Facultat de Nàutica de Barcelona

# Maintenance Plan for a Recreational boat of 47m in length

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# General Appendix

## Objectives

The objective of this thesis is to create a maintenance plan for a 15 year old recreational boat of 47m in length. It must be mentioned that the boat is a private yacht and there is a high allowance for reparations and general maintenance.

To create the maintenance plan, the manuals of the equipment will need to be revised and find out which kind of maintenance has been performed till now, if any at all.

There needs to be taken into consideration that being a boat with a few years of age, some of the equipment might need to be replaced.

This thesis aims to compare the maintenance recommended by the manufacturers with the one used on a day to day basis, keeping in mind that they can differ and the advantages that this can have.

On the other hand, it wants to be proved the importance of having a maintenance plan in place and its advantages, both operative and economic wise.

Lastly, different ways of keeping the maintenance will be exposed from the organization point of view.

This thesis is of a great interest due to the fact that there is a practical application of the knowledge acquired during the studies and, in this case, they are applied to a fully operational ship.

# Chapter 1: The maintenance

1. Definition and need for maintenance

According with the Normalization French Society (AFNOR) maintenance is *a group of actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order.*

The need for maintenance is predicated on actual or impending failure – ideally, maintenance is performed to keep equipment and systems running efficiently for at least the design life of the component(s). As such, the practical operation of a component is time-based function. If one were to graph the failure rate of a component population versus time, it is likely the graph would take the "bathtub" shape shown in Figure 1. In the figure the Y axis represents the failure rate and the X axis is time. From its shape, the curve can be divided into three phases: infant mortality, useful life, and wear-out periods.

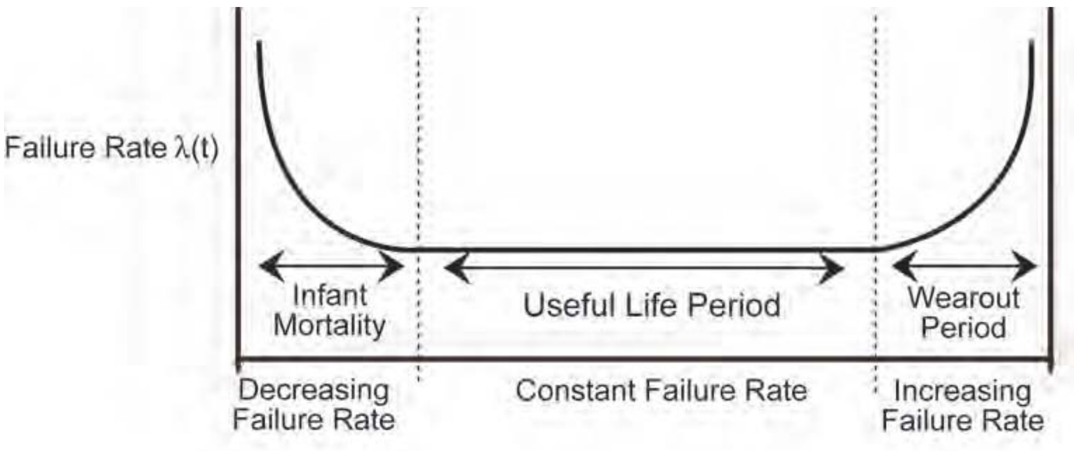


**Figure 1 Component failure rate over time for component population**

The initial infant mortality period of bathtub curve is characterized by high failure rate followed by a period of decreasing failure. Many of the failures associated with this region are linked to poor design, poor installation or misapplication. The infant mortality period is followed by a nearly constant failure rate period known as useful life. There are many theories on why components fail in this region, most acknowledge that poor maintenance often plays significant role. It is also generally agreed that exceptional maintenance practices encompassing preventive and predictive elements can extend this period. The wear-out period is characterized by a rapid increasing failure rate with time. In most cases this period encompasses the normal distribution of design life failures.

The design life of most equipment requires periodic maintenance. Belts need adjustment, alignment needs to be maintained, proper lubrication on rotating equipment is required, and so on. In some cases, certain components need replacement to ensure that the main piece of equipment last for its design life. Anytime we fail to perform maintenance activities intended by the equipment's designer, we shorten the operating life of the equipment.

## 2. The maintenance's place in an industrial company

Internationally, the activity of maintenance evolved in the industrial companies considering the compromise that should be done between the needs and exigencies, from the technical, economic and human point of view.

Until the 60's, the activity of maintenance was a synonym of repairing and the equipments were improved only when it was possible. It could be noticed the fact that when improving the equipments, the human security was guaranteed. Therefore they would be stopped just to examine the wearing level and completely abandoned when the persons' security wasn't in stake.
The period 1960-1970 generated three fundamental mutations in the industrial's maintenance's approach:

- Creating the diagnostic maintenance, that led lately to the conditioned maintenance. It's about applying the techniques of nondestructive control, the vibrations' control, fluids' analysis, etc.
- Taking into consideration the economic aspects in defining the maintenance's attempt. Any equipment at which an accidental failure or a decline of the functioning parameters determines in a significant manner a decrease in the production's quantity or quality is considered a "critical" one. The concept of "failure cost" appears and the indirect financial incidence of the activity of maintenance is considered. But it isn't enough just to consider the economical aspects when the

maintenance actions are decided (the cost of the equipments' non-efficiency, the non-maintenance' cost). It's also necessary to evaluate the risk and the probabilities of equipments' malfunctions.

- The appeal to the reliability theory. The reliability models of studies, which were initially hard to apply in the industrial units, were, subsequently, used more and more.

After the 1970, two philosophies related to the industrial maintenance were developed. In USA it was applied the concept of *Life Cycle Cost* (LCC), which covers the totality of the costs of the research, design, construction, exploit and maintenance processes for an equipment's entire life. The objective aimed is the minimization.
The second philosophy was the Japanese one, *Total Productive Maintenance* (TPM). If LCC approaches the maintenance from the economic point of view, TPM approaches it from a human point of view. Its objective is the maximization of the production equipment's global efficiency and it presupposes the participation of all the "actors" that contribute to its efficiency: the designers, the users (the production staff), the maintenance staff, from all the management's hierarchical levels, starting with the worker to the general manager.

## 3. Types of maintenance programs

As it's been described on the previous points, over the last 30 years different approaches to how maintenance can be performed to ensure equipment reaches or exceeds its design life have been developed. In addition to waiting for a piece of equipment to fail (reactive maintenance), we can utilize preventive maintenance, predictive maintenance, or reliability centered maintenance.

### 3.1. Reactive maintenance

Reactive maintenance is basically the "*run it until it break*s" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached.

Advantages to reactive maintenance can be viewed as a double-edged sword. If we are dealing with new equipment, we can expect minimal incidents of failure. If our maintenance program is purely reactive, we will not expend in manpower or incur capital cost until something breaks. Since we do not see any associated maintenance cost, we could view this period as saving money. The downside is reality. In reality, during the time we believe we are saving maintenance and capital cost, we are really spending more money than we would have under a different maintenance approach. We are spending more money associated with capital cost because, while waiting for the equipment to break, we are shortening the life of the equipment resulting in more frequent replacement. We may incur cost upon failure of the primary device associated with its failure causing the failure of a secondary device. This is an increased cost we would not have experienced if our maintenance program was more proactive. Our labor cost associated with repair will probably be higher than normal because the failure will most likely require more extensive repairs than would have been required if the piece of equipment had not been run to failure. Since we expect to run equipment to failure, we will require a large material inventory of repair parts. This is a cost we could minimize under a different maintenance strategy.

### 3.2. Preventive maintenance

Preventive maintenance can be defined as follows: *actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level*.

The U.S. Navy pioneered preventive maintenance as means to increase the reliability of their vessels. By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased. In addition to an increase in reliability, money is saved over that of a program just using reactive maintenance. Studies indicate that this savings can amount to as much as 12% to 18% on the average. Depending on the facilities current maintenance practices, present equipment reliability and facility downtime, there is little doubt that many facilities purely reliant on reactive maintenance could save much more than 18% by instituting a proper preventive maintenance program.

While preventive maintenance is not the optimum maintenance program, it does have several advantages over that of a purely reactive program. By performing the preventive maintenance as the equipment designer envisioned, we will extend the life of the equipment closer to design. This translates into money saving. Preventive maintenance (lubrication, filter change, etc.) will generally run the equipment more efficiently. While we will not prevent equipment catastrophic failures, we will decrease the number of failures. Minimizing failures translates into maintenance and capital cost savings.

### 3.3. Predictive maintenance

Predictive maintenance can be defined as follows: *measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state*. Results indicate current and future functional capability.

Basically, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule; preventive maintenance is time-based. Activities such as changing lubricant are based on time, like calendar time or equipment run time. For example, most engines will require an oil change every 500 hours traveled. This is effectively basing the oil change needs on equipment run time. No concern is given to the actual condition and performance capability of the oil. It is changed because it is time. This methodology would be analogous to a preventive maintenance task. If, on the other hand, the operator discounted the run time and had the oil analyzed at some periodicity to determine its actual condition and lubrication properties, he/she may be able to extend the oil change until the engine has run 1000 hours. This is the fundamental difference between predictive maintenance and preventive maintenance, whereby predictive maintenance is used to define needed maintenance task based on quantified material/equipment condition.

The advantages of predictive maintenance are many. A well-orchestrated predictive maintenance program will all but eliminate catastrophic equipment failures. We will be able to schedule maintenance activities to minimize or delete overtime cost. We will be able to minimize inventory and order parts, as required, well ahead of time to support the downstream maintenance needs. We can optimize the operation of the equipment, saving energy cost and increasing plant reliability. Past studies have estimated that a properly functioning predictive maintenance program can provide a savings of 8% to 12% over a program utilizing preventive maintenance alone. Depending on a facility's reliance on reactive maintenance and material condition, it could easily recognize savings opportunities exceeding 30% to 40%. In fact, independent surveys indicate the following industrial average savings resultant from initiation of a functional predictive maintenance program:

- Return on investment: 10 times
- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in downtime: 35% to 45%
- Increase in production: 20% to 25%.

On the down side, to initially start into the predictive maintenance world is not inexpensive. Training of personnel to effectively utilize predictive maintenance technologies will require considerable funding. Program development will require an understanding of predictive maintenance and a firm commitment to make the program work by all facility organizations and management.

## 3.4. Reliability maintenance

Reliability centered maintenance (RCM) magazine provides the following definition of RCM: *a process used to determine the maintenance requirements of any physical asset in its operating context*.

Basically, RCM methodology deals with some key issues not dealt with by other maintenance programs. It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. It also approaches the structuring of a maintenance program recognizing that a facility does not have unlimited financial and personnel resources and that the use of both need to be prioritized and optimized. In a nutshell, RCM is a systematic approach to evaluate a facility's equipment and resources to best mate the two and result in a high degree of facility reliability and cost-effectiveness. RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach.

Because RCM is so heavily weighted in utilization of predictive maintenance technologies, its program advantages and disadvantages mirror those of predictive maintenance. In addition to these advantages, RCM will allow a facility to more closely match resources to needs while improving reliability and decreasing cost.

Table 1 below highlights guidance on RCM development by equipment application. It is important to both define the equipment criticality and cost of down-time when determining the optimal mix of maintenance elements. Once defined, the equipment can be prioritized in the developing of a functional RCM program.

| Reliability Centered Maintenance Hierarchy | | |
|---|---|---|
| ***Reactive* Element Applications** | ***Preventive* Element Applications** | ***Predictive* Element Applications** |
| Small parts and equipment | Equipment subject to wear | Equipment with random failure patterns |
| Non-critical equipment | Consumable equipment | Critical equipment |
| Equipment unlikely to fail | Equipment with known failure patterns | Equipment not subject to wear |
| Redundant systems | Manufacturer recommendations | Systems which failure may be included by incorrect preventive maintenance |

**Table 1 Reliability centered maintenance element applications**

4. How to initiate reliability centered maintenance

The road from a purely reactive program to a RCM program is not an easy one. The following is a list of some basic steps that will help to get moving down this path.

1- Develop a Master equipment list identifying the equipment in the facility.

2- Prioritize the listed components based on importance or criticality to operation, process, or mission.

3- Assign components into logical groupings.

4- Determine the type and number of maintenance activities required and periodicity using:

a. Manufacturer technical manuals

b. Machinery history

c. Root cause analysis findings - Why did it fail?

d. Good engineering judgment

5- Assess the size of maintenance staff.

6- Identify tasks that may be performed by operations maintenance personnel.

7- Analyze equipment failure modes and impacts on components and systems.

8- Identify effective maintenance tasks or mitigation strategies.

# Chapter 2: Ship's information

The boat that will be the main focus of this thesis is Motor Yacht Lady Allison, a 47 meter Feadship. She is a private yacht with American owners and cruises 6 months of the year on the Caribbean and Florida waters (USVI, BBI, St Martin, St Barths, Fort Lauderdale, Miami) and 6 months on the Mediterranean sea (Greece, Croatia, Italy, Sardinia, France).

Lady Allison is used for private purposes only and has a Caiman Island flag. Aboard we can find 5 suites and a master suite, a gym, dinning and lounge areas and accommodation for up to 12 crew. The crew needed to operate the boat is as follows: captain, first mate, boatswain or second mate, deckhand, chief engineer, 2nd engineer/deckhand, chef, chief stewardess and 3 stewardesses.

## 1. Data and dimensions

Following there is a list of basic information about Lady Allison's specifications such as capacities and dimensions, as well as some building information.

### 1.1. General data

| | |
|---|---|
| Yacht Name | Lady Allison |
| Builder | Feadship |
| Year of Build | 1991 |
| Construction | Steel/Aluminum |
| Callsign | ZHFT9 |
| Inmarsat voice 1 & telex 1 | 1756312 |
| Inmarsat telefax 1 | 1756313 |
| Flag | Cayman Islands |
| Port of Registry | George Town C.I. |
| Document Number | 715855 |
| Fuel Capacity | 73.049 l / 19.300 USG |
| Water Capacity | 20.060 l / 5.300 USG |
| Cruising Speed | 12,5 Kn |

| | |
|---|---|
| Range | 5.000 miles |
| Engines | 2 Detroit Diesel High Disp. |

### 1.2. Dimensions

| | |
|---|---|
| Displacement | 473 Ton |
| Gross Tonnage | 458,42 reg. Ton |
| Net Tonnage | 137 reg. Ton |
| Panama Gross Tonnage | 567,9 Ton |
| Suez Net Tonnage | 355,47 Ton |
| Suez Gross Tonnage | 567,9 Ton |
| Length over all | 45,72m |
| Length waterline | 41,53m |
| Beam extreme | 8,81m |
| Depth | 4,65m |
| Draft fully loaded | 2,72m |

### 1.3. Height dimensions

The following dimensions are with tanks half loaded and even keel.

| | |
|---|---|
| A – Total height above water | 16,13m |
| B – Height sundeck/fly bridge above water | 6,88m |
| C – Height bridge deck above water | 4,48m |
| D – Height main deck above water | 2,08m |
| E – Waterline above base (draft) | 2,57m |

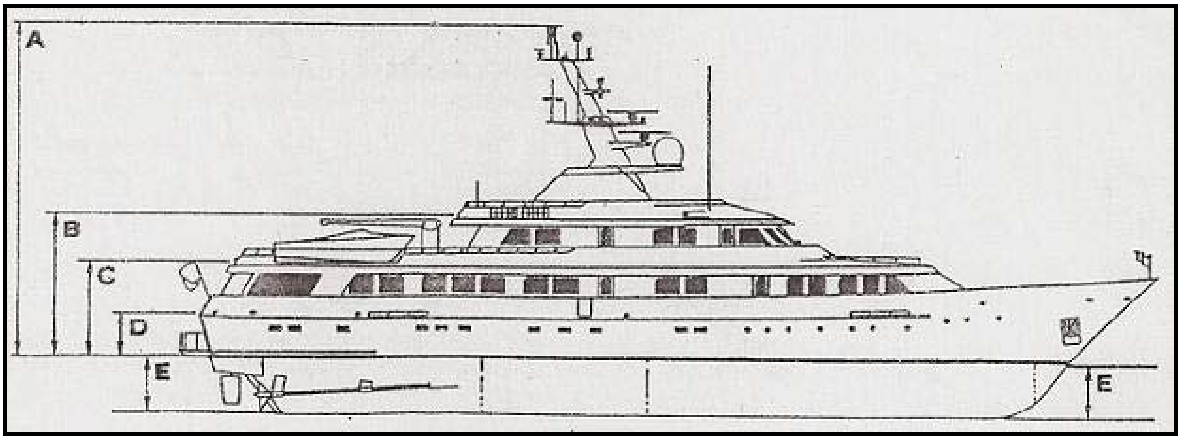


**Figure 2 Height Dimensions**

2. Tank capacities and docking plan

Lady Allison has a capacity of 73.049 l of fuel, distributed with 2 tanks on the mid section of the boat with a capacity of 49.205 l, plus 3 more tanks on the back section of the boat with 22.520 l of capacity. The day tank located on the back of the engine room has a capacity of 1.324 l.
The luboil and dirty oil tanks are located under the floor on the middle section of the engine room, with a capacity of 2.940 l and 1.920 l respectively.
The fresh water tanks, located directly behind the mid section fuel tanks, hold up to 20.060 l of water.

