



# Engine Management

## Concept for LNG Carriers



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# Engine Management Concept for LNG Carriers

## Introduction

The world has enormous quantities of natural gas, but much of it is located in areas far from where the gas is needed. To move this environmentally friendly fuel across great distances, across oceans, natural gas must be converted into liquefied natural gas (LNG).

Shipping is a vital component in any LNG supply train. But an LNG project's shipping could simply be considered as a floating pipeline for the transportation of LNG, therefore LNG shipping is normally considered in the long term.

As the only type of commercial vessel, Liquefied Natural Gas (LNG) carriers have in the past many years maintained the steam turbine as their preferred propulsion system. This trend has persisted despite the fact that all other types of commercial vessels changed to the more efficient diesel engines in the 1970s, as a consequence of the rising fuel prices and increased environmental awareness. Moreover, diesel engines have also proved their reliability during many years of operation.

The LNG carrier did maintain the steam turbine as its propulsion system because the natural evaporated boil-off gas from the cargo is available anyway, and because no other solution for the use of boil-off gas has been made available, at that time.

There are, in principle, two ways of exploiting the boil-off gas, it can be burnt in a boiler, gas turbine or dual fuel diesel engine and provide power for the propulsion of the vessel, or the boil-off gas can be reliquefied in a reliquefac-



Fig. 1: Engine Management Concept for LNG Carriers

tion system and returned to the cargo tanks.

The reliquefaction of the boil-off gas from the LNG cargo makes it possible to increase the cargo quantity delivered to the customers, instead of using it as fuel, and to install more efficient propulsion systems on LNG carriers.

An LNG carrier is a special-purpose ship in which sophisticated technology is used to transport liquefied gas, a highly flammable cargo. Safety is, of course, paramount, as is the reliability and availability of the propulsion system of such a ship, because these factors influence the whole supply chain from the well to the consumer.

Gas transportation contracts are typically long-term, and the sailing schedules of LNG carriers are very precise. Missing a schedule can have far-reaching consequences. It is therefore nec-

essary to make every effort to avoid such a risk, which calls for emphasis on maintenance to guarantee high availability and smooth operation.

The proper maintenance planning is essential to satisfy the vessel's operating needs without sacrificing reliability and availability.

Recently, quite a significant number of newbuilding contracts have been signed for LNG carriers. These new carriers feature efficient low speed two-stroke diesel engines, burning heavy fuel oil or boil-off gas, in combination with reliquefaction and MAN Diesel & Turbo GenSets.

MAN Diesel & Turbo has not only played a very active role in the development, design and configuration of the propulsion arrangement for this new generation of LNG vessels, but also developed a new service concept, named Engine

Management Concept (EMC), to support the operation and maintenance of the engine arrangement for these vessels.

Operation and maintenance of diesel engines is a straightforward process for the skilled and experienced engine crew, if the maintenance jobs are planned, prepared and controlled in details. In general, superintendents and engine crews are well-educated and skilled professionals that are very dedicated to their profession. Nevertheless, there is an increasing pressure on shipowners/operators and engine crew regarding regulation and legislation within the shipping business. Furthermore increasing complexity of vessels makes it difficult for the engine crew to get a continuous update on all technical issues on board the vessel.

With the extended Time Between Overhauls (TBO) on MAN B&W engines, it can very well happen that a highly skilled marine engineer can be promoted to Chief Engineer without ever having had the opportunity to participate in the type of major overhauls that he, as Chief Engineer, later on has the responsibility to manage and supervise. Lack of experience can lead to inefficient management of maintenance and the danger of maintenance introduced failures.

With the Engine Management Concept, MAN Diesel & Turbo wants to support the high safety standards which characterise the LNG transport business, and where the concept of operational reliability must be understood in the widest sense of the word.

