

Fig. 2.1 Limiting curves for instant load steps proposed by IACS

The engine can be loaded most quickly by a successive gradual increase in load. In principle the large DP system load changes, i.e. loads imposed by the thrusters, can in normal circumstances be accommodated with such gradual increase. On the other hand operations, such as drilling, might require instant loading of the generator sets. As suggested by the International Association of Classification societies (IACS) to achieve quickest response it is recommendable to increase the load in three or four steps rather than two. Further more, it is equally important that the engine can cope with instant load rejections from 100 - 0% load. The performance both ways is normally verified during the factory acceptance tests of the engine. Figure 2.1 shows the IACS reference values for load steps.

In addition to the time required to accelerate the turbocharger and hence get enough air into the combustion chambers the performance is affected by rotational inertia of the whole generator set, the speed governor adjustment and behaviour, generator design, alternator excitation system, voltage regulator and nominal output of the unit.

With a carefully engineered power management system and integration with the positioning logic and the propulsion units a power plant with diesel engine driven gensets offer capability to comply with the strict loading requirements. Today dynamic simulation models are frequently used to optimise the system components such as the control units and the turbochargers of the diesel prime movers to match these requirements.

3. Operation on different fuels

Modern diesel engines are very “fuel tolerant”. A variety of liquid and gaseous fuels can be used safely and efficiently. Most medium speed diesel engines available in the market are designed for burning HFO. However, the engines can be operated with lighter fuels, e.g. MDO, without any modifications.

The differences are found in the auxiliary systems, mainly in the fuel treatment units. Figure 3.1 shows a typical fuel feed system for a plant operating on distillate fuel, e.g. MDO. The system is rather straight forward and has relatively low investment costs. For fuels with viscosity below 115 cSt at 50°C such a system with an open deaeration tank can be considered provided the tank is located high enough to prevent cavitation of the circulating pump.

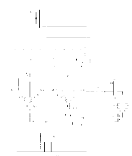
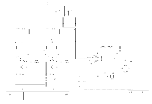


Fig 3.1 Fuel feed system for MDO operation

A typical HFO feed system is shown in figure 3.2. In order to achieve the required injection viscosity the HFO needs to be heated. This in turn means that a pressurised fuel feed system, typically 6-8 bar at the engine inlet, should be installed. The over pressure in the system prevents evaporation of water and lighter hydrocarbons possibly present at the bunker fuel. This ensures proper operation of the circulation and injection pumps, in other words prevents cavitation, and prevents formation of gas and vapour in the return lines from the engines. Further, the fuel lines of a HFO system, oil viscosity above 180 cSt at 50°C, have to be properly insulated and trace heated.