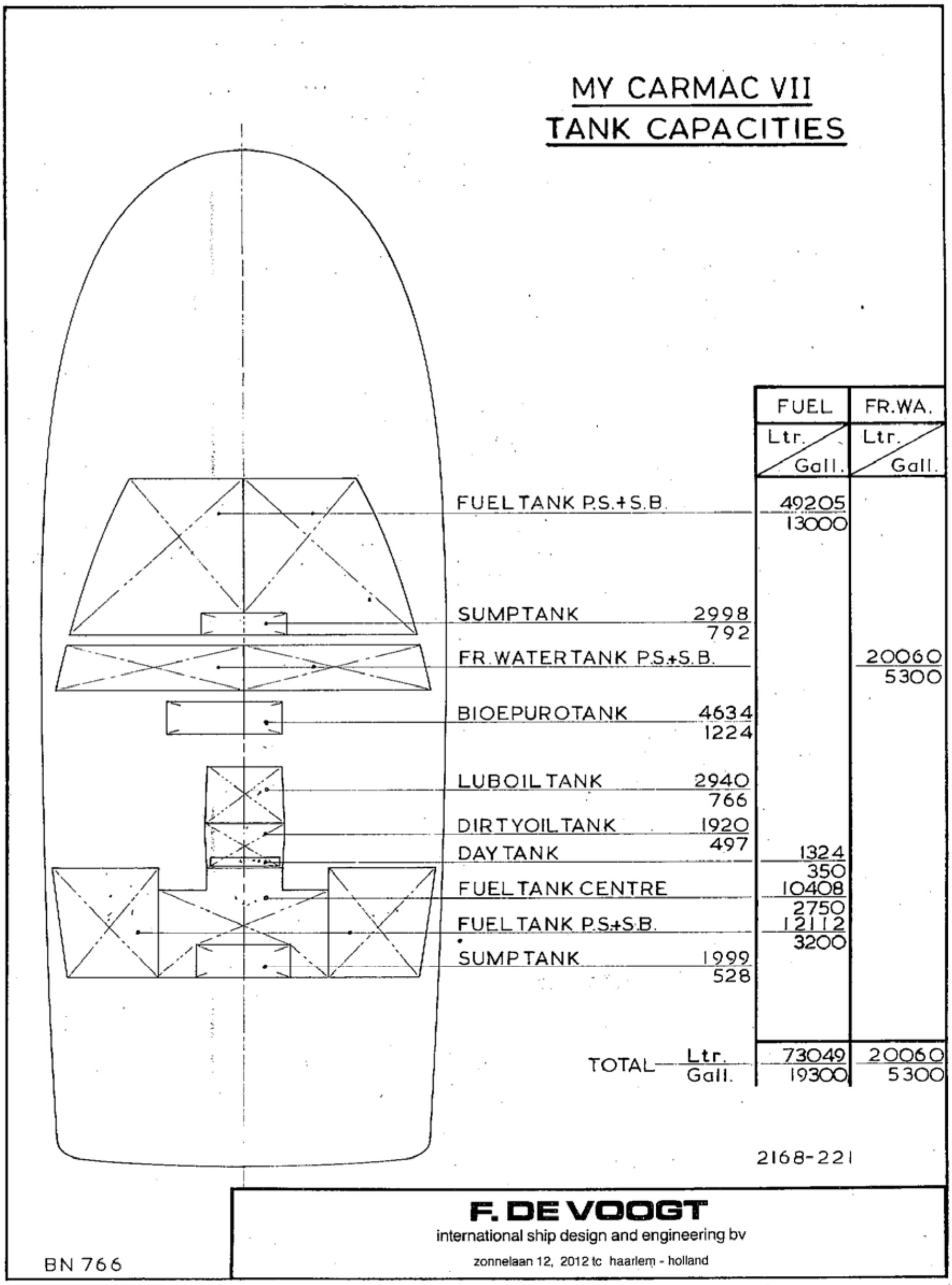


**Figure 3 Tank Capacities Diagram**

The lower deck has five crew cabins on the front part with the crew mess and the walk in fridge and freezer. The engine room is on the mid section of the boat plus one suite cabin. On the aft section there are 4 guest cabins; two masters and two double ones.

On the main deck we find the owners cabin, the galley and the saloon with the dinning area, plus the aft deck also with dinning area.

The boat deck has the wheel house, captains cabin, officers office, gym and big outside area with the two tenders and two cranes.

The fly bridge is located on the sundeck, where we also find the mast with all the navigation lights and the exhaust line from the engine room.

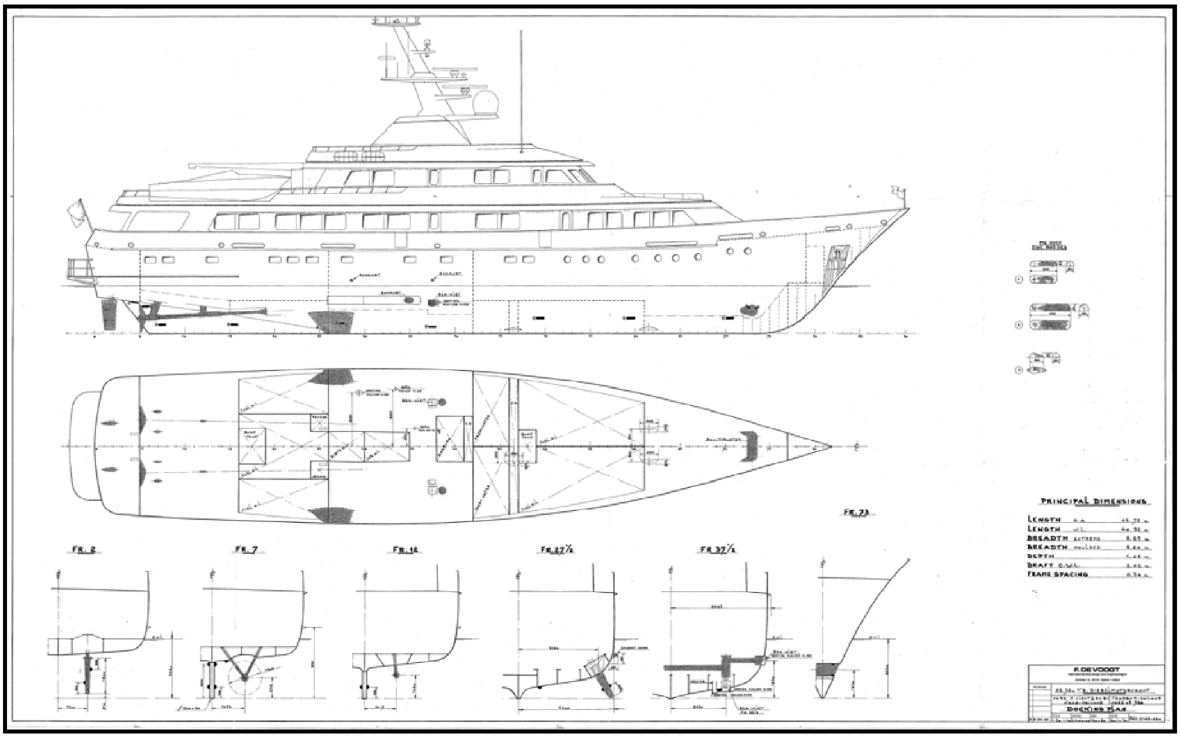

**Figure 4 Docking Diagram**

3. Engine room arrangement and machinery on board

As aforementioned, the engine room of Lady Allison is located on the mid section of the ship.
It has 2 main engines, two generators, 2 air compressors, 4 air conditioning compressors (2 refrigerated by water and 2 by air), fuel separator (Alfa Laval), oil water separator, bilge/fire fighting pumps, stabilizers, shore power transformers, control panel, 2 watermakers and black water treatment plant, to mention some.

Following there is the engine room arrangement plus three zoom in views that show most of the components located on the engine room and give a good idea of the dimensions and distribution.

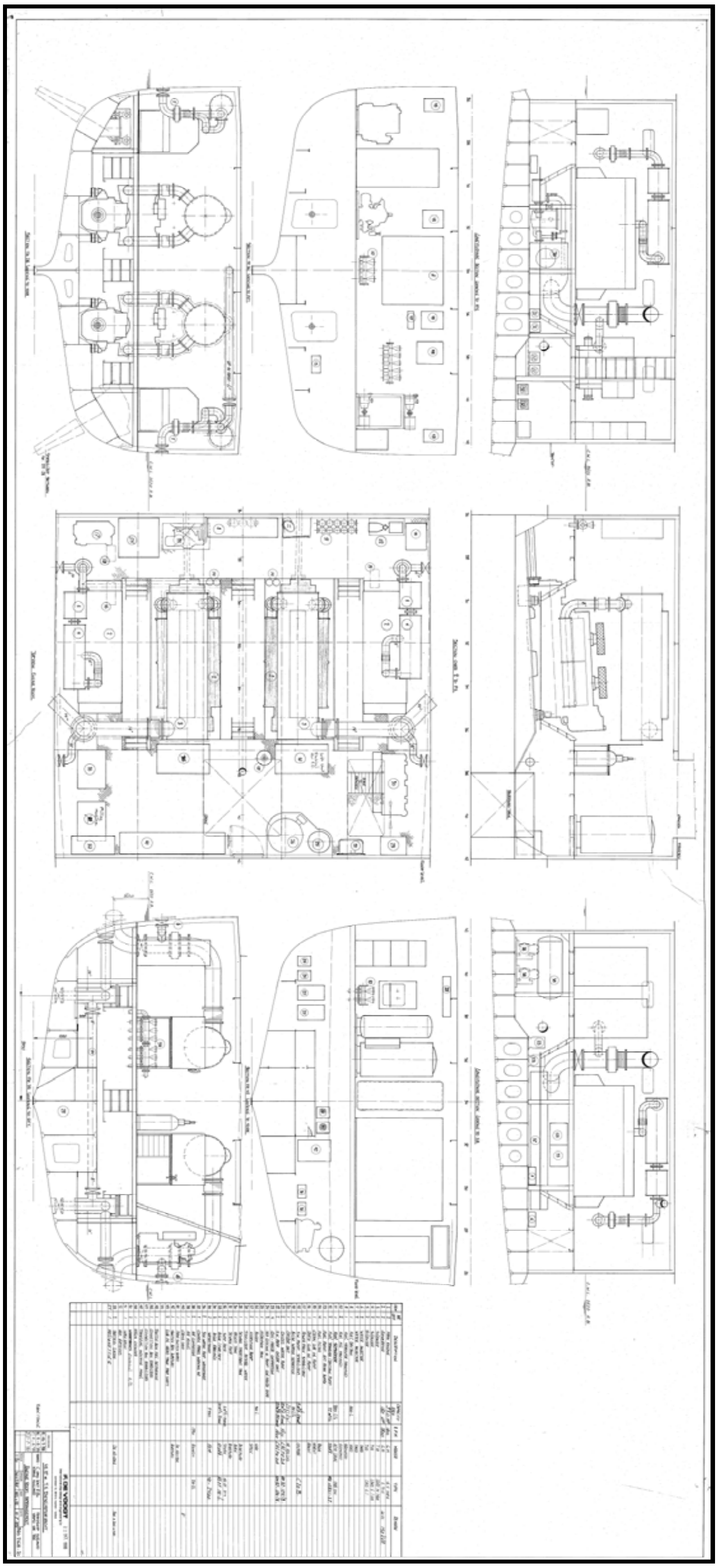

**Figure 5 Engine Room Arrangement**

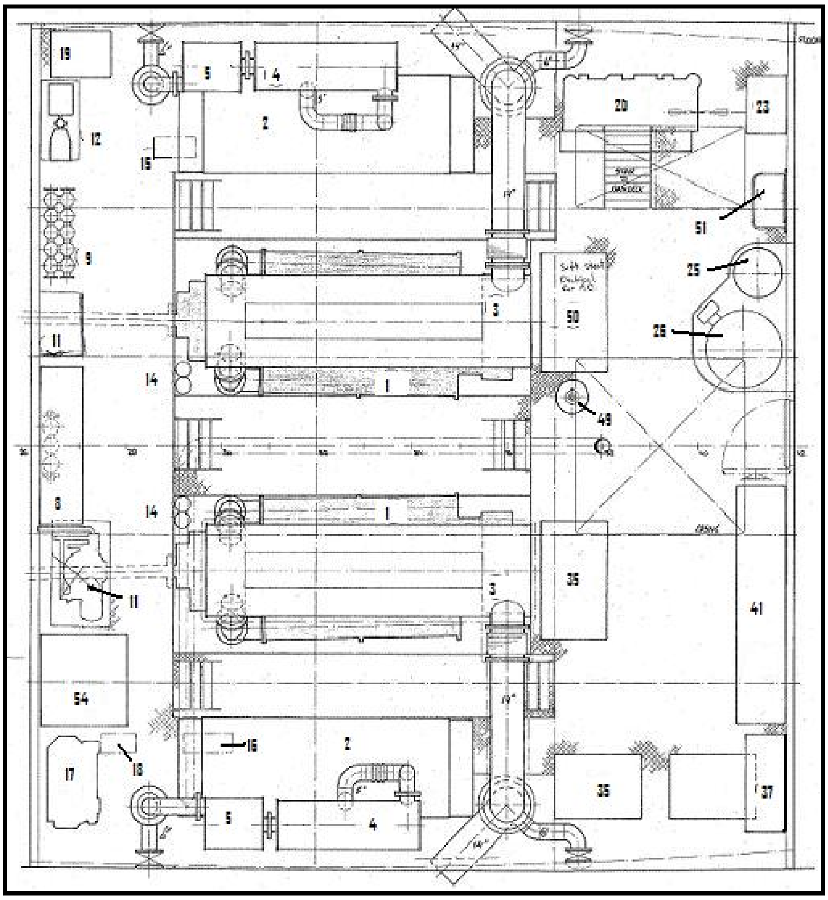


**Figure 6 Top View Engine Room**

| ITEM | NR OFF | DESCRIPTION | ITEM | NR OFF | DESCRIPTION |
|---|---|---|---|---|---|
| 1 | 2 | Main Engine | 18 | 1 | S.W. Pump Stabilizers |
| 2 | 2 | Generator | 19 | 1 | Bilge Water Separator |
| 3 | 2 | Silencer | 20 | 1 | Chiller Unit |
| 4 | 2 | Silencer | 23 | 4 | Cool-Freeze Compressor |
| 5 | 2 | Silencer | 25 | 1 | Hydrophor Tank |
| 8 | 1 | Fuel Daytank | 26 | 1 | Boiler |
| 9 | 1 | Fuel Transfer Manifold | 35 | 2 | Watermaker |
| 11 | 1 | Fuel Separator | 37 | 1 | Control Panel Working Air |
| 12 | 2 | Fuel Transfer/Daytank Manifold | 41 | 1 | Main Switch Board |
| 14 | 4 | Fuel Filter | 49 | 1 | Halon Cylinder |
| 15 | 1 | Clean Lub Oil Pump | 50 | 2 | Electrical A.C. |
| 16 | 1 | Dirty Lub Oil Pump | 51 | 1 | Wash Basin |
| 17 | 1 | Powerpack Stabilizer | 54 | 1 | Helianeitics |