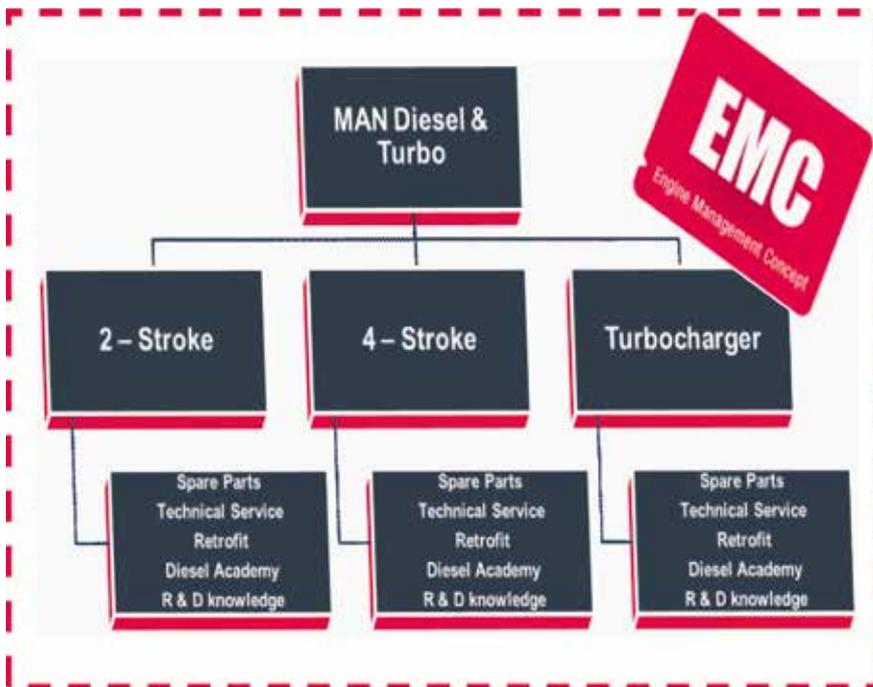


Fig. 2: PrimeServ versus Engine Management Concept

The intention of the following description is to give a clear picture of what exactly the Engine Management Concept is. What are the key elements of the Engine Management Concept? What are the challenges? What are the opportunities? What are the benefits to the shipowner/operator, and why should potential customers buy it? Is the Engine Management Concept the path to successful operation of the vessels?

The above-mentioned selection of questions and many more will, hopefully, be answered in the following description, and explain exactly what kind of product and service the Engine Management Concept is.

The description of the Engine Management Concept is not to be considered as a rigid specification on how exactly it has to be designed, but more an

example of what it could contain and what MAN Diesel & Turbo can offer. The Engine Management Concept product and services are very flexible and can be adjusted to the customers' requirements.

Almost anything can be accomplished on a temporary, one-off basis. The key to success with the Engine Management Concept is to institutionalize the concept and process.

The Engine Management Concept agreements are an excellent way of using the synergies from various MAN Diesel & Turbo engineering and service products. This is done internally to bring the agreed results effectively to the customer.

## Description

The purpose of the Engine Management Concept is to ensure that the means of production/operation are available to meet mission, availability, schedule, quality and cost commitment at optimum effectiveness.

The Engine Management Concept supplies effective, predictable capacity to meet mission, business and production objectives.

In other words, the Engine Management Concept will substitute that part of the shipowner's technical management function dealing with MAN Diesel & Turbo products. The new challenge is that MAN Diesel & Turbo will take over the maintenance management process in a close partnership with the shipowner.

The Engine Management Concept is designed to optimise plant operations and will ensure the reliable operation of the main engine, auxiliary engines

and turbocharger and other MAN Diesel & Turbo products. This opportunity is available to marine prime movers as well as power plants. Newbuildings and plants in service can take advantage of the many benefits made possible with this pioneering business concept.

The duration of the agreement can be 5, 10 or 15 years, but should be as long as possible due to the initial investments in start-up activities, spare parts storage implementation of computerized maintenance management system and other data capturing systems. The Engine Management Concept agreement can last as long as the lifetime of the equipment under consideration.

At a fixed monthly rate, MAN Diesel & Turbo plans the entire maintenance schedule, using the most recent monitoring and diagnostics systems, and supplies the agreed spare parts and defined manpower.

The Engine Management Concept provides a flat fee over the contract period. For the customer, this means that it is more convenient to have a predictable cost over the years as illustrated in Fig. 3 and it reduces their financial risk.

Priority access to technical support experts and the worldwide network of MAN PrimeServ Service Centres is guaranteed 24 hours a day, every day of the year. Each MAN Diesel & Turbo employee has a head full of knowledge, and a heart full of hope for you to be successful.

The customer's staff, who can be trained by MAN Diesel & Turbo, will conduct daily operational procedures as agreed.

The Engine Management Concept consists of a mix of management, processes, systems, practices and technologies strategically implemented to achieve a specific mission and/or objective. Take into consideration the market, business and operating conditions, related opportunities and site-specific requirements and conditions. The Engine Management Concept strategy addresses issues as diverse as environmental compliance, class compliance, safety, reliability, operating efficiency, maintenance planning/control/cost, resource allocation and spare parts management.

The Engine Management Concept supplies the predictable capacity. Predictable capacity means that MAN Diesel & Turbo equipment performs with optimal effectiveness and reliability and that capacity will be available when required to meet schedule and quality commitments.