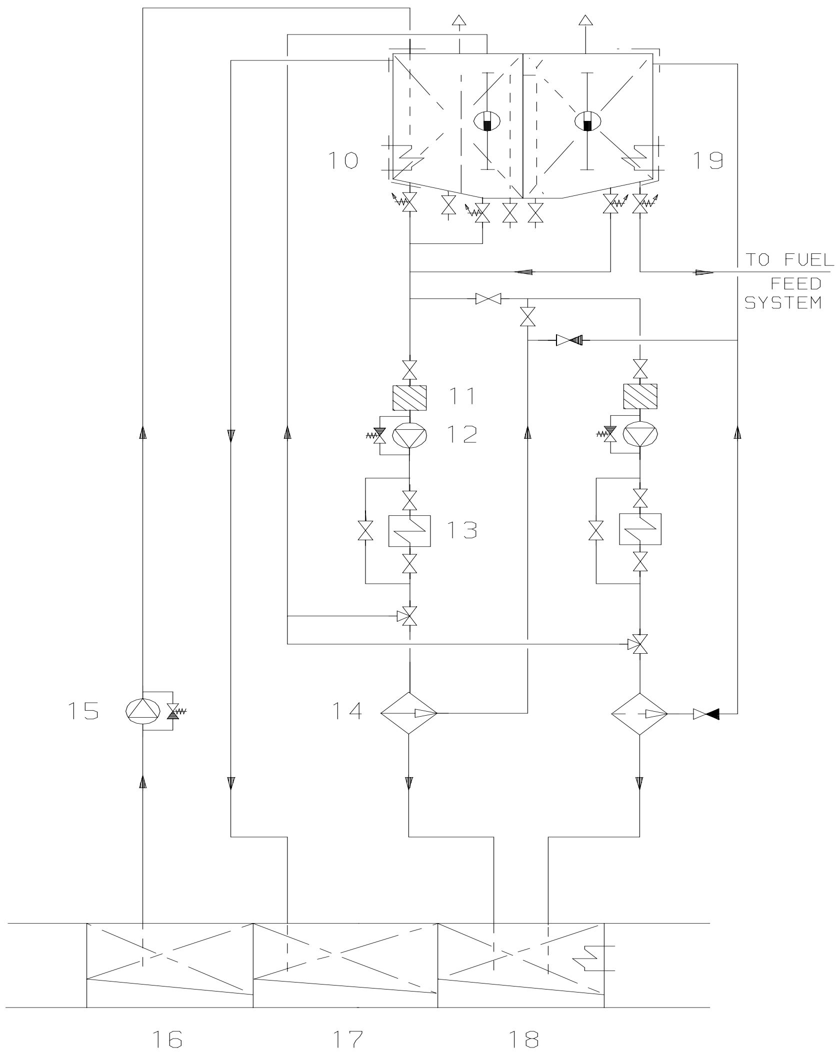


System components

01	Diesel engine	11	De-aeration tank
03	Safety filter	12	Circulating pump
04	Pressure control valve	13	Heater
05	Day tank, heavy fuel	14	Automatic filter
06	Day tank, diesel fuel	15	Viscosimeter
07	Change-over valve	16	Overflow valve
08	Suction filter	17	Leak fuel tank, clean fuel
09	Fuel feed pump	18	Leak fuel tank, dirty fuel
10	Flow meter	19	Pressure control valve

Fig 3.2 Fuel feed system for HFO operation

The pre-treatment system, i.e. centrifugal separator units, of HFO operation is more complex than that of a MDO system. It is essential that the fuel oil is cleaned and water is separated from it before introducing into the feed system. Typical HFO pre-treatment system is shown in figure 3.3. In case MDO is used centrifuging is still recommended as the fuel may be contaminated in the storage tanks. In fact, normally a parallel MDO treatment system is installed also in the HFO operated ships. This is mainly to facilitate flushing of the system with MDO prior to planned maintenance of the diesel engines or other fuel system equipment. It also serves as back-up system in emergency situations.



System components

10	Settling tank	15	Transfer pump
11	Suction filter	16	Bunker tank
12	Feeder pump	17	Overflow tank
13	Heater	18	Sludge tank
14	Separator	19	Day tank

Fig 3.3 Fuel pre-treatment system for HFO operation

In other engine auxiliary systems the HFO operation has also some consequences. The lubricating oil treatment has to be more effective because of the higher contamination from the fuel. Larger capacity lubricating oil centrifuges are required and use of automatically cleaning (back flushing) filters is recommended. The cooling water system needs to be equipped with a preheater unit adequate to heat the system close to the operating temperature in order to be able to start the engine on HFO.

Even if the engine itself needs no modifications to be able to operate on different fuel grades the component life times and time between overhauls is affected by the selection of fuel. Table 3.4. shows a typical example of the differences.

Component	**Time between overhauls [h]**		**Expected lifetime [h]**	
	HFO	MDO	HFO	MDO
Piston	12 000 - 20 000	20 000 - 24 000	24 000 - 40 000	40 000 - 48 000
Piston rings	12 000 - 20 000	20 000 - 24 000	12 000 - 20 000	20 000 - 24 000
Cylinder liner	12 000 - 20 000	20 000 - 24 000	60 000 - 100 000	60 000 - 100 000
Cylinder head	12 000 - 20 000	20 000 - 24 000	60 000 - 100 000	60 000 - 100 000
Inlet valve	12 000 - 20 000	20 000 - 24 000	24 000 - 40 000	40 000 - 48 000
Exhaust valve	12 000 - 20 000	20 000 - 24 000	12 000 - 20 000	24 000 - 32 000
Injection valve nozzle	2 000	2 000	4 000 - 8 000	8 000
Injection pump	16 000	16 000	16 000 - 24 000	32 000
Main bearing	16 000 - 20 000	16 000 - 20 000	32 000 - 40 000	32 000 - 40 000
Big end bearing	12 000 - 20 000	20 000 - 24 000	12 000 - 20 000	20 000 - 24 000

Table 3.4 Component life times

The benefit of the HFO operation is that the fuel cost is much lower than using MDO. To evaluate the feasibility of HFO operation a comprehensive study of life cycle costs taking into account the estimated load profiles is necessary. Also availability of different fuels in the operating locations and development phases are to be considered.

4. Exhaust gas emission control

Environmental aspects are another important factor to be considered when prime movers of the offshore, or any other vessel for that matter, are selected. The modern medium speed diesel engine with a highly efficient combustion ensures not only low fuel consumption figures but also practically complete combustion of the fuel into water and carbon dioxide. The emissions of CO_2, CO and hydrocarbons and particles are low because of the efficient combustion. However, this results in high combustion temperatures, which in turn promote the formation of NO_x. In other words the more fuel efficient the engine is the higher the emissions of NOx are. On the other hand prime movers with a less efficient combustion, and thus lower NOx emissions the, will have higher emissions of CO, HC, particles and also higher specific emission of CO_2.