**Table 2 List of components from Figure 6**

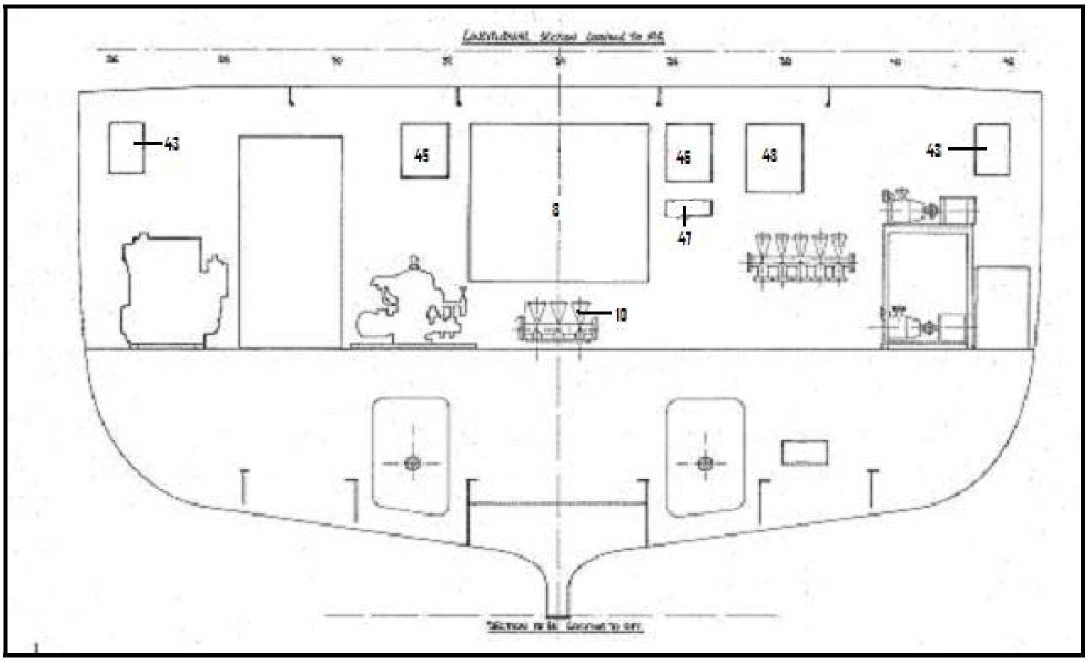

Figure 7 Section FR26 Looking to Aft

| ITEM | NR OFF | DESCRIPTION |
|---|---|---|
| 8 | 1 | Daily Fuel Tank |
| 10 | 2 | Fuel Fill Manifold |
| 13 | 1 | Fuel Pump Aft Peak Supply |
| 43 | 2 | Lub Oil Head Tank Prop. Shaft |
| 45 | 1 | Switch Box Fuel Separator |
| 46 | 1 | Connection Box Stabilizers |
| 47 | 1 | Connection Box Stabilizers |
| 48 | 1 | Tank Level Indicator Panel |

**Table 3 List of components from Figure 8**

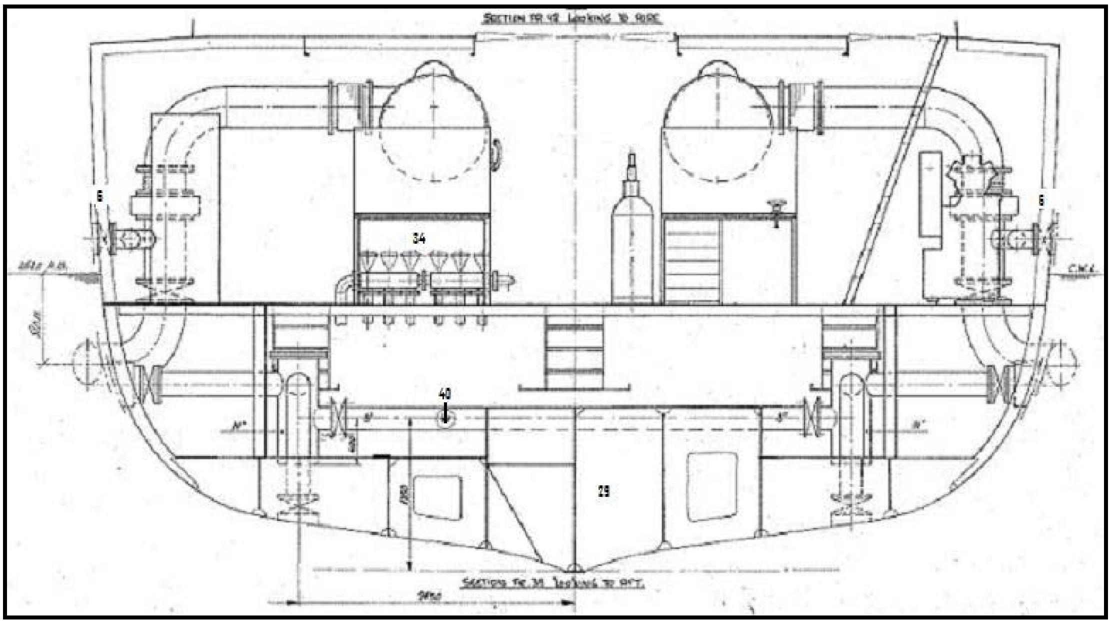


**Figure 8 Section FR39 Looking to Aft**

| ITEM | NR OFF | DESCRIPTION |
|---|---|---|
| 6 | 2 | Daily Fuel Tank |
| 29 | 1 | Sterilizer Potable Water |
| 34 | 2 | Bilge Manifold |
| 40 | 1 | Cross Over |

**Table 4 List of components from Figure 9**

# Chapter 3: Rules and regulations

## 1. Introduction

Yachts must comply with various rules and regulations in order to operate legally. These can be broken into four main categories:

- International conventions (and Large Yacht Codes)
- National regulations
- Port State regulations
- Classification Society rules and regulations

While charter yachts must comply with all of the previous requirements due to their commercial nature, only some of these also apply to private yachts. The crews of charter yachts in excess of 500GT are required, by the International Safety Management (ISM) Code, to be familiar with these requirements.

## 2. Glossary

*Class, Class Society or Classification Society* refers to a non-governmental body that promotes the safety and protection of the environment of ships and offshore structures. This is achieved by setting technical rules, confirming that designs and calculations meet these rules, surveying ships and structures during the process of construction and commissioning, and periodically surveying vessels to ensure that they continue to meet the rules.

The six Class Societies most common in yachting are: the American Bureau of Shipping (ABS), Bureau Veritas (BV), Det Norske Veritas (DNV), Germanischer Lloyd (GL), Lloyd's Register (LR) and Registro Italiano Navale (RINA).

A ship or yacht is said to be "*classed*" when it is in possession of a valid Certificate of Class issued by a Class Society.

*Flag, Flag State or Flag Administration* refers to that governmental authority under which a country exercises regulatory control over the vessels which is registered under its flag. This involves the inspection, certification and issuance of safety and pollution prevention documents in accordance with the international conventions and national regulations. For example, the MCA is the Flag State of the UK, and is the authority which regulates and certificates all vessels registered in the UK.

To certify vessels in accordance with the international conventions, a Flag State must be a signatory to the conventions and also ratify the convention in their domestic merchant shipping law.
The Bermuda, Cayman Islands, Gibraltar and Isle of Man Flag States are not signatories to the conventions, but have ratified them by proxy via the UK's MCA, which is a signatory to them as the mother Flag State of the Red Ensign Group (the group of British shipping registers).

*IMO* refers to the International Maritime Organization, a specialized agency of the United Nations (UN) founded in 1959 to develop and maintain a comprehensive regulatory framework for shipping. Its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping. Within yachting, IMO is best known as the body that maintains and updates the main conventions: SOLAS, Load Lines, MARPOL, STCW and COLREGS.

*Port State* refers to that governmental authority under which a country exercises a regulatory control over the vessels which are registered under other countries' Flags whilst they are operating within its territorial waters. For example, the Spanish Port State authority regulates foreign shipping engaged on voyages in Spanish territorial waters.

## 3. International Conventions and Large Yacht Codes

The following requirements apply to charter yachts of ALL Flag States unless otherwise stated. A certificate issued under the provisions of these requirements is generally valid for five years, but must be re-validated every year by means of a periodic survey by a Flag State inspector or duly authorized Class surveyor. The certificate will be re-issued after a satisfactory renewal survey every five years.

## 3.1. SOLAS

International Convention for the Safety of Life At Sea (SOLAS) has the following applicability:

Chapter I, General: All charter yachts over 500GT
Chapter II, Construction: All charter yachts over 500GT
Chapter III, Life-saving appliances: All charter yachts over 500GT
Chapter IV, Radio (GMDSS): All charter yachts over 300GT
Chapter V, Safety of Navigation: All yachts
Chapter IX, ISM Code: All charter yachts over 500GT
Chapter XI, ISPS Code: All charter yachts over 500GT

The main objective of the SOLAS convention is to specify minimum standards for the construction, equipment and operation of ships (and carter yachts), which are compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the convention as evidence that compliance has been satisfactorily achieved.

The SOLAS convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914 as a response to the Titanic disaster, and the current version of the convention which entered into force in 1980 (having been "adopted" – agreed by the IMO's contracting governments – in 1974) is referred to as 'SOLAS 74, amended version'.

Amendments can be made to SOLAS without the need to re-publish it or create a new version; this is achieved by the International Maritime Organization publishing Marine Safety Committee circulars that contain the amendments.

Private yachts or "pleasure yachts not engaged in trade", as they are defined in the convention, do not need to comply with the requirements of SOLAS (except for Chapter V which is mandatory for all vessels). Charter yachts carrying up to 12 passengers must comply with its Cargo Ship requirements, whilst those carrying 13 or more passengers must comply with the Passenger Ship requirements.

Some countries will permit compliance with large commercial yacht codes as an alternative to meeting the requirements of SOLAS and, in order to do so, the countries have formally informed IMO that they are applying national rules as an equivalent to SOLAS's international rules, as discussed later in this section.

## 3.2. MARPOL 73/78

International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) has the following applicability:

Annex I, Oil: All yachts. Additional requirements for those over 400GT
Annex IV, Sewage: All yachts over 400GT or which carry 15 or more persons
Annex V, Garbage: All yachts. Additional requirements for those over 400GT or carrying ≥ persons
Annex VI, Air: All yachts over 400GT

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships for operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 and updated by amendments over the years.

Similar to SOLAS, the MARPOL Convention came about as a result of a shipping disaster, in this case the Torres Canyon disaster in 1967 in which the oil tanker spiller 120.000 tons of crude into the English Channel after running aground. The convention's requirements set minimum standards for the prevention of pollution of the marine environment in all forms, although the only four that affect yachts are oil (from the engine room), sewage, garbage and air (sulphur and nitrogen oxides from the combustion of fuel oil).

The current version of the convention is still MARPOL 73/78 although changes are regularly made to it by means of Marine Environment Protection Committee circulars from the IMO.

## 3.3. Load Lines

International Convention of Load Lines, 1966, which needs to be complied by all charter yachts in excess of 24 meters of length.

The main objective of the Load Lines convention is to give limits to the draught to which a ship may be loaded, in addition to setting standards for external watertight and weathertight integrity. For example, provisions to prevent water from entering a ship via doors, hatches, air pipes, ventilators, windows, portlights, etc.

The convention contains provisions for determining the freeboard of ships by subdivision and damage stability calculations, the regulations taking into account the potential hazards present in different zones and different seasons (Winter North Atlantic, Summer, Tropical Fresh, etc.).

The load lines which are assigned based on the aforementioned calculations must be marked amidships on each side of the ship, together with the deck line. The marks consist of a circle with a horizontal line just beneath its centre (the Plimsoll Mark) and the permitted draft marks for the various conditions, as shown below.

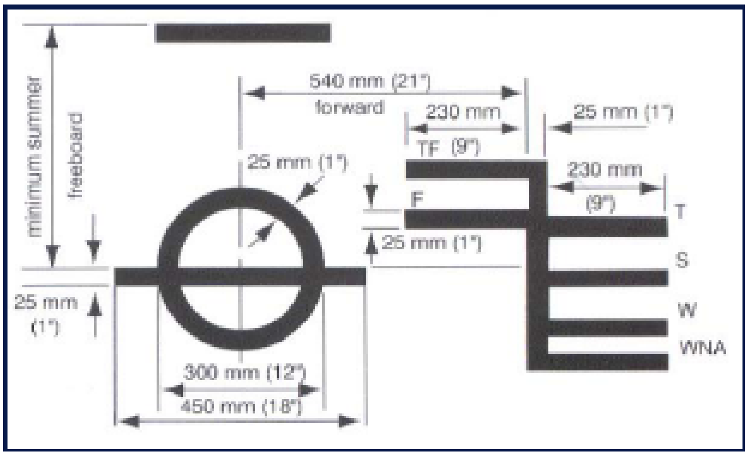


**Figure 9 Plimsoll Mark**

Compliance with the convention's requirements for weathertight integrity is extremely difficult for typical modern large yachts, so, like SOLAS, some countries have included equivalent requirements in their national large yacht codes. These codes have less onerous weathertight integrity requirements, but they are offset by the need to comply with some basic damage stability requirements, which are not required in the Load Lines convention.

## 3.4. STCW

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) applies to all charter yachts.

As the name suggests, the STCW convention, which first entered into force in 1984, sets standards for the training, certification and watchkeeping for seafarers working onboard ships engaged on international voyages. Whilst the correct name of the convention is STCW 78, it is often referred to as STCW 95 to reflect the major amendments that were adopted in 1995 and which entered into force in 1997.

As with the SOLAS and Load Lines conventions, the requirements of STCW 95 have been deemed by some Flag States as too onerous for the officers and crew of charter yachts, particularly with respect to the substantial sea time required to obtain higher levels of certification combined with the constant demand for crew by the large yacht industry. Therefore, yacht qualifications equivalent to those of STCW 95 have been introduced, the most common one well known is the MCA's yacht (Y) qualification. Such qualifications can't be used on merchant ships, but merchant seamen, subject to them having the required level of certification, can work onboard yachts.

Crew with yacht qualifications can only work on yachts up to 3.000GT, above which only crew with full STCW qualifications can work.

## 3.5. COLREGs

International Regulations for Preventing Collisions at Sea, 1972, is applicable to all yachts.

COLREGs' sole objective is to set out the rules of the road for vessels engaged in voyages on the high seas. The current version of the convention entered into force in 1977 and was adopted in 1972. It contains rules for steering and sailing, the conduct of vessels in sight of each other and the conduct of vessels in restricted visibility, which includes prescriptive requirements for the carriage of signs, sounds and shapes. The main addition to the current version of COLREGs is the recognition of traffic separation schemes.

## 3.6. Large commercial yacht codes

The applicability of such codes is to all charter yachts in excess of 24 meters in length.