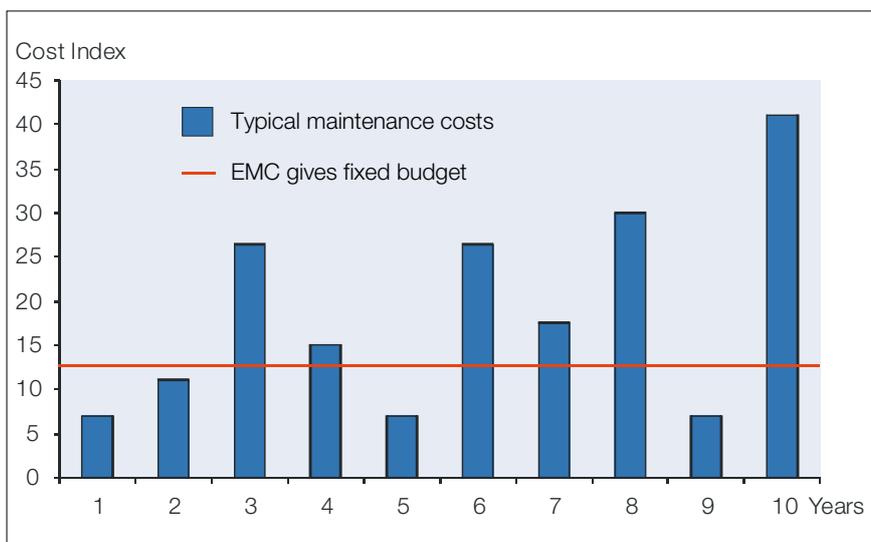


Fig. 3: Engine Management Concept

The Engine Management Concept is developed on the premise that application of the process, practices and technology are market, business and site specific in order to gain optimum effectiveness. The Engine Management Concept includes continuous improvement to steadily elevate effectiveness. In short, every planned maintenance job order is an authorization to spend money. That is why it is important to do the minimal amount of work at minimal cost, granted it will still meet the expectations for reliability and safe operation.

The Engine Management Concept generally includes all of the activities and related activities necessary to perform effective maintenance, and can include (but is not limited to) the following:

- Maintenance and maintenance controlling
- Maintenance planning and administration
- Reporting, administration and analysis
- Provision of spares
- Performance monitoring and reporting
- Provision of special tools and equipment if necessary
- Provision of labour (if agreed)
- Provision of supervision and management

- In the Engine Management Concept planning is one of the key elements when executing maintenance jobs. Planning is the development of a detailed program to achieve an end. It is the advanced preparation of a specific job so that it can be performed in an efficient and effective manner, as illustrated in Fig. 4.

Planning ensures that all necessary logistics have been coordinated for the job execution phase to take place at a scheduled future date. Planning is a process of detailed analysis that determines and describes the work to be performed, the sequence of associated tasks, methods to be used for their performance and the required resources – including skills, crew size, man hours, parts, materials, special tools and equipment. It also includes identification of safety precautions, required permits, communication requirements and reference documentation such as instructions.

The combination of planning, controlling, coordinating and scheduling constitute “Job Preparation”. They are supportive functions characteristic of the Engine Management Concept, which is responsible for monitoring the job execution, and are performed by MAN Diesel & Turbo superintendents.

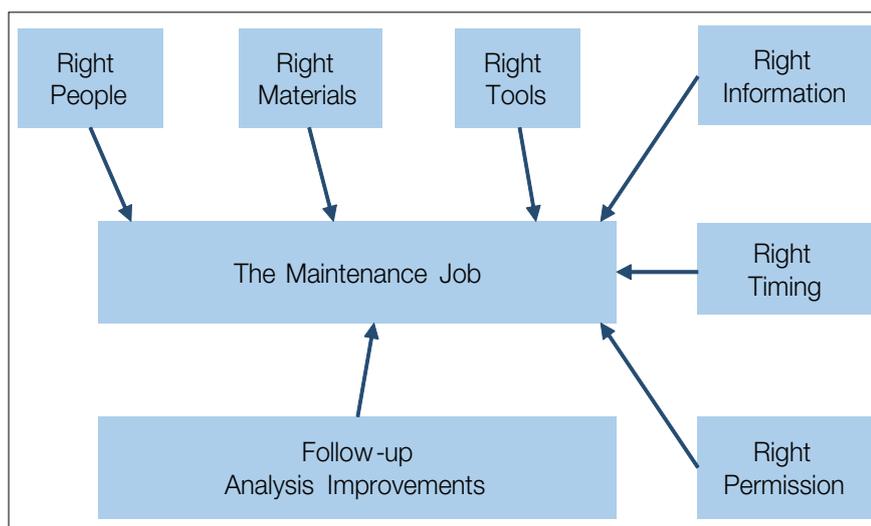


Fig. 4: Planning

## **Spare Parts Management**

Proper planning and control of spare parts inventory is a critical component of an effective Engine Management Concept program. If the right parts are not at hand when needed for maintenance jobs, downtime is prolonged; on the other hand too many parts at hand will absorb excessive costs. Clearly, effective spare parts management plays a critical role in the Engine Management Concept, which, in turn, keeps the plant running.