Most major manufacturers medium speed diesel engines meet the NOx requirements proposed by the IMO for ships operating globally. Figure 4.1. shows the curve. However, regional requirements might specify further reductions of emissions. For that purpose optional NOx control techniques have been developed.

Primary methods concentrate in ensuring right condition in the combustion chamber so that the formation of NO_x is reduced. E.g. with direct water injection into the combustion space the NOx levels can be reduced with 50%, using any type of fuel.
Secondary control methods means that the actual exhaust gasses are cleaned with different equipment. With selective catalytic reaction techniques, SCR, the NOx levels can be reduced as much as 80-90%.

Another item having an impact on emissions is the diesel engine ability to burn poor quality fuels. These normally contain high amounts of ash and sulphur, which invariably will come out in the form of particle and SOx emissions. On the other hand the specific emission levels from a medium speed diesel is smaller that if the same poor quality fuel would be used in a less efficient power source.

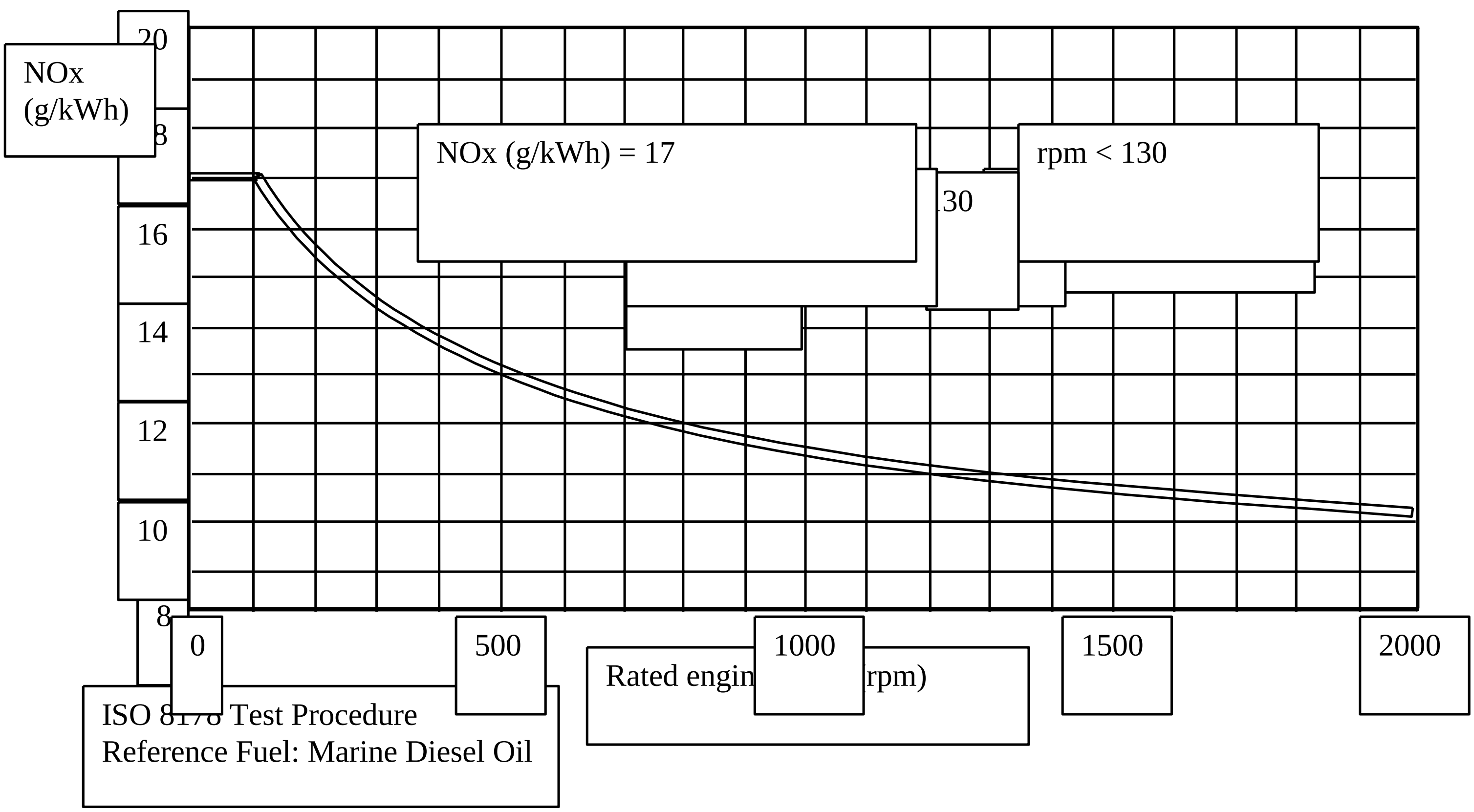


Fig 4.1 International Maritime organisation (IMO) NOx limiting curve