As already mentioned in this section, some Flag States in the mid-1990's decided to develop equivalent sets of requirements to the major shipping conventions for application to large commercial yachts, i. e. charter yachts, to circumvent the need to comply with prohibitively onerous merchant shipping requirements.

The best known and seemingly most popular of these is the Large Commercial Yacht Code, written, maintained and enforced by the Category 1 Registers of the British Red Ensign Group whose members are the UK (MCA), Bermuda, Cayman Islands, Gibraltar and the Isle of Man. This code is often incorrectly referred to as the MCA Code, largely because the MCA's appears on the front cover, but it is actually the collective work of all the aforementioned British Flag States. Both the original version of this code and its latest revision, LY2, contain equivalent standards to the SOLAS, Load Lines and STCW conventions.

Since the launch of the original British code, and having seen its widespread success all over the world, other Flag States have now developed their own large yacht codes, but all are base closely to the original.

4. National regulations

As mentioned in the previous section, it is a Flag State's responsibility to enforce the international conventions. Additionally, as each Flag State is a governmental body, they also enforce their own national requirements, which are usually published by means of Merchant Shipping Acts, Laws and Regulations.

These requirements apply to ships registered in that country, and some will also be applicable to visiting (foreign) ships. For example, Bermuda's Merchant Shipping Act, 2002, has sections that are applicable to vessels registered in Bermuda and some that are applicable to foreign ships engaged in operations within Bermuda's territorial waters. This section concentrates on the former requirements.

Most contracting governments to the international conventions have a modest set of national requirements, many simply echoing the requirements of the international requirements, whereas others have quite substantial amounts of domestic legislation, such as the MCA and particularly the US Coast Guard.

Whilst national requirements are often the same or very similar to international ones, some can be very different or cover aspects not addressed in the conventions. For example, there are currently no international requirements for the design, construction, certification, manning and operation of submersible craft[1], yet various Flag States, such as Cayman Islands, have very prescriptive requirements for submersible craft operating within the waters of the Cayman Islands, and more importantly for large yachts, for submersible craft operating from yachts and ships registered in the Cayman Islands.

Many companies and individuals in the large yacht industry who have a responsibility or a need to meet any national requirements sometimes do not realize it. It is therefore strongly recommended that copies of the relevant domestic legislation are acquired and read in advance, or the advice of the relevant Flag State is sought directly.

[1] IMO has published its Guidelines for the Design, Construction and Operation of Passenger Submersible Craft, but compliance with them is not mandatory.

5. Port State regulations

As well as regulating the vessels that are registered in its country, a contracting government to the international conventions is also obligated to regulate visiting vessels that are registered in foreign countries. This local regulation of vessels is achieved by means of Port State inspectors, which are carried out by the same surveyors that conduct Flag State inspections or sometimes by dedicated teams of inspectors, depending on the size of the country, port and Flag/Port State organizations.

Charter yachts should be prepared to be visited by Port State inspectors, and in readiness ensure that they continue to comply with the international conventions and also by the crew acquainting themselves with the local laws that are applicable to the waters in which they are operating.

It can be difficult to remain abreast of all the Port State requirements, but most yachts do not visit a vast number of different countries so obtaining a copy of the local legislation should not be a difficult task. Alternatively, the yacht's management company can make enquiries and conduct research on its behalf.

If time is not in abundance, it is strongly recommended that Masters familiarize themselves with at least the following local requirements when entering a new country or port:

- Pollution requirements (oil, garbage and sewage in particular)
- Navigation, especially any deviations from COLREGs (like the reversal in US domestic waters of red and green markers for entering and leaving a navigational channel)
- Ballast requirements
- Anchoring/berthing requirements

## 6. Classification Society rules and regulations

Historically, compliance with the rules and requirements of a Classification Society wasn't mandatory. Back in the early 1800s when Lloyd's Register developed its first rules, ship owners chose to comply with them in the absence of any other rules or standards, to demonstrate to charterers that their vessels were safe and their goods would be in good hands with them for the duration of the voyage.

However, in the more recent versions of SOLAS and in most of the Large Yacht Codes, compliance with the rules and regulations of a recognized classification society has become a necessity. Whilst there are over a hundred Class Societies in the world today, the top three (ABS, DNV and LR) between them class approximately 90% of world shipping.

Whereas the international conventions, SOLAS in particular, set standards of safety in terms if life-saving appliances, fire prevention, detection and extinguishing, stability, etc., class rules are more concerned with the integrity and strength of the hull, machinery, control engineering and electrical arrangements. Most Class Societies have either removed or significantly reduced their rules that relate to life-saving and fire-fighting to minimize the overlap with the conventions.

For a vessel to be 'Classed', it must be designed, constructed, tested, operated and maintained in accordance with class rules and regulations, with a Certificate of Class issued to a new vessel upon completion of its new build surveys. Similarly to the certificates showing compliance with the international requirements, a Certificate of Class is generally valid for five years, and is re-validated each year by means of an annual survey. After five years the certificate is re-issued upon the satisfactorily completion of a very through Special Survey, the extent of which is dependent on the type, material and age of the vessel. Additionally, twice during a five year period a Classed boat must be dry-docked so the shell plating, shafting, propellers and rudders can be closely examined.

Some of the surveys required to maintain the international convention certificates are often carried out by Class surveyors, due to the degree of overlap between the Class and international requirements in areas such as ship construction and weather tightness. However, Flag State inspectors cannot carry out surveys in behalf of Class. The extent to which a Flag State is prepared to delegate surveys to Class depends on the Class Society, the Flag State and, particularly in the case of yachts, the location of the vessel when the survey is due.

Some Class Societies such as RINA have different rules for charter and private yachts.

**Table 5 Compliance Matrix for large yachts**

| | | **Length < 24m** | | **Length ≥ 24m and GT < 500** | | **GT □ 500 but ≤ 3.000** | | **GT □ 3.000** | |
|---|---|---|---|---|---|---|---|---|---|
| | | Private | Charter | Private | Charter | Private | Charter | Private | Charter |
| | COLREGS | Y | Y | Y | Y | Y | Y | Y | Y |
| | Small Yacht Codes[1] | x | Y | x | x | x | x | x | x |
| | Large Yacht Codes[2] | x | x | x | Y | x | Y | x | x |
| | International Convention on Load Lines | x | x | x | Y | x | Y | x | Y |
| MARPOL | Annex I[3] - Oil Pollution | Y | Y | Y | Y | Y | Y | Y | Y |
| MARPOL | Annex IV - Sewage | Y | Y | Y | Y | Y | Y | Y | Y |
| MARPOL | Annex V - Garbage | Y | Y | Y | Y | Y | Y | Y | Y |
| MARPOL | Annex VI - Air Pollution | Y | Y | Y | Y | Y | Y | Y | Y |
| SOLAS | Chapter I - General | x | x | x | x | x | Y | x | Y |
| SOLAS | Chapter II - Construction | x | x | x | x | x | Y | x | Y |
| SOLAS | Chapter III - LSA | x | x | x | x | x | Y | x | Y |
| SOLAS | Chapter IV[4] - Radio | x | x | x | Y | x | Y | x | Y |
| SOLAS | Chapter V[5] - Navigation | Y | Y | Y | Y | Y | Y | Y | Y |
| SOLAS | Chapter IX - ISM Code | x | x | x | x | x | Y | x | Y |
| SOLAS | Chapter XI-1 - Maritime Safety | x | x | x | Y[6] | x | Y | x | Y |
| SOLAS | Chapter XI-2 – ISPS Code | x | x | x | x | x | Y | x | Y |
| | STCW | x | Y | x | Y | x | Y | x | Y |

[1] The MCA's Codes of Practice for the Safety of Small Commercial Vessels and the Marshall Islands' Safety Code of Practice for Small Yachts.
[2] The MCA's Large Commercial Yacht Code (LY2) and the Marshall Islands' Safety Code of Practice for Large Yachts.
[3] MARPOL Annex I applies to all yachts, but only those of 400GT and over need an International Oil Pollution Prevention Certificate.
[4] SOLAS Chapter IV applies to all Charter yachts of 300GT and over.
[5] SOLAS Chapter V applies to all yachts but only Charter yachts of 500GT and over need a Cargo Ship Safety Equipment Certificate.
[6] All yachts of 300GT and upwards are to have a ship identification (IMO) number.
Length refers to Load Line or Registered Length, not Length Overall.
Charter refers to a yacht either actively chartering or registered as commercial vessel.

# Chapter 4: Planning of the maintenance

## 1. General considerations

Chapter 5 will show the scheduled maintenance for most of the machinery on board Lady Allison. Although the manufacturers recommend specific intervals of time or running hours where the tasks need to be due, experience will show that there will be some modifications on the time frames.

A good example of that is the interval of change of oil and oil filter on the main engines. The manuals specify to do this every 250h, but overtime and with the results of the oil samples obtained, is was seen that the oil was still in good conditions and therefore it was changed every 500h.

There are a few modifications to be done, but once the maintenance program is been done, it is easy to then modify time intervals accordingly.

The same with adding extra equipment that needs to be maintained and inspected. Once the proper schedule is set, there is the possibility of adding and/or removing extra equipments or tasks to it. That is why the maintenance program that will be compiled for M/Y Lady Allison is a guide that will set up the basis for the full maintenance, once all the equipment and items have been added to it.

It needs to be mentioned that due to her GT, the ship doesn’t need to comply with most of the rules and regulations, and not being part of any Classification Society, the inspections to be carried out are less.

Although there is no legal obligation, the boat will be on dry dock once a year and several maintenance activities will be carried out during this period. The hull will most likely be painted with new antifouling, for appearance purposes; shafts and propellers will be annually or biannually checked.

## 2. Maintenance status of the yacht

At the moment of organizing the maintenance of Lady Allison, there was no real scheduled plan in place. The maintenance carried out was of a reactive type in most of the equipment.

Only important machinery for the running of the boat has a preventive maintenance, but not even in all tasks to be performed. In the case of main engines and generators, the oil and fuel filters would be changed every specific amount of hours according with manufacturers specifications, but there would be no care for the rest of the maintenance to be carried out.

There is minimum control over what needs to be done and when, leaving the lubrication and cleaning matters to the engineers knowledge and considerations. Few records about repairs and maintenance are kept on board and there is been times were guest trips have had to be cancelled due to problems with the machinery.

This obviously affects the functioning of the whole boat and puts extra pressure on the engineers that need to work extremely careful to make sure the boat can keep up with the busy seasons.

The general status of the engine room is not too great. Previous engineers didn’t take great care of the storage of spare parts and tools in general. There is no organization and no specific place for things. Nuts, bolts and screws can be found in plastic cups or plastic bottles pretty much anywhere. Bilges are only cleaned when on the shipyard and there in no care of pipes with little paint left on them.

The boat is operational but the conditions are not the desirable ones. Therefore it will take a few months before the maintenance plan and its results can be seen.

# 3. How to organize maintenance tasks

When the list of the maintenance intervals has been done in accordance with the manufacturers' specifications, there are different ways of organizing the maintenance program.

Different systems can be used, some are simpler than others and, when possible, the use of new technologies will be of great help. Simple excel sheets can be compiled to help keep track of the running hours of the machinery; boards on a visible area of the engine room are also very helpful when organizing the maintenance; or even computer programs that will specify exactly when next maintenance is due.

## 3.1. Service due board

The generators in particular receive different treatments at different service intervals and should something be changed between service intervals due to a suspected problem then tracking what is due and when it's due can get very messy. If there is more than one engineer on a rotation system like 3 months on and 3 months off, then reviewing the service status of the generators at hand-over time can easily become a major project. The Service Due Board takes care of all this.

It is a whiteboard listing of all the different service items performed on regularly serviced equipment, primarily engines and generators although more items can be added. Running hour intervals are used to indicate when the next tasks are due. The running hours when each item is next due are constantly updated on the board as and when the current task is completed, quite simple.

It is best to keep the board only for the critical items that must be done on the generators and engines. There should be another scheduler or listing in operation for all other tasks. If the board becomes overcrowded it will eventually be ignored.

Having everything together on the one board provides an easily current service status report for these frequently serviced items. It can be viewed at a glance and is so called the 'Quick Glance' Service Due Board.

The board is very simple and easy to keep updated and at hand-over time it is immediately clear to the incoming engineer what the current service status is for the listed equipment.

The following is a board example where only main engines and generators service routines are considered.

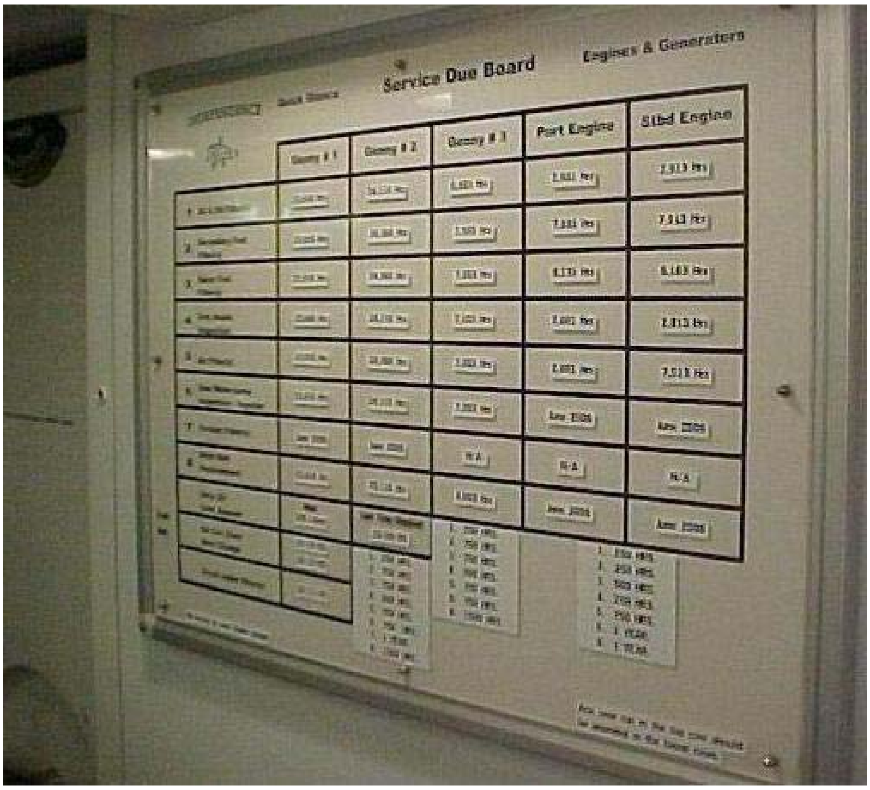


**Figure 10 Service due board view**

Each routine 250Hour service requires different items to be maintained and this board is an easy way to track the items.

The top row lists the equipment in the service cycle. The left hand column lists the different tasks. The running hours between the different tasks are written on the bottom row and can be amended if necessary. The running hours when next due service are written in the boxes.

This board uses labels but a white board and a marker will do the job just as well.

**Figure 11 Another view of the service due board**

Other boats/engineers might prefer to put a bit more of information on the board like the Alfa Laval, air conditioning unit (especially filter changes), watermakers and sea water strainers. Some safety tests can also be added, normally the ones to be carried out every month (crash pump, engine room fire dampers, fire alarm system, bilge and fire alarms).

**Figure 12 Service due board with safety test included**

## 3.2. Checklists

Check lists and to do lists are complementary to the maintenance service due board. All items that need to be serviced can be put on an excel list that the engineers will use to keep track of the maintenance to be done.

There will be general 'check lists for pre departure trips', to make sure all the checks have been done and nothing has been forgotten; this will be used every time there is a guest trip or the boat need to navigate somewhere. Simple things like topping up the day tank, double check oil levels or making sure the Alfa Laval is on will be on this check list.

'To do lists' will help organize the jobs that appear on a day to day basis; there will always be some unexpected reparations that will need to be done, not only on the engine room but on the guest and crew areas too.