Put in another way, if the spare part management is run inadequately, such as poor inventory accuracy, parts unavailable when needed due to poor replenishment and procurement practices, etc., the rest of the maintenance operation has no chance of achieving high service levels of equipment availability and reliability.

In the Engine Management Concept, original spare parts are included in the package, thus it is up to MAN Diesel & Turbo to supply and ensure the availability of the spare parts and services when needed. Strategically, spare parts can be stored, and it is the duty of MAN Diesel & Turbo to optimise spare parts stock levels.

For the shipowner, this will reduce capital costs and the risk of damage during storage and lead to a corresponding reduction in administrative costs. When the spare parts stock is outsourced to one dedicated supplier it makes the process easier to administer (each spare parts order can easily cost the shipowner 100 US\$ in administration alone), communication will be facilitated and, consequently, it will

provide greater assurance of meeting corporate standards and compliance with authority regulations such as NO<sub>x</sub> requirements.

All storage, as well as use of spares and logistics, are controlled with the help of the computerised maintenance management system, which provides periodic reviews to recommend changes to the storage and replenishment levels and identifies slow movers and obsolete parts.

As some of the objectives of the Engine Management Concept are optimised maintenance, increased availability and reliability, these objectives alone will reduce the requirement for spares and, thereby, improve the benefits of the Engine Management Concept.

**Information Flow**

To operate a world class maintenance organization, you need precise information combined with the ability to act quickly in response to impending emergencies.

Information is the lifeblood of successful maintenance, and is required for effective equipment and logistics management. This includes equipment-specific information such as operating and maintenance history.

Successful maintenance practice depends a great deal on a robust information system. This involves having a computerised maintenance man-

agement system that is suitable, well supported and easy to use. Engine Management Concept will supply and implement specific high quality data on MAN Diesel & Turbo equipment.

By profiting from the extensive data base supplied by MAN Diesel & Turbo, you will save the time and resources normally needed to input correctly the engine data required by maintenance software. The Engine Management Concept does not mean that customers lose control over the maintenance of the equipment. An extensive, open and active communication between the shipowner/ship operator and Engine Management

Concept is essential for both parties to keep each other updated with the necessary information.

Frequent reporting in an agreed manner will verify that maintenance and performance parameters are being met. MAN Diesel & Turbo already has reporting procedures and report templates that can also be tailor-made to satisfy specific customer needs.

Successful implementation of the Engine Management Concept depends on two additional factors – ongoing financial justification and immediate access to information demonstrating results.

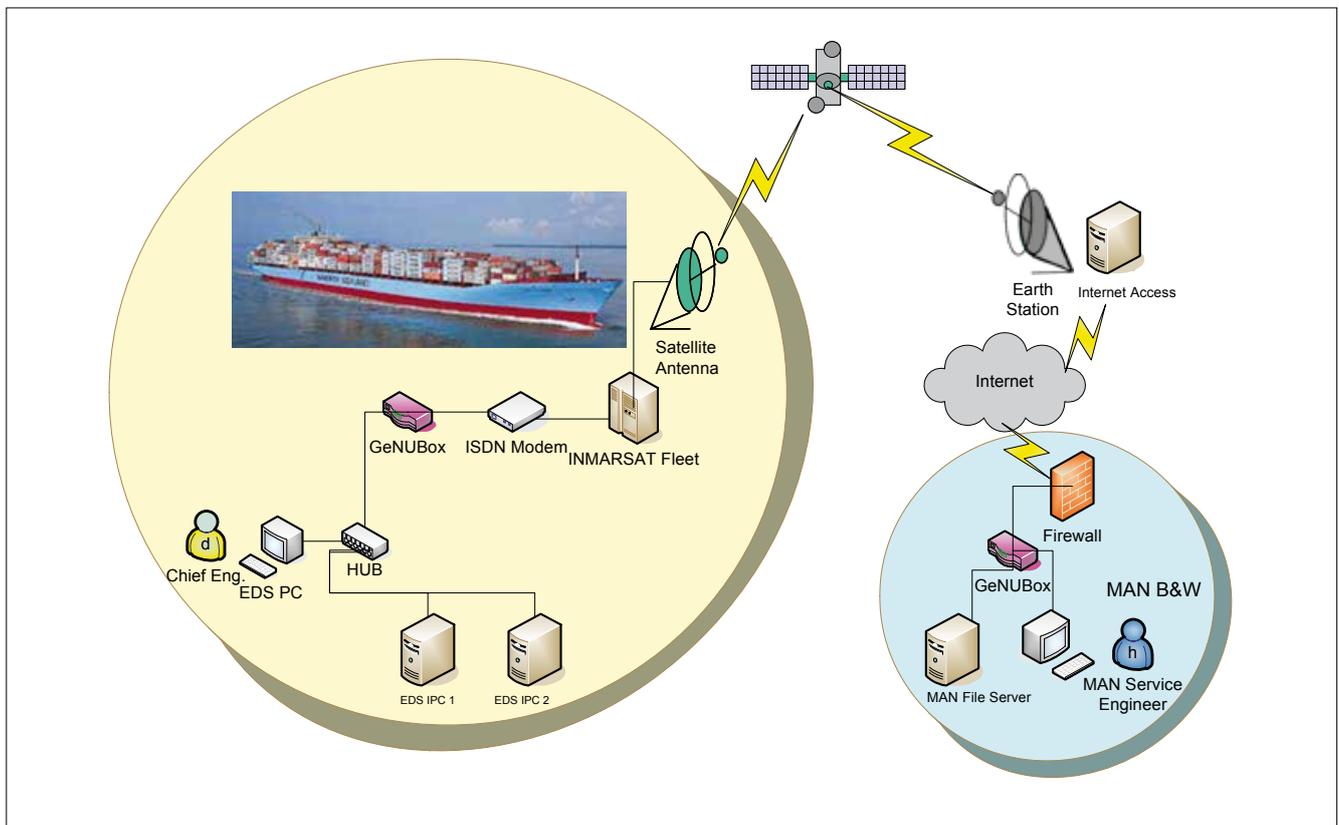


Fig. 5 : On-line monitoring

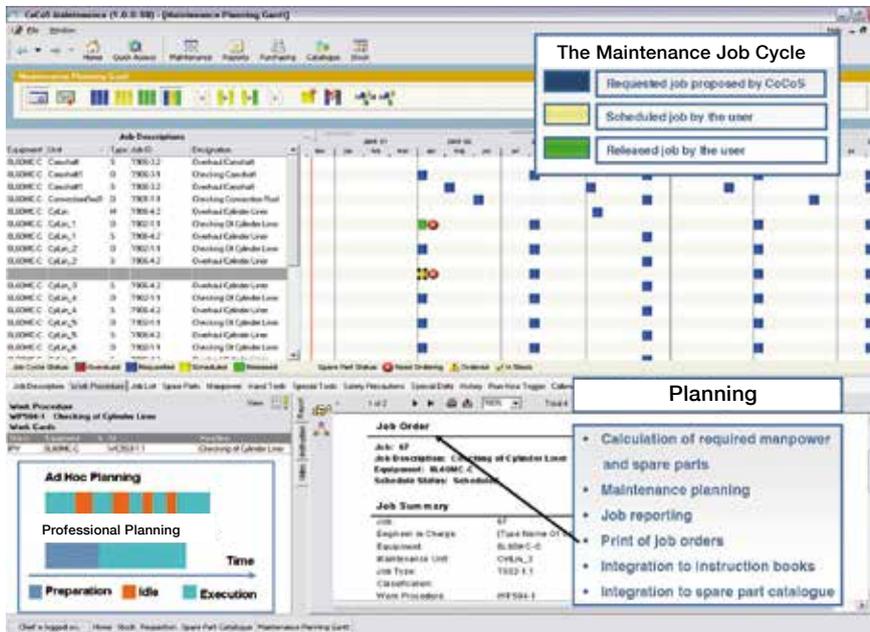


Fig. 6: Computerised maintenance management system – the crankshaft in engine management concept

### Working with Class Rules

Although class rules differ from one classification society to another there are close similarities. Regarding machinery, many shipowners apply ordinary continuous machinery survey. The conditions of continuous machinery survey are, in general, that 20% of all surveys required for class renewal shall be completed every year.

A class approved maintenance management system scheme will make it possible to carry out overhaul and class survey at the same time.

As the intervals between overhauls are getting longer, it is time consuming and therefore very expensive to open equipment for class purposes only. Furthermore, it is well-known that, statistically, the failure rate of a system increases in the early hours following intervention on equipment. Consequently, class societies propose change by shifting from item inspection to system auditing.

These costs can be minimised by using a computerised maintenance management system like in the Engine Management Concept. It is the intention that MAN Diesel & Turbo will take care of all class related issues regarding MAN Diesel & Turbo equipment.