'Shipyard lists' will also be compiled and they will generally be quite extensive as all the reparations and services that can be scheduled to be done while on the yard they will be done at the end of the seasons.

Following, some example of the checklists that is used on board:

| | | | |
|---|---|---|---|
| **M/Y Lady Allison** | | | |
| **Date Of First Journey:** | | | **Page:** |
| | | | |
| **Departing Port:** | | | |
| **Arrival Port:** | | | |
| | | **Date** | |
| **Engineering Pre Starts** | **Units** | | |
| | | | |
| **Main Engine PORT** | Hours | | |
| Engine oil level | % | | |
| Coolant level | % | | |
| Gearbox oil level | % | | |
| Shaft header tank level | % | | |
| Thrust bearing header tank | % | | |
| Visual Inspection | Tick if OK | | |
| | | | |
| | | | |
| **Main Engine STB** | Hours | | |
| Engine oil level | % | | |
| Coolant level | % | | |
| Gearbox oil level | % | | |
| Shaft header tank level | % | | |
| Thrust bearing header tank | % | | |
| Visual Inspection | Tick If OK | | |
| | | | |
| | | | |
| **Auxiliary Engine PORT** | Hours | | |
| Oil Level | % | | |
| Water Level | % | | |
| Online/Offline/Stdby | | | |
| Visual Inspection | Tick If OK | | |
| | | | |
| **Auxiliary Engine STB** | Hours | | |
| Oil level | % | | |
| Water Level | % | | |
| Online/Offline/Stdby | | | |
| Visual Inspection | Tick If OK | | |

| | | | |
|---|---|---|---|
| | | | |
| **Initials** | | | |
| | | | |
| | | | |
| | | **Date** | |
| **Engineering Pre Starts** | **Units** | | |
| | | | |
| Steering Gear Oil Level | % | | |
| Bow thruster header tank | % | | |
| Stabilizer header tank | % | | |
| Engine room ventilation | in/out | | |
| Emergency Generator | Tick if OK | | |
| | | | |
| **Day Tank** | Liters | | |
| Fuel Tank 1 PORT | Liters | | |
| Fuel Tank 1 STBD | Liters | | |
| Fuel Tank 2 | Liters | | |
| Fuel Tank 3 PORT | Liters | | |
| Fuel Tank 3 STBD | Liters | | |
| | | | |
| **Total FOB** | Liters | | |
| | | | |
| **Compressed Air** | Bar | | |
| | | | |
| **Alfa Laval Fuel Separator** | on/off | | |
| | | | |
| **Initials** | | | |
| | | | |

**Table 6 Pre departure check list**

### 3.3. Computerized programs and data bases

With the new technologies, engineers have a big advantage at the time of organizing the maintenance plan of a boat. Nowadays there are computer programs that will set up the maintenance schedule automatically and will let know what is due every day, week, month or year.

Although they are of great help, these programs require an incredible amount of work to have them set up. Great amount of time needs to be put on in order to type all the services required for each component. Once that first step is done though, the system will give you all details and information required and even redirects the user to the service manuals that explains the maintenance procedure to be followed.

The most common programmed used on yachts is 'IDEA'. Once the user knows how to navigate through it, the maintenance tasks will be a much easier task. However, it is a very expensive program that requires licenses and renewals every year as well as pay of fees. That is the reason why smaller yachts do not invest on such a program, leaving the engineers with a greater task regarding the organization of services and general maintenance.

One of the chief engineers that worked on Lady Allison spent a few months creating and perfecting a program to organize the maintenance of the boat. It is of simple use and of great help to keep track of the maintenance, reparations and renewals that are done on board, both while the season is on going and on the shipyard periods.

The programmed IDEA has a simple menu system. Each button on the different menus is operated by a single click.

**Figure 13 IDEA main menu screen shoot**

After starting the program the main menu is the first menu to choose from. The options are: technical and inventory database; maintenance; search function; reports and datasheets; utilities; general information; and settings.

IDEA has a reminder form that will notify the users of the due/overdue dates in the database. This way, the engineers only need to take a look at the list to see which items need to be serviced. The jobs shown in this list will be:

- high priority maintenance jobs due that day or the following day
- any overdue reminder entered into the crew and guest database
- expired inventory items
- any document with overdue reminder date

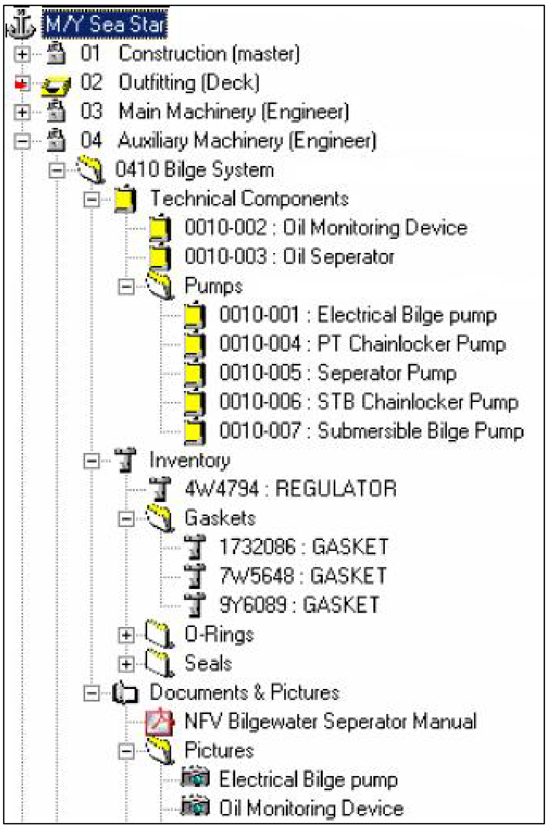

**Figure 14 IDEA technical & inventory database**

The technical and inventory database system inside IDEA is designed to provide quick access to information about onboard systems, equipment and inventory.

Information is divided into domains, which are divided into groups that contain a number of technical components, inventory items and documents (such as photos, user manuals, drawing or schematics).

With IDEA, it is possible to link a photo to each component for easier location and identification.

To make sure all maintenance work is carried out in time, IDEA has a built-in maintenance management system in which it is possible to schedule an unlimited number of regular maintenance jobs for each technical component.

All service and repair work carried out on the selected component can be recorded on the ‘Service History’ tab.

The location of a component can be marked on the system with an indicator on the general arrangement drawing of the vessel. Also a more detailed description of the location can be entered in a text field.

The maintenance management system inside IDEA helps coordinate the various planned and corrective maintenance routines onboard.

The maintenance submenu looks as the following picture:

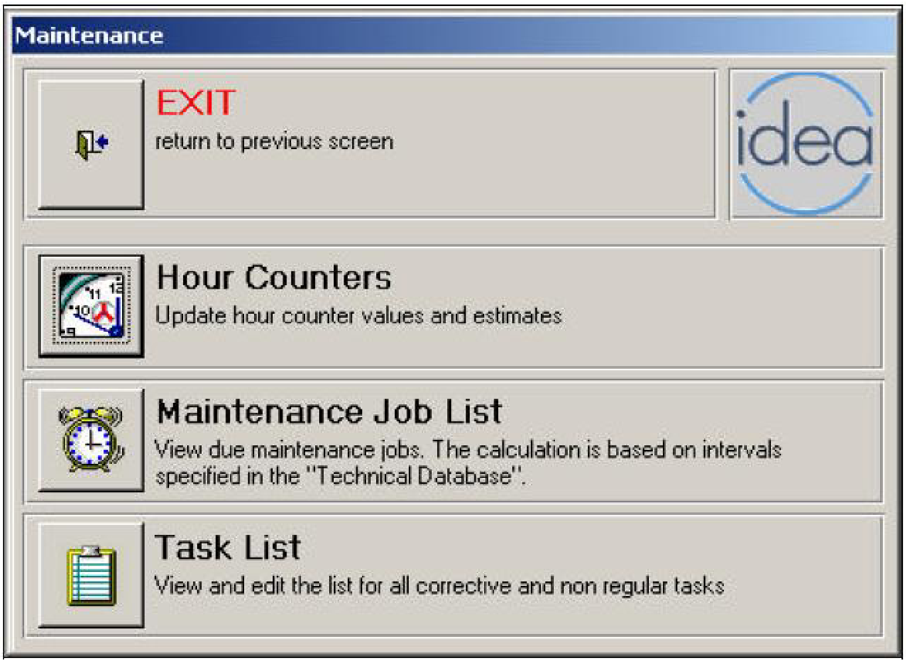


**Figure 15 IDEA maintenance menu**

On this system the hour counters can be updated as well as the estimates. A list of all maintenance tasks programmed in the 'Technical and Inventory Database' due now or during a specified time frame can be viewed or printed. Also a list f all non regular tasks for the maintenance and repair of systems and for the operation of the vessel can be viewed.

All in one, IDEA is a very complete programmed that is of great help regarding maintenance and servicing of the boat's items. It is always good to have some back up plans, should the system failed or the computer stop working. It would be recommended to have a back up copy of IDEA on an external hard drive as well as some complimentary check lists that can be updated and reprinted once a week, once a month or as per the engineers advise.

4. Programmed maintenance

On a yacht, the work revolves around the schedule of the season. Although the engineers are continuously working, when guests are on board it is not possible to do some of the maintenance activities. The maintenance needs to be kept to a minimum, trying not to bother or interrupt the flow of the trip.

Generally, other issues will arise while guest are on board. Interior systems will require some repairs or adjusting, sewage system will have problems due to blocked toilets, watermakers will be fully on operational as there will be a bigger usage of water on board, the boat will constantly be starting and stopping engines as the guest decide to move from one to another anchorage spot or port, TV's and sound systems will also require attention… the list never ends.

That is why most of the maintenance will be scheduled to be done after the seasons, when the boat goes to the shipyard. Everything will need to be fixed in preparation for the new season ahead and the time frame is usually quite tight.

Lady Allison nevertheless, being a private vessel has more flexibility regarding time frames on the yard. The intention is to be finished as soon as possible so that the boat can do the Atlantic Ocean crossing and be ready for the following season. But if major problems occur while on the yard and something requires greater inspection, repair or maintenance, the boat will stay longer on the shipyard and the items will be fixed.

While the season is on going, a few items will surely start failing or giving problems. Temporary repairs will be done when permanent ones aren't possible, too costly or require too much time, and notes will be done on the 'shipyard list' that was mentioned previously on this chapter to fixed such problems.

On the other hand, the monetary allowance of a private yacht is considerably higher than in any other commercial boat. Yachts are a luxury and therefore, owners want to have the very best on board. Unnecessary paint jobs will be done because the boat needs to always look like new, or the owner is simply tired of the superstructure color and wants to do some changes.

Hull will be cleaned once a year if not more often depending on the time frame in between seasons and the state of such. Antifouling will also be re applied as soon as it starts to look a bit deteriorated, even though might still be in good conditions.

All of the above need to be put into consideration when planning the maintenance of a super yacht.

# Chapter 5: Scheduled maintenance

All shipboard equipment for navigation, cargo handling, safety, operation of machinery and prevention of pollution shall be operated and maintained in accordance with the instruction manuals that have to be available on board.

There is a need to ensure that critical equipment is maintained to effect continued safe and pollution-free operation. This will be achieved by planned maintenance in line with the manufacturers' requirements. The Master and the Chief Engineer are responsible for ensuring that all maintenance is performed to meet SOLAS and MARPOL Regulations, using Company approved contractors where necessary.

*Essential items* and *functions* are hull, equipment, systems, components and functions subject to Class or statutory survey that, if not maintained, may result in hazardous situations or accidents.

*Critical items* and *functions* are items and functions where a sudden loss of functional capability or failure to respond when activated, manually or automatically, may create hazardous situations or accidents.

The items defined in the following table are generally identified as critical:

| | |
|---|---|
| Hull | Shell plating, joins, welding seams, hatch closures, ship side/back opening/closures and seals. |
| Navigation equipment | Radar installation, steering gear, engine control equipment, emergency steering, remote stops, emergency and navigation equipment. |
| Safety equipment | Alarm systems, fire fighting equipment, fire pumps, protection suits, extended spindle valves, closure flaps. |
| Communication equipment | Radio equipment, ship's telephone system, distress call receiver, emergency telephone. |
| Machinery | Main engine and controls, auxiliary engines/generators, fuel conditions, bilge pumps, bilge system, emergency generators, switchboard electrical equipment, alarms, bunkering equipment. |
| Refuse/sewage system | Sewage system, sludge system. |

**Table 7 Critical equipment list**

The following list provides an example of which equipment is considered essential and should be attended to regularly according to an inspection and maintenance plan:

| | |
|---|---|
| Hull | Preservation, hatch coamings, seals of doors, flaps and closures on deck (e.g. goosenecks), bilges, bilge covers, sounding pipes, pilot's ports. |
| Navigation equipment | Position finding appliances, automatic pilot, indicating equipment, navigation and signaling lamps, acoustic signaling equipment, batteries, charts, nautical manuals, etc. |
| Cargo-handling gear | Cranes, standing and running gear, bearings, hydraulic systems, winches, etc. |
| Safety equipment | General emergency alarm system, breathing sets, fire party equipment, gas detectors and measuring tubes, lifeboats and life rafts, boat equipment, distress signals, life buoys, life-jackets, thermal protection suits, escape route marking, escape routes and emergency exits, emergency lighting. |
| Communication equipment | Aerials, manuals, signal flags, EPIRB, walkie-talkies, intercom. |
| Steering gear | Rudder angle indicator, rudder blade, rudder head. |
| Anchor and mooring equipment | Anchor, chains, chain markings, capstains, brakes, mooring winches, capstain heads, mooring lines, wire ropes, shackles, line stoppers. |
| Machinery operation | Cooling systems, fuel tanks, lines, pumps and valves, measuring instruments, compressors and compressed air system, drinking-water treatment, stabilizers and batteries. |
| Medical equipment | Medicines, bandages, anesthetics, surgical instruments and appliances, sick bay, etc. |

**Table 8 Essential equipment list**

Before starting with the manufacturers recommendations regarding the maintenance of the equipment on board, there are a couple terms that must be defined.

A component will be *rebuilt* when it can be reconditioned in order to comply with reusability guidelines.
A component will need to be *replaced* when its service life is exhausted. The part may fail before the next maintenance interval and must be replaced with a part that meets functional specifications. The replacement part may be a new part, a remanufactured one, a rebuild part or even a used part.

1. Propulsion system

1.1. Main Engine

Lady Allison has two electronically controlled Detroit Diesel high displacement engines, mechanically actuated unit injector diesel engine. The engines are 4 strokes cycle, with a 60 degree V-16 arrangement, with a bore of 170mm and a stroke of 215mm. The displacement is 58,5 l. The engine is configured for an aftercooling system that is either a separate circuit or jacket water. The engine utilizes a two-piece piston with a forged steel crown and a cast aluminium skirt. Each engine has an output of 694 kW at 1800 RPM.

The electronic unit injector (EUI) eliminates many of the mechanical components of a mechanical unit injector. It also provides increased control of the timing and the fuel ratio control. The timing advance is achieved by the precise control of the injector firing time. Engine rpm is controlled by adjusting the firing duration. A special pulse wheel provides information to the electronic control module for detection of the cylinder position and the engine rpm.

The engine has a built-in diagnostics in order to ensure that all of the components are operation properly. An electronic service tool can be used to read diagnostics.