Further, it is possible for the shipowner to take a more sophisticated class notation into use when using a type approved maintenance management system. The way the Engine Management Concept implements and uses a class approved maintenance management system makes it possible for the shipowner to get a system approval for a planned maintenance system and,

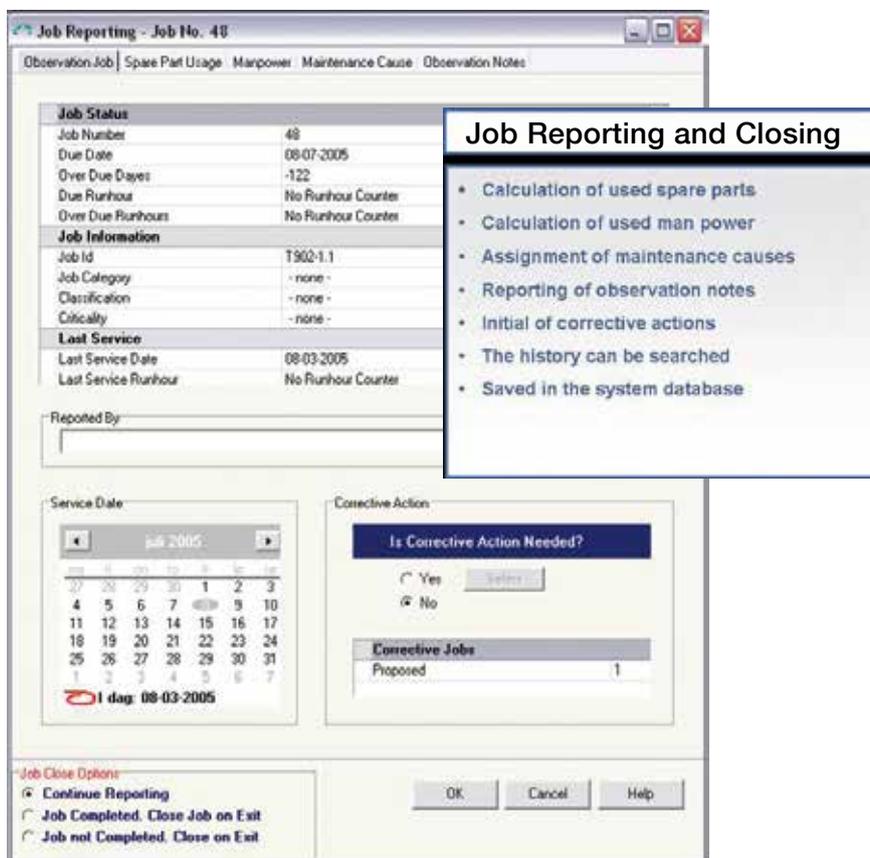


Fig. 7: Reporting

thereby, achieve a lot of benefits and a cost reduction.

With the help of the Engine Management Concept, it will be possible for the chief engineer to credit class surveys when doing overhauls. With a Machinery PMS (Planned Maintenance System) survey arrangement, class crediting of machinery components is based on evaluation of overhaul records that are carried out and credited at the next annual survey after completion by class surveyor. Vessels with Machinery PMS will not have a due date in the class status. In some classification societies it is furthermore possible to obtain discount on class machinery fee.

The Engine Management Concept fulfils the class requirements regarding MAN Diesel & Turbo equipment to obtain PMS notation. Furthermore, the Engine Management Concept can offer consultancy in getting the complete machinery arrangement in compliance with PMS class rules.

Further benefits can be obtained by implementing the class notation Machinery CM (Condition Monitoring). If an approved PMS system is implemented, combined with an additional condition monitoring system like CoCoS EDS Engine Diagnostics System it is possible to obtain the class notation Machinery CM.

### **Working with the Authorities**

The Engine Management Concept will also take care of administration and activities regarding fulfillment of requirements by which the operator can verify compliance with the IMO "NO<sub>x</sub> Technical Code".

Furthermore, the Engine Management Concept will be in compliance with the IMO "Safety Management (ISM) Code".

The above-mentioned issues will make it easier for the operator to carry through Port State Controls.

### **Training**

One important area where MAN Diesel & Turbo's various service products can be combined is personnel training. When or if required, MAN Diesel & Turbo also uses the services of its MAN PrimeServ Academy Copenhagen to train the personnel working with the Engine Management Concept.

Within the Engine Management Concept program it is also possible for the MAN Diesel & Turbo superintendents to train personnel on site during maintenance supervision.

## Strategic Maintenance

Over the years maintenance management has evolved from a largely reactive, “fix it when it breaks” approach through preventive maintenance to condition-based and proactive maintenance. Each stage in the process has been proclaimed as the solution that makes previous approaches obsolete.

With the increasing amount of attention that has been paid to the subject of maintenance management over the recent years, even more new maintenance strategies and maintenance theories have been developed to improve maintenance management.

But the fact that academics, practitioners and consultants have proposed numerous theories connected with maintenance management has resulted in a “maintenance theory jungle” a region that can give birth to confusion for many who are going to decide for the right maintenance strategy.

The search for the “ultimate solution” for maintenance management can result in a continuous wave of modified theories, which in the worst case can lead to a regressive environment where real improvements in maintenance management are lost in a sea of repetitive and fruitless activity.

For MAN Diesel & Turbo equipment it is an ongoing process to develop and innovate the living maintenance plans, maintenance models, maintenance schedules and introduce the relevant maintenance theories together with the optimum maintenance strategies and also by implementing the latest service experiences. The EMC uses concepts and ideas from all elements, assembled in a mix to best address mission, business and site requirements

The best concepts and practices are assembled within the EMC to gain greatest effectiveness and optimal solution by utilising the synergies, recognizing that a comprehensive maintenance management strategy will include a blend of reactive, preventive and proactive elements based on specific circumstances.

To support the maintenance management strategy, MAN Diesel & Turbo has developed a series of powerful “tools” with a content of specific data to process maintenance.

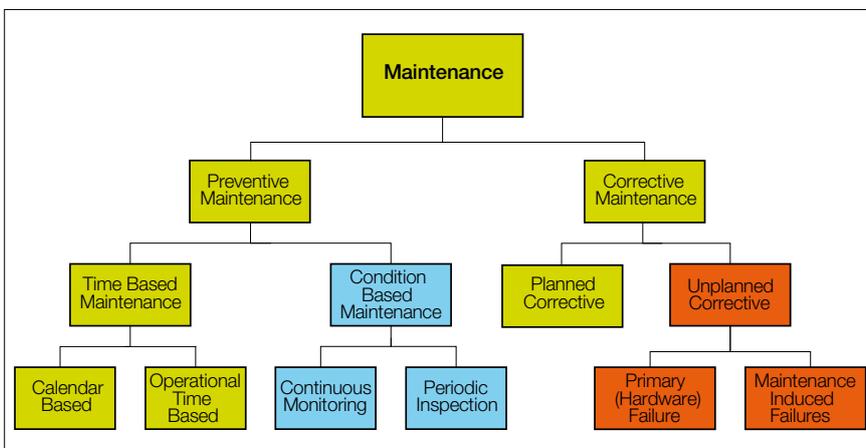


Fig. 8: Maintenance strategies

### Performance

During engine operation, several basic parameters need to be checked and evaluated at regular intervals.

The purpose is to follow alterations in:

- the combustion condition,
- the general cylinder condition,
- the general engine condition,

in order to discover any operational disturbances.

This enables the necessary precautions to be taken at an early stage, to prevent the further development of trouble.

This procedure will ensure optimum mechanical condition of the engine components, and optimum overall plant economy.

CoCoS-EDS Engine Diagnostics System provides such online surveillance, keeping the EMC organisation informed at all times of the engine condition with relevant data that are currently analyzed and facilitate early intervention so

as to reduce the risk of costly engine stoppage and even breakdowns.

The data from the online performance measurements can also contribute to control and monitoring of the conditions of hull and propeller efficiency.

Economically optimum precautions can only be taken, if the propulsion condition of the ship is well defined, and this requires not only a reliable performance monitoring system, but also rigorous methods of analysis which can be carried out within the EMC organisation if agreed.