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| ***Interval: DAYLY*** | |
|---|---|
| *Component* | *Task* |
| Air starting motor | Check lubricator oil level |
| Air tank | Drain moisture and sediments |
| Cooling system | Check coolant level |
| Driven equipment | Inspect, replace and lubricate as needed |
| Engine air cleaner | Inspect service indicator |
| Lubrication system | Check oil filter pressure |
| | Check oil level |
| Fuel system | Check fuel filter pressure |
| | Drain primary filter/water separator |
| | Drain fuel tank water and sediments |
| Instrument panel | Inspect |
| Marine transmission | Check oil level |

| ***Interval: Every 50 Hours*** | |
|---|---|
| *Component* | *Task* |
| Zinc rods | Inspect/replace |

| ***Interval: Every 250 Hours*** | |
|---|---|
| *Component* | *Task* |
| Alternator | Inspect/adjust/replace |
| Cooling system | Test/add coolant additive |
| Hoses and Clamps | Inspect/replace |

| ***Interval: Every 500 Hours*** | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Obtain oil sample |
| | Change oil and oil filter |

| Interval: Every 1000 Hours | |
|---|---|
| *Component* | *Task* |
| Engine | Clean |
| Crankcase | Clean crankcase breather |
| Engine protective devices | Check |
| Fuel system | Clean/replace primary filter |
| | Clean/replace water separator |
| | Replace secondary filter |

| Interval: Every 2000 Hours | |
|---|---|
| *Component* | *Task* |
| Air starting motor | Clean lubricator bowl |
| Crankshaft | Inspect vibration damper |
| Driven equipment | Check |
| Engine mounts | Check |
| Turbocharger | Inspect |

| Interval: Every 3000 Hours or 3 years | |
|---|---|
| *Component* | *Task* |
| Cooling system | Change coolant |
| | Add coolant extender |

| Interval: Every 4000 Hours | |
|---|---|
| *Component* | *Task* |
| Engine valve lash | Adjust |
| Fuel system | Adjust fuel injector |

| *Interval: Every 6000 Hours or 6 years* | |
|---|---|
| *Component* | *Task* |
| Air starting motor | Inspect |
| Cooling system | Change coolant |
| | Replace water temperature regulator |
| Electric starting motor | Inspect |
| Engine speed | Clean/inspect timing sensor |
| Lubrication system | Inspect prelube pump |
| Water system | Inspect water pump |

| *Interval: Between 9000 and 11000 Hours* | |
|---|---|
| *Component* | *Task* |
| Cylinders | Removal/inspection/rework of cylinder head components. |
| Fuel system | Replace unit injectors |
| | Inspect/recondition/replace fuel pressure regulating valve |
| | Inspect/recondition/replace priming pump |
| | Inspect/recondition/replace transfer pump |
| Camshaft and camshaft followers | Inspect/recondition/replace as needed |
| Pushrods | Inspect/recondition/replace as needed |
| Rocker arms | Inspect/recondition/replace as needed |
| Lubrication system | Inspect/recondition/replace oil pump |
| | Inspect/recondition/replace scavenge oil pump |
| | Inspect/recondition/replace prelube pump |
| Exhaust system | Inspect/recondition/replace manifold seals and bellows |
| | Inspect/recondition/replace as needed |
| | Inspect/recondition/replace as needed |
| Turbocharger | Inspect/recondition/replace as needed |
| Cooling system | Inspect aftercooler core |
| Driven equipment | Inspect alignment |
| Engine control module | Inspect |

| ***Interval: Between 9000 and 33000 Hours*** | |
|---|---|
| *Component* | *Task* |
| Major overhaul | Schedule manufacturers inspection and refit |

| ***Interval: When required*** | |
|---|---|
| *Component* | *Task* |
| Batteries | Replace |
| Air system | Clean/replace engine air cleaner element |
| Fuel system | Prime system |

1.2. Gearbox

The gears used in Lady Allison are ZF Marine gears, BW 750 Family. The design engine speed for this gearbox is approximately 1.650 to 2.300 rpm, with a maximum of 3.000N of additional forces on transmission input in radial direction. They have a capacity of 75 liters of oil and the shaft rotates clockwise (when viewed towards transmission input flange).

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| ***Interval: DAYLY when operating*** | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Check oil level |
| | Turning off oil filter handle |
| General | Check/inspect leaks on housing, pipes and connections |

| ***Interval: Every 500 Hours*** | |
|---|---|
| *Component* | *Task* |
| General | Cleaning outside of transmission |
| | Re-tight all bolt connections accessible from the outside |
| Lubrication | Lubricate external moving parts |

| *Interval: Every 1000 Hours* | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Oil change |
| | Clean oil filter |

| *Interval: Every 4000 to 6000 Hours* | |
|---|---|
| *Component* | *Task* |
| Flexible coupling | Visual check |
| Transmission | Visual check of transmission mountings |
| Clutch discs | Visual check |
| Gearing | Visual check |
| Lubrication system | Check oil pump |
| Control unit | Check |
| Actuation unit | Check |
| Cooling system | Clean oil cooler |
| Shaft seal | Check input |

1.3. Generators

Lady Allison has two Northern Lights M6125T turbocharged 1500 RPM marine diesel generator set, with specifications as follows:

| **AC Output** | |
|---|---|
| 1500RPM, 50 Hz | 155kW |
| Phase | 3 |
| Voltages | 110/190, 110/220, 115/230, 120/208, 127/220, 220/380, 240/416 |
| High Output Pleasure Craft (HPPC) | 490HP/2300rpm |
| High Output | 460HP/2300rpm |
| Medium Duty | 425HP/2300rpm |
| Continuous Duty | 325HP/2300rpm |
| | |

| Engine | |
|---|---|
| Aspiration | Turbo |
| Cylinders | Inline 6 |
| Displacement | 11 l |
| Bore | 125mm |
| Stroke | 150mm |
| Crankcase oil capacity | 32 l |
| Freshwater system capacity | 32 l |
| Minimum battery capacity | 200 amp hrs/800cca |
| | |
| **Approximate dry weight:** | |
| Keel cooled, less gear | 1090Kg |
| Heat exchanger cooling, less gear | 1115Kg |
| | |
| **Engine angle** | |
| Engine rotation (facing flywheel) | Counter-clockwise |
| Max. operating angle, any direction | 35º for less than 2 minutes |
| Max. installed operating angle | 10º rear down, 0º front down |

**Table 9 Generator specifications**

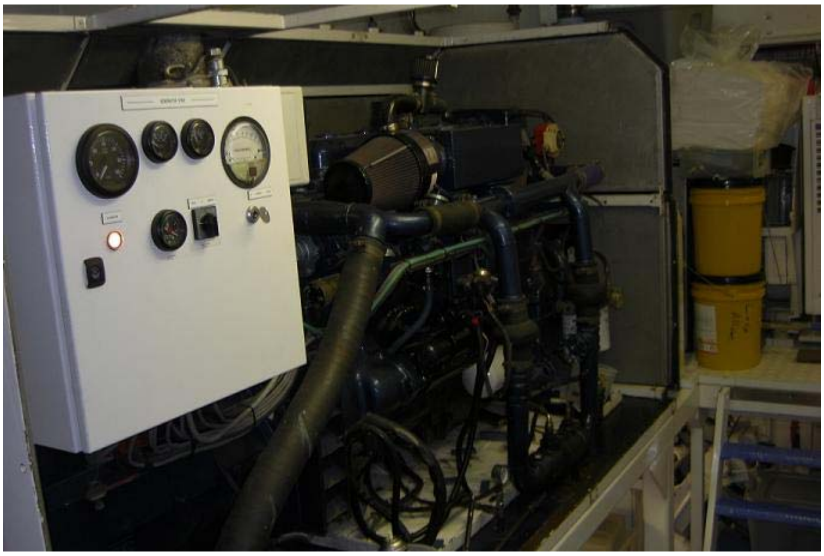

**Figure 16 Starboard side generator, with the protection covers off**

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| *Interval: DAYLY* | |
|---|---|
| *Component* | *Task* |
| Air tank | Drain moisture and sediments |
| Cooling system | Check coolant level |
| Air system | Inspect air cleaner service indicator |
| | Clean air precleaner |
| Lubrication system | Check oil filter pressure |
| | Check oil level |
| Fuel system | Check fuel filter pressure |
| | Drain fuel tank water and sediments |
| Instrument panel | Inspect |
| *Interval: Every 250 Hours* | |
| *Component* | *Task* |
| Alternator | Inspect/adjust/replace alternator and fan belts |
| Cooling system | Test/add coolant additive |
| Lubrication system | Obtain oil sample |
| Hoses and Clamps | Inspect/replace |
| Battery | Check electrolyte level |
| Fan drive | Lubricate bearing |
| Radiator | Clean |

| *Interval: Every 250 Hours* | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Obtain oil sample |
| | Change oil and oil filter |

| *Interval: Every 1000 Hours* | |
|---|---|
| *Component* | *Task* |
| Engine | Clean |
| Crankcase | Clean crankcase breather |
| Engine protective devices | Check |
| Fuel system | Clean/replace primary filter |
| | Replace secondary filter |
| Cooling system | Obtain coolant analysis |

| *Interval: Every 2000 Hours* | |
|---|---|
| *Component* | *Task* |
| Air starting motor | Clean lubricator bowl |
| Crankshaft | Inspect vibration damper |
| Fuel system | Inspect/adjust fuel injector |
| Engine mounts | Check |
| Turbocharger | Inspect |

| *Interval: Every 3000 Hours or 3 years* | |
|---|---|
| *Component* | *Task* |
| Cooling system | Change coolant |
| | Add coolant extender |

| *Interval: Every 6000 Hours or 6 years* | |
|---|---|
| *Component* | *Task* |
| Air starting motor | Inspect |
| Cooling system | Change coolant |
| | Replace water temperature regulator |
| Electric starting motor | Inspect |
| Alternator | Inspect |
| Lubrication system | Inspect prelube pump |
| Water system | Inspect water pump |
| Water system | Inspect water pump |

| *Interval: Between 9000 and 11000 Hours* | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Clean oil suction screen |
| Cylinders | Inspect/rebuild/replace cylinder head assemblies |
| Fuel system | Replace fuel injectors |

| *Interval: Between 18000 and 22000 Hours* | |
|---|---|
| *Component* | *Task* |
| Major overhaul | Schedule manufacturers inspection and refit |

| *Interval: When required* | |
|---|---|
| *Component* | *Task* |
| Batteries | Replace |
| Air system | Clean/replace engine air cleaner element |
| Fuel system | Prime system |

## 1.4. Steering gear

Lady Allison is equipped with and electronic steering gear with the following technical data:

| **Steering pump mod. P89 with tank (emergency)** | |
|---|---|
| Type | axial piston pump |
| Nº of pistons | 7 |
| Capacity | 89 $cm^3$/rev. |
| Operating pressure | 63 bar |
| Fittings | G 3/8" |
| Tank cap | G 3/8" |
| Weight | 9,5 Kg |
| **Hydraulic cylinder mod. MT1600** | |
| Max torque | 1735 Kg |
| Operating pressure | 63 $Kg/cm^2$ |
| Planning pressure | 78 $Kg/cm^2$ |

| | |
|---|---|
| Testing pressure | 118 Kg/cm$^2$ |
| Setting pressure | 78 Kg/cm$^2$ |
| Thrust | 6075 Kg |
| Piston stroke | 400 mm |
| Tiller length | 350 mm |
| Tiller angle | 70º |
| Volume | 3857 cm$^3$ |
| Weight | 78,8 Kg |
| **Electro hydraulic pump type CO354B-380** | |
| Voltage | 380 V AC |
| Power consumption | 9A |
| Setting pressure | 68 Kg/cm$^2$ |
| Delivery | 25,8 l/min |
| Tank | 180 liters |
| **Hydraulic fluid** | |
| Hydraulic oil | ISO VG 46 |
| Viscosity index | 175 |
| Pour point ºF | -1004 |

**Table 10 Steering gear specifications**

The electro-hydraulic power unit is divided into two parts with independent tanks. Each motor-pump is supplied with two electro-valves, one for the auto-pilot and the other one for the electronic steering.

This system allows the selection from different boat controls, in this case left wing, right wing, flybridge or wheel house. It can also be controlled manually from the engine room.

In case failures with the main steering system or the hydraulic pump unit occur during navigation, the boat can be controlled by means of the emergency steering system.

The steering gear system is relatively maintenance free; no time-scheduled service is required. The system should be operated and maintained with the following rules:

| *Interval: Every month* | |
|---|---|
| *Component* | *Task* |
| Emergency steering pump | Test rudder movement using emergency pump |
| | Check communication to bridge |
| | Check change over procedure |
| Hydraulic power pack | Check hydraulic unit for leaks |
| | Check gauges for proper reading |
| | Check/clean return filter |

| *Interval: 500 Hours or 2 years* | |
|---|---|
| *Component* | *Task* |
| Filter | Change filter and fluid |

1.5. Shafts and propellers

The shafts are built with steel C45N with a total length of 12123,6 mm. The propeller shaft is 2997 mm long and the intermediate shaft 1474,75 mm, with and oil bath sterngear.

**Figure 17 Portside propeller off at dry-docking**

The aft and forward seals are Simplex-Compact type SC 2A and SC 2Z respectively.
The Gravity tanks are in the lazaret at floor level on the fwd bulkhead and above each prop shaft. Normally they are kept topped up with (any or the same oil) to maintain pressure on the inside of the aft prop seals (not the aft oil bath seals) thus helping to prevent any ingress of sea water.

The propellers have 5 fixed blades each, with a diameter of 1.500 mm and a pitch of 1.467 mm.

According to the manufacturer's specifications, there is few required maintenance and that is concerning the oil used in the shaft's sealing system.

| *Interval: Every month* | |
|---|---|
| *Component* | *Task* |
| Seals | Check level in header tank |
| | Visual check of inner seal |

| *Interval: 6 months* | |
|---|---|
| *Component* | *Task* |
| Oil | Change oil from seals and tank |


**Figure 18 Shaft oil pump situated in Engine Room**

Other than that, the maintenance regarding the shafts and propellers depends on the boats class. Lady Allison doesn't need to apply with any class society due to her gross tonnage, but every time the boat goes to dry docking it gets checked that the shafts are not bent and that the anti fouling coat on the propellers is still correct. Most likely, it will be repainted every year or two maximum.

Sea water in and out lines will be checked as well as their general external condition.

1.6. Bowthruster

Lady Allison has a Koopnautic VT140 tunnel thruster, consisting of a 4 bladed propeller, a 132kW 3 phase motor coupled to the thruster through a constant velocity coupling and a main control system.

The routine maintenance should be preformed at the intervals specified in the maintenance schedule below as per manufacturer's specifications:

| ***Interval: Every 1 week*** | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Check lube oil level in pod lube oil header tank |
| | Inspect lube oil circuit for leaks |

| ***Interval: Dry-docking/3years/4000hours*** | |
|---|---|
| *Component* | *Task* |
| Major refit | Renew lube oil in pod lube oil header tank |
| Dry-dock | Check back lash and wear conditions of all gear, pinions, keys and shaft |
| | Check corrosion, erosion, pitting, bend defects on blades |
| | Check propeller bush clearances |
| | Check propeller shaft oil pipe for leaks/tightness |

2. Auxiliary systems

2.1. Fuel separator

**Figure 19 Alfa Laval view**

The purpose of a fuel separator, also call Alfa Laval, can be:

- to free a liquid of solid particles
- to separate two mutually insoluble liquids (in this case fuel and water) with different densities, removing any solids at the same time
- to separate and concentrate solid particles from a liquid

The separator used on M/Y Lady Allison is a MAB 104. These are centrifugal separators intended for the removal of impurities from fuel and lubricating oils. The separator must be stopped at regular intervals and the bowl opened for removal of sediment.

**Figure 20 Cleaning of separator bowl**

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| ***Interval: DAYLY*** | |
|---|---|
| *Component* | *Task* |
| Inlet and outlet | Check for leakage |
| Separator bowl | Check for vibration and noise |
| Lubrication system | Check oil level |
| Electrical motor | Check for heat, vibration and noise |

| ***Interval: Every 800 Hours or 1 year*** | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Change oil in gear housing |

| *Interval: Every year* | |
|---|---|
| *Component* | *Task* |
| Inlet and outlet | Clean/inspect threads and connection housing |
| Separator bowl | Clean/check bowl hood and body, discs, distributor, corrosion/erosion, cracks. |
| | Renew o-rings and sealings |
| Worm wheel shaft and gear housing | Check worm wheel and worm and axial play of coupling disc. |
| | Renew oil ingear housing |
| Vertical driving device | Clean/check bowl spindle, buffers, ball bearing housing indentations, radial wobble of bowl spindle. |
| | Renew ball bearings and top bearing spring |
| Brake | Clean/check spring and brake shoe |
| | Renew brake plug |
| Pump | Check/clean bushings, wearing seals, shear pin, coupling and impeller shaft. |
| | Renew lipseal ring |
| Friction coupling | Clean/check friction coupling |
| | Renew friction pads and lipseal ring |
| Frame feet | Renew rubber cushions |
| Electrical motor | Clean/check position of coupling disc |

## 2.2. Fresh water system: watermakers and sterilization system

Lady Allison's watermakers are from the manufacturer HEM, model 'SERIES40HEM' and with a capacity of 4.000-4.500 liters per day, using an osmotic process.

Sea water is taken in by the low-pressure pump set to approx. 3 bar and pushed to the sand filter first and to pre-cleaners second, first 25 micron and then 5 micron. From the high-pressure pump it flows through the membranes where a reverse osmosis occurs.

**Figure 21 Watermaker**

Despite a low Part per Million (PPM) or Total Dissolved Solids (TDS), bacteria can still exist in the water and it is better to install a UV steriliser in the system. Natural sunlight kills off bacteria in water and therefore the use of ultraviolet rays guarantees the destruction of the bacteria inside the sterilisation chamber. All the parts that come into contact with the fluid are made of an ISI 304 stainless steel or quartz glass, with o-ring in Viton tight.

The model used in Lady Allison is suitable for the sterilisation of profiteered water with an iron content of no more than 0,5 PPM and a low content of organic substances. Under these conditions the system is able to guarantee the destruction of 95% of the bacteria, at the nominal capacity.

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| ***Interval: Weekly*** | |
|---|---|
| *Component* | *Task* |
| Sand filter | Counter wash |
| Membranes | Regular check and change when needed |
| Dosing unit | Check chemical tank level |

| ***Interval: Every 6 months*** | |
|---|---|
| *Component* | *Task* |
| Dosing unit | Check pump functioning |
| | Clean valves and filter |
| Sanitation system | Check/change germicidal lamps |
| | Clean protective quartz |

| *Interval: General* | |
|---|---|
| *Component* | *Task* |
| Fresh water tanks | Internal inspection and cleaning of tanks |
| Sand filter | Change after min 5 years |

## 2.3. Sewage system

Lady Allison has a Hamann sewage treatment plant, vacuum pumps, automatic pumps, dry running protection pump and submersible electrical pump. The vacuum pumps are from the brand Jets, model 25 MB A and with a capacity of 26 $m^3$/h.

Jets Vacuum systems use differential air pressure (vacuum) for transport of the sewage from the toilets to the sewage treatment plant (STP).

The water from sinks, washing machines, showers, etc. is transported to the grey water tank, equipped with a level switch and the ED-valve (electronic discharge). The valve is activated by the water level inside the tank.

The discharge pump is a small system-integrated, non clogging centrifugal pump. It is designed for discharging sewage from the sewage treatment plant.

| | |
|---|---|
| Pump | Herbomer 4/HK 50-F |
| Electric engine | AEG AM 100 LS 2 |
| Material pump housing | Cast iron |
| Material pump impeller | Cast iron |
| Material pump shaft | Stainless steel 1,4571 |
| Connection inlet | DN 50, PN 10 |
| Connection outlet | DN 50, PN 10 |
| Total weight | 49 Kg |

**Table 11 Discharge pump technical data**

The sewage treatment plant on board Lady Allison is a Hamann HL-CONT, $1m^3$/Mini L-Frame. The power of the plant is 1,7 kW, with and organic loading of 18 Kg/day of Biochemical Oxygen Demand (BOD).

The components of the plant are a mix/draining pump ($1,5m^3$ 0,75 kW), macerator (0,55 kW), dosing pump (0,02 kW) and dry run protection pump (0,31 kW).

According to the manufacturer's recommendations, the maintenance schedule would be as follows:

| ***Interval: Every day*** | |
|---|---|
| *Component* | *Task* |
| Vacuum unit | Check supply of sealing liquid |
| | Clean hose/nozzle If required |
| | Clean main connection pipe for pressure switches by letting in air |
| | Clean function preset switches |
| ***Interval: Every week*** | |
| *Component* | *Task* |
| Dry running protection pump | Check/clean strainer |
| | Check non return valve |

| ***Interval: Every month*** | |
|---|---|
| *Component* | *Task* |
| Dry running protection pump | Check inlet constaflow |
| | Check/clean non-return valve |
| Dosing pump | Check dosing valve and foot valve |
| Vacuum unit | Reset pressure switches (if needed) |
| | Clean level switches |

| *Interval: Every 3 months* | |
|---|---|
| *Component* | *Task* |
| Dosing pump | Check diaphragm for damage |
| | Check discharge and suction valves |
| | Check chemical seepage at vent hole |
| | Check that discharge tubing is connected firmly to liquid end |
| | Check that liquid end is generally watertight |
| | Check for correct feed |
| | Check electrical connections |
| | Check that liquid and screws are fastened tightly |

| *Interval: Every 6 months* | |
|---|---|
| *Component* | *Task* |
| Suction line | Check aeration hole |
| Tank | Check inside tank coating for damages |

| *Interval: Every 2 years/6000hours* | |
|---|---|
| *Component* | *Task* |
| Vacuum unit | Replace shaft seal Vacuumarator |
| | Change bearing on electro motors |

| *Interval: Every 3 years* | |
|---|---|
| *Component* | *Task* |
| Toilets | Replace rubber membranes |

## 2.4. Stabilizers

The stabilizers on Lady Allison are VK3537 Series 2 Koopnautic Samos. Their installation comprises the following:

- Control System
- 2 Hydraulic Piston pumps / 200L Oil Reservoir
- Two Fin and two Top Plate Assemblies

According to the manufacturer's manuals, the maintenance schedule would be as follows:

| ***Interval: DAYLY*** | |
|---|---|
| *Component* | *Task* |
| Hydraulic system | Check for leaks |

| ***Interval: Every month*** | |
|---|---|
| *Component* | *Task* |
| Hydraulic system | Inspect flexible hoses (replace if necessary) |
| Sea water system | Check sealing arrangements |

| ***Interval: Every 8 months*** | |
|---|---|
| *Component* | *Task* |
| Control panels | Check/visually examine control panels |
| Starting system | Check/visually examine motor starters |

| ***Interval: Every 1 year*** | |
|---|---|
| *Component* | *Task* |
| Oil system | Clean/examine oil cooler waterways |
| General | Renew pressure filter elements |
| | Renew return filter element |

| Interval: Every 2 years | |
|---|---|
| *Component* | *Task* |
| Hydraulic system | Renew oil and flush hydraulic system |
| | Clean/examine hydraulic tank |
| Fins | Check fin/stock coupling arrangements (DOCKING) |
| ***Interval: Every 4 years*** | |
| *Component* | *Task* |
| Hydraulic system | Recondition hydraulic actuators |
| Plates | Recondition top plates (DOCKING) |

## 2.5. Emergency generator

The emergency generator on board is a diesel Northern Lights M984K with 36kW of power.

According to the manufacturer's manuals, the maintenance schedule would be as follows, always bearing in mind that being an emergency generator the use will be minimum and all maintenance should be performed once a year even if the hour level has not been reached:

| Interval: DAILY | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Check oil level |
| Fuel system | Check primary fuel filter |
| Cooling system | Check cooling water level. |
| | Check sea strainer |

| Interval: Every 50 hours | |
|---|---|
| *Component* | *Task* |
| V-belt | Check V-belt tension |
| Battery | Check electrolyte level in batteries |

| *Interval: Every 200 hours* | |
|---|---|
| *Component* | *Task* |
| Lubrication system | Change engine oil |
| | Change lube oil filter |
| Fuel system | Change primary fuel filter element |
| | Change secondary fuel filter |
| Air system | Check air cleaner |
| Electrodes | Check zinc electrodes |

| *Interval: Every 200 hours* | |
|---|---|
| *Component* | *Task* |
| Valves | Check valve clearances |
| Fuel system | Check injectors |
| Cooling system | Check and flush cooling system |
| Impeller | Change impeller |
| Battery | Check state of charge of batteries |

| *Interval: Every 2400 hours* | |
|---|---|
| *Component* | *Task* |
| Fuel system | Check fuel injection pump |
| Cooling system | Check/clean heat exchanger |

## 2.6. Sea water cooling system


**Figure 22 View of both high and low sea chest**

Special care has to be taken to the sea water pumps and the sea chest suction filters due to their constant contact with sea water which is extremely corrosive.

As follows, the minimum checks that should be done to this elements:

| ***Interval: Every 1 month*** | |
|---|---|
| *Component* | *Task* |
| Sea pumps | Check abnormal noise and vibrations |
| | Check for leaks |
| | Check gauges |
| Sea chests suction filters | Secure suction filter |
| | Depressurize filter and drain sea water |
| | Clean inside/outside filter |

## 2.7. Cathodic protection

Cathodic protection is one of the most effective ways of reducing or eliminating the corrosion damage that inevitably affects metals (iron in particular) that are in permanent contact with sea water or other liquids. Paint provides only limited protection over time for ship’s hulls. This means effective cathodic protection system must be implemented using sacrificial anodes, impressed currents, or systems combining both.

Anodes are expected to last approximately 1.5 years. A Cathelco system normally has two anodes, one to prevent corrosion in the pipe work (TC - Trap Corrosion) and one to prevent marine growth in the pipe work (MG - Marine Growth). MG anodes are made from copper. Depending on the metal type used on the raw water pipe work the TC anode can be either aluminium (for predominately steel pipes) or cast iron (FE) for copper, nickel or aluminium brass pipes. Lady Allison uses Aluminium and Copper anodes.

One of each type of anode is fitted in each main sea chest. They are supplied stack mounted with the aluminium one mounted above the copper one. This stacking arrangement has the Cathelco term of 'Super Plenty Anode'.

There is not much maintenance needed on this system, although it is very important for a good functioning of the boat. The anodes should be checked every year when dry docking and changed if there is less than 50% left. The current consumption also needs to be checked every week.

Lady Allison has a total number of 42 zincs on her hull of different types. The main zincs are of type Zimar CL-18, with 9 of these zincs per side. The bowthruster tunnel, stabilizers and rudders have type Zimar Z-4, with 6 of these per side. There also are 8 engine cowl zincs and bowthruster mounting bracket and nose cone zincs.


**Figure 23 View of Cathelco display panel showing the light in "Normal" conditions**

## 2.8. Air conditioning system

The installed system on board is a Condaria FB-225, ambient terminal unit type (fan-coil), with a supply of treated fresh air. The external air, after being treated by the air handling unit, is conveyed to the cabins by means of galvanized sheet ductwork.

The media (water) chilled or heated by the chiller or electric boiler, located into the Engine Room, will be distributed to the various utilizers by means of copper and plastic pipes.

The system is completed by an air exhauster system. The exhausters, made for a continuous service, are sized in such a way to allow alight overpressure in the air conditioned spaces, in order to avoid the external air to get in.

The system has a nominal cooling capacity of 360.000Kcal/h and 110kW of power.

According to the manuals maintenance, the schedule would be as follows:

| ***Interval: Every 2 weeks*** | |
|---|---|
| *Component* | *Task* |
| Condenser | Check/replace zinc anodes |
| Air handling unit | Clean/replace air filter |
| | Check condensate water |
| Exhausters | Check/clean fan impeller |
| Fan coils | Check/clean air filters |

| ***Interval: Every 1 month*** | |
|---|---|
| *Component* | *Task* |
| Water chiller | Visual inspection of working pressure |
| Heater | Visual inspection |
| Air handling unit | Check belts/pulleys. Regulate belt tension if required |
| Exhausters | Check belts/pulleys. Regulate belt tension if required |

| ***Interval: Every 3 months*** | |
|---|---|
| *Component* | *Task* |
| Water chiller | Check refrigerant humidity (R22) |
| Condenser | Visual inspection of any corrosion of pipes/cover plate |
| Air handling unit | Check amperage |
| Exhausters | Check amperage |

| *Interval: Every 6 months* | |
|---|---|
| *Component* | *Task* |
| Sea water pumps | Leak control and change seal/gasket if required |
| | Clean impeller |
| Condenser | Clean inside of pipes under cover plate |
| Compressors | Check oil level |
| | Check for leaks |
| Heater | Check safety valve |
| | Check thermostat |
| Air handling unit | Valve working control |

| *Interval: Every 6 months* | |
|---|---|
| *Component* | *Task* |
| Air handling unit | Check/clean coil |

## 2.9. Pumps

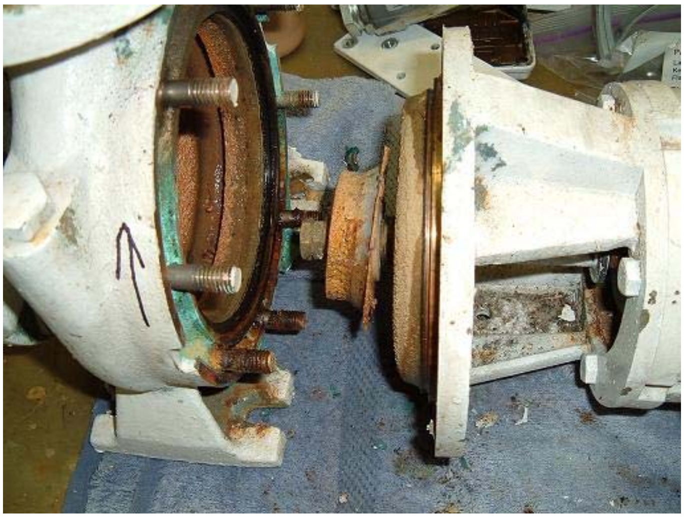

**Figure 24 Strip down and overhaul of a pump unit**

The following maintenance schedule is for all pumps on board, from lube oil, sea water, fresh water, fuel oil, fire and bilge pumps. This is the minimum requirements regarding maintenance, but some of the pumps will also have specific inspections to be done.

| *Interval: DAILY* | |
|---|---|
| *Component* | *Task* |
| Pump | Check suction/discharge pressure |
| | Check seals for leaks |
| | Check coupling condition |
| | Check for vibration/noise |

| *Interval: Every week* | |
|---|---|
| *Component* | *Task* |
| Pump | Grease bearing chamber |
| | Change defective pressure gauges |
| | Check electrical connections for tightness |

| *Interval: Every 5000 hours* | |
|---|---|
| *Component* | *Task* |
| Pumps | Strip down and overhaul pump unit |

## 3. Pollution control

### 3.1. Oil water separator

The oily-water separator system on board of M/Y Lady Allison is a DVZ system, prototype tested acc. IMO-Resolution A 393/X, maximum oil content less than 5 ppm in overboard discharge water.

The **DVZ-VC-"OILMASTER"** is a combined gravity coalescence oil separator to avoid unnecessary mechanical emulsions the oil separation pump draws mixture from the bilge or bilge water tanks through the oil separator.

According to the manufacturer's manuals, the maintenance needs to be carried out as per the following table:

| ***Interval: Every 1 month*** | |
|---|---|
| *Component* | *Task* |
| Air pipes | Drain water out |
| Transfer pump | Check stuffing bush |
| Filter | Clean filters and non return valves |
| Suction pipes | Check stuffing bushes from manifolds |
| Alarm | Clean glass tube of 15ppm alarm |

| ***Interval: Every 1 year*** | |
|---|---|
| *Component* | *Task* |
| Transfer pump | Check/change stuffing bush |
| Valves | Dismantle all valves, clean and change o-rings and seals if needed |
| | Check safety valves |
| | Dismantle/clean all non return valves |
| General | Check/tight screws/bolts |
| Alarm | Check/change sample pipe to 15ppm alarm |

| ***Interval: Every 2 years*** | |
|---|---|
| *Component* | *Task* |
| General | Dismantling of dome cover and inside inspection |
| Coalescence | Remove and clean with compressed water |
| Seals | Renew dome cover seal and other flange packing |
| Sensing electrode | Function check and niveau relay |
| Transfer pump | Check/renew pump stator |

## 3.2. Fire fighting and life saving equipment

All equipment on board, survival at sea and fire fighting, applies with the legislation and complies with the amendment version of the STCW95'.

Lady Allison has life rings, life jackets, immersion suits, EPIRBs, grab bags and liferafts. Its maintenance will be carried out as per the regulations require and will normally happened while the boat is on the shipyard.

There are two bilge-fire fighting pumps on board of 30 kW each, capable of pumping 3.600 litres in 30 minutes (120 L/min) at a pressure of 123 bar.

In case of a fire, there are smoke and heat detectors around the boat that will make the alarm panel on the bridge go off. The engine room has both heat and smoke detectors while on the other accommodations are only heat detectors. There also are Break Glass systems around the boat that will set off the fire alarm when broken.

Figure 25 View of CO2 bottle at Engine Room entrance

The engine room and the galley have a CO2 system installed which is MCA and Lloyds approved.

The boat has 20 fire extinguishers situated in various locations, from the type 1, 2 and 3. The crew is trained to use them properly and periodically drills are done on board, to make sure everything will go smoothly in case of an emergency.

| *Interval: WEEKLY* | |
|---|---|
| *Component* | *Task* |
| Lifeboat davits and winches | Lubricate davits and winches |
| | Check davit limit switches |
| Emergency fire pump | Start and run pump for at least 5 minutes |
| | Check fuel tank (must be full) |
| Engine room fire flaps | Test all fire flaps |
| Emergency generator | Start and run pump for at least 5 minutes |
| | Check fuel tank (must be full) |

| *Interval: Every month* | |
|---|---|
| *Component* | *Task* |
| Lifejackets | Check they are in good condition |
| Fire flaps and dampers | Check/operate all |
| Fire extinguishers | Check they are in good condition/correct pressure |
| Emergency alarms/sirens | Check proper operation |
| Multi-gas detectors | Leak test |

| *Interval: Every 3 months* | |
|---|---|
| *Component* | *Task* |
| Emergency lighting | Check/replace accommodation and engine room emergency lighting |
| Fire hose boxes | Check they content correct equipment. |
| Emergency stops | All remote controls to be tested |
| Fire detecting equipment | Test detector heads for correct operation |
| Fresh air breathing apparatus | Check condition face mask and head straps |
| | Check pump operation |
| | Check condition of safety and signaling tally plate |
| Fire extinguishers | Check they are all In position |
| | Dry powder extinguishers, remove caps, invert and shake powder loose. |
| | Check/weigh all CO2 discharge cartridges |
| | Check condition of contents of foam extinguishers |

| ***Interval: Every 6 months*** | |
|---|---|
| *Component* | *Task* |
| Life rafts | Inspect/renew lashings |
| | Manually operate hydrostatic releases |
| Lifeboat | Inspect/repair hull for damage and chafing |
| | Inspect/renew all wire and rope |
| | Check lockers for water tightness |
| Distress signals | Inspect for condition |
| Pyrotechnics | Check details for renewal |
| Life buoys | Inspect/replace for damage/deterioration |
| | Re-mark with ships name when necessary |
| | Check self-igniting lights and buoyant lines |
| | Check Man Overboard life buoys are free to operate |
| Fire doors | Lubricate hinges, check correct operation |
| Fixed CO2 system | Inspect cylinders, pipework, wires and pulls |
| | Verify cylinders are securely clamped |
| | Check cylinders levels |
| CO2 fire extinguishers | Check discharge hoses for signs of perishing |
| | Ensure discharge horns are fitted correctly |
| | Change cylinders if weight is less than 90% |

| ***Interval: Every 1 year*** | |
|---|---|
| *Component* | *Task* |
| Life raft | Required to be landed for servicing |
| Pyrotechnics | Check condition, correct number held and all in date |
| Fire extinguishers | Pressure test max every 4 years |
| Oxygen breathing cylinders | Test hydraulically pressure at no more than every 5 years |

3.3. Portable fire/bilge pump

Lady Allison has a Lombardini 6LD435/V emergency fire pump, with a maximum flow of 120 Gallons per minute and a maximum lift of 18 feet. It comes with two 2” suction and discharge port sizes and a silicon carbide seal.

According to manufacturer’s specifications, the maintenance to be carried out is as follows:

| ***Interval: Every 10 Hours*** | |
|---|---|
| *Component* | *Task* |
| Air cleaner | Clean oil-bath air cleaner |
| | Check/replace oil level on air cleaner |
| Lubrication system | Check crankcase oil level |

| ***Interval: Every 50 Hours*** | |
|---|---|
| *Component* | *Task* |
| Battery | Check fluid level |

| ***Interval: Every 250 Hours*** | |
|---|---|
| *Component* | *Task* |
| Pump | Clean feed pump filter |
| Engine | Check valve rocker arm clearance |
| Oil system | Replace crankcase oil |
| | Replace oil filter cartridge |
| Fuel system | Replace fuel filter cartridge |

| ***Interval: Every 500 Hours*** | |
|---|---|
| *Component* | *Task* |
| Injection system | Clean injectors |
| | Check injector setting |

| *Interval: Every 1000 Hours* | |
|---|---|
| *Component* | *Task* |
| Fuel system | Clean fuel tank |

| *Interval: Every 2500 Hours* | |
|---|---|
| *Component* | *Task* |
| Overhaul inspection | Check cylinders, piston rings, guides, springs, grinding valve seats, de-carboning heads and cylinders, check injector pump, check injectors. |

### 3.4. Tanks

Fresh water tanks should be inspected on every dry-docking. The tanks will be drained, the manhole cover removed and the internal surfaces will be wiped and cleaned. They need to be inspected for any rust or scale deposits. The relief valve to be tested and the manhole cover join needs to be renewed.

Fuel and ballast tanks will be visually inspected externally. Any defective lagging needs to be fixed. That will be done every 6 months.

## 4. Deck equipment

### 4.1. Cranes

The boat has 2 cranes on the boat deck in order to bring the tenders to the water. They can also be used for general purposes of lifting anything into the boat.

Figure 26 View of port side crane cable after replacement

Basic but very important maintenance need to be done on the cranes, especially because during the season they are used constantly to pick up and drop the tenders while guest are on board so they need to be ready for frequent use.

Maintenance schedule would be as follows:

| *Interval: Every month* | |
|---|---|
| *Component* | *Task* |
| Lubrication | Grease crane internally |
| Switches | Test limit switches and emergency stops |
| Oil system | Check all oil levels |

| *Interval: Every 3 months* | |
|---|---|
| *Component* | *Task* |
| Hydraulic system | Change filters if needed |
| General | Check tightness in all screws and holding down bolts |
| Electrical | Check all electrical connections |
| | Inspect/clean main contractors and contacts |
| Motor | Check condition of rubber mountings |
| | Grease main motor bearings |

| *Interval: Every 1 year* | |
|---|---|
| *Component* | *Task* |
| Gearbox | Change gearbox oil |
| Oil system | Change hydraulic oil |
| Electrical | Check limit switches and main connections |
| | Check all terminal and junction boxes are sealed properly |
| Cable drum | Open/inspect/clean cable drum sliprings |

| *Interval: Every 2 years* | |
|---|---|
| *Component* | *Task* |
| Accumulates | Change pressure accumulates |

4.2. Winches

Minimum maintenance needs to be carried out for the winches on board to ensure their proper functioning and the safety of the crew using them.

| *Interval: Every 250 hours* | |
|---|---|
| *Component* | *Task* |
| Bearings | Grease wires and nipple points |
| Clutches | Inspect claw clutches and operating levers |
| Piping | Check pipes and joints for leakage |
| Gears | Grease and inspect for wear |

| *Interval: Every 1 year* | |
|---|---|
| *Component* | *Task* |
| Lubrication | Remove all old grease and renew |
| General | Check tightness of foundation bolts |

## 4.3. Windlass

The Anchor Windlass is a Steen. The start current is 147.5A and the low speed current is 37.5 with a high speed current of 11.4A. The Motor has an electro magnetic brake attached to the bottom end.


**Figure 27 View inside the windlass with the wheel gear arrowed**

The gear box has several gears, one of which, the Worm Wheel Gear, is bronze and appears to act as the sacrificial gear. The motor is vertical and drives the vertical Worm Wheel Shaft which drives the Worm Wheel Gear. The Worm Wheel Gear is in two parts bolted together as an assembly which is fixed to the Spur Wheel Shaft thus providing horizontal drive to the rest of the windlass. The two parts of the Worm Wheel Gear are the steel centre hub and the outer bronze Worm Wheel Gear.

Maintenance to be carried out as follows:

| *Interval: Every 250 hours* | |
|---|---|
| *Component* | *Task* |
| Bearings | Grease wires and nipple points |
| Clutches | Inspect claw clutches and operating levers |
| Piping | Check pipes and joints for leakage |
| Gears | Grease and inspect for wear |
| Pins | Check proper functioning of pins and guillotines |
| Brake | Inspect brake lining. Grease threaded parts of brake control |

| *Interval: Every 1 year* | |
|---|---|
| *Component* | *Task* |
| Lubrication | Remove all old grease and renew |
| General | Check tightness of foundation bolts |
| Brake | Check brake lining for oil, grease and dirt |

| *Interval: Every 200 anchorings or 2 years* | |
|---|---|
| *Component* | *Task* |
| Oil system | Change oil |

### 4.4. Anchor and chain locker

Lady Allison has two anchors with a weight of 180Kg each. The chains have a pass of 64mm and a diameter of 16mm.

This link is made up of 3 pieces, the main loop or ring is 2 pieces and the centre piece is the third. The 2 pieces making up the ring look like two letter 'J's' and when joined together form an oval ring. The long legs of each 'J' have a squared female groove at the top and the short legs have a squared male flair. With the slots and the flairs located the two halves can be slid together. This connection of the flairs in the slots gives the completed ring its pulling strength. The centre piece also has a wide connecting slot on both of its connecting sides where it locates and slides into the centre of the ring from the front and thus prevents the two 'J' pieces from sliding apart. This centre piece itself is prevented from sliding out by two pins inserted from either side and in turn the two pins are held in place by filling the end of the pin holes with lead. How well these pins are fitted determines the overall security of this joining link.

Another type consisting of 2 pieces is like two letter 'Us' laid on top of each other to form an oval loop type link. Each 'U' has pins on one straight leg and holes on the other and when laid on top of each other to form the loop the pins of one piece fit through the holes of the other. Once fitted together the pins should be securely riveted or better still, welded.

Maintenance schedule for the chain and the anchors would be as follows:

| ***Interval: Every 250 hours*** | |
|---|---|
| *Component* | *Task* |
| Sea water valves | Inspect for ease of operation of anchor chain washing |
| Anchor | Visual examine for deficiencies |
| Chain | Check shackles and connecting pins |
| Lubrication | Grease pins |

| ***Interval: Every 1 year*** | |
|---|---|
| *Component* | *Task* |
| Chain lockers | Inspect and house interior |
| | Wire brush corroded areas, patch prime and repaint |
| Chain | Wire brush and paint were needed |
| | Inspect bitter ends |

4.5. Capstans

The capstans are Steen, Type 59.46-6. They are designed to run in one direction and have a built-in ratchet which will be destroyed if the motor direction is ever reversed.

The top bearing should always be a sealed bearing to ensure longer life. A new lip seal must always be installed with a new sealed bearing.


**Figure 28 View of port side stern capstan**

As follows, the little scheduled maintenance needed to be performed on the capstans:

| ***Interval: Every 200 maneuvers or 2 years*** | |
|---|---|
| *Component* | *Task* |
| Oil system | Change oil |

| ***Interval: Every 5 to  years*** | |
|---|---|
| *Component* | *Task* |
| Grease | Renew grease on warping head of bearing |

# Chapter 6: Spare parts and inventories

## 1. Spare parts

A spare part, service part, or spare, is an item of inventory that is used for the repair or replacement of failed parts.

A yacht is continuously moving from one location to another. Sometimes it will be crossing oceans and days away from land. Therefore, the importance of having a minimum amount of spare parts on board, should something go wrong while the boat is ongoing, at least temporary repairs can be done to get to the nearest port.

All boats need to have critical spare parts on board to prevent the ship from being immobilized or its operations stopped due the lack of important spare parts.

These critical spare parts shall include parts for the main and auxiliary engines and other critical auxiliary machinery. For example, the starting air compressor, the steering gear pump, etc.

Reconditioned spare parts can also be used to lower the cost of the spare part whilst maintaining the operational level and the safety of operation. In many cases it is possible to recondition damaged spare parts at a much lower cost than new spare parts. To ensure safety, the quality of the reconditioned spare parts shall be equal to that of new spare parts.

According to IACS[1], there are minimum recommended spare parts to be carried on board for main and auxiliary engines as well as essential auxiliary machinery[2]. Following, the lists of these minimum recommended spare parts:

[1] International Association of Classification Societies
[2] Recommendations No. 26, 27, 28, 29 and 30 of IACS.

| *Main internal combustion engines* | |
|---|---|
| *Item* | *Spare parts* |
| Main bearings | Main bearings, or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts |
| Cylinder | Cylinder liner, complete with joint rings and gaskets |
| Cylinder cover | Cylinder cover, complete with valves, joint rings and gaskets. For engines without covers, the respective valves |
| | Cylinder cover bolts and nuts, for one cylinder |
| Cylinder valves | Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder |
| | Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder |
| | Starting air valve, complete with casings, seats, springs and other fittings |
| | Cylinder overpressure sentinel valve, complete |
| | Fuel valves of each size and type fitted, complete with all fittings, for one engine |
| Connecting rod bearings | Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder |
| | Top end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder |
| Pistons | Piston of each type fitted, complete with skirt, rings, studs, nuts, gudgeon pin and connecting rod |
| Piston rings | Piston rings for one cylinder |
| Piston cooling | Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit |
| Cylinder lubricators | Lubricator, complete, of the largest size, with its chain drive or gear wheels |
| Fuel injection pumps | Fuel pump complete or, when replacement at sea is practicable, a complete set of working parts for one pump |
| Fuel injection piping | High pressure fuel pipe of each size and shape fitted, compete with couplings |

| | |
|---|---|
| Scavenge blowers (including turbochargers) | Rotors, rotor shafts, bearings, nozzle rings and gear wheels or equivalent working parts in other types |
| Scavenging system | Suction and delivery valves for one pump of each type fitted |
| Reduction and/or reverse gear | Complete bearing brush, of each size fitted in the gear case assembly |
| | Roller of ball race, of each size fitted in the gear case assembly |
| Main engine driven air compressor | Piston rings of each size fitted |
| | Suction and delivery valves complete of each size fitted |

The availability of other spare parts, such as gears and chains for the camshaft drive, should be specially considered and decided upon by the engineers. When the spares are recommended, it is assumed that the crew has onboard the necessary tools and equipment.

When the recommended spares are utilized, replacement spares are to be supplied as soon as possible. In case of multi-engine installations, the minimum recommended spares are only necessary for one engine.

| ***Auxiliary internal combustion engines*** | |
|---|---|
| *Item* | *Spare parts* |
| Main bearings | Main