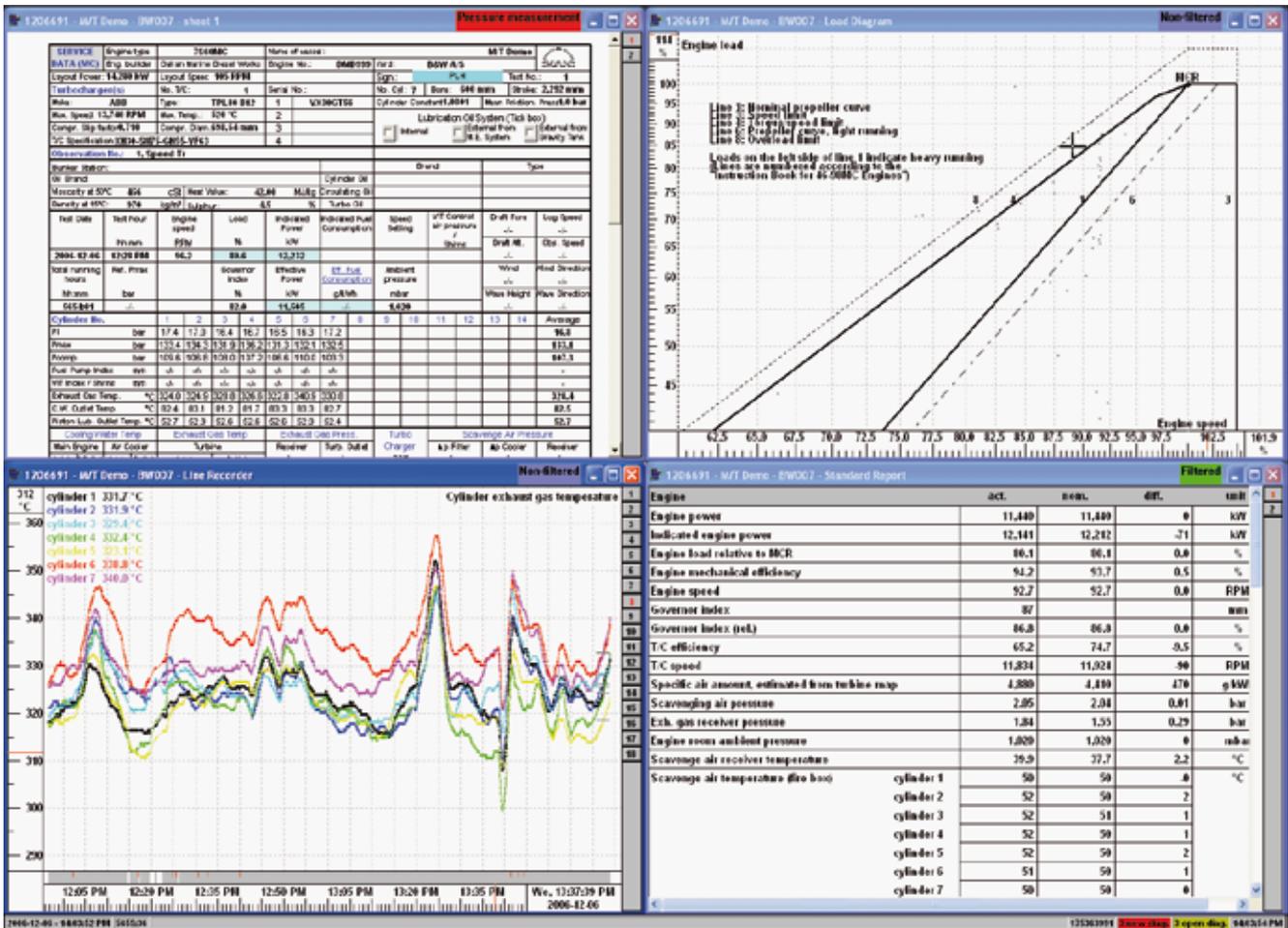


Fig. 9 : Performance monitoring and evaluation

## Summary

Traditionally, maintenance programs have been conducted by shipowners-/ship operators, rather than by the manufacturers or designers of the equipment. That is to say, the shipowners/ship operators or a contracted third party (other than the manufacturers or designers) have, customarily, performed the maintenance action required by a maintenance program.

Hence, the Engine Management Concept provision constitutes a departure from the traditional way of conducting maintenance business.

The development of the Engine Management Concept has now come to an end, and it is a well-proven service product from MAN Diesel & Turbo. All signs point to the Engine Management Concept being a sure-fire path to success in the highly innovative LNG shipping business area.

Since the needs and expectations of each case vary, even in case of similar ships, every Engine Management Concept agreement is tailored in a close teamwork with the customer to gain the desired benefits. Setting up an Engine Management Concept agreement is not a standard piece of paper which is identical for all ship owners/operators. Depending on the requested service level, the Engine Management Concept agreement can cover all the needs of an effective tailor-made maintenance management programme. A tailor-made maintenance plan, based on the operation profile, will be the perfect starting point for a specific Engine Management Concept agreement.

Performance data capture will be carried out with the help of CoCoS EDS (Computer Controlled Surveillance – Engine Diagnostic System), and control of all activities will be carried out with the help of computerised maintenance management system

## Objectives for Engine Management Concept

- To ensure shipowners/ship operators reliability, availability and power to trust regarding MAN Diesel & Turbo equipment
- To establish a close “partnership” with customers through the Engine Management Concept agreements based on trustworthiness, innovation and build up on an intensive and long-term customer relationship.
- To provide the industry with added value through innovative solutions to the mutual benefit of our customers and partners.
- Innovation and development of MAN Diesel & Turbo maintenance strategies, maintenance plans and methods.

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**MAN Diesel & Turbo**

Teglholmmsgade 41  
2450 Copenhagen SV, Denmark  
Phone +45 33 85 11 00  
Fax +45 33 85 10 30  
info-cph@mandieselturbo.com  
www.mandieselturbo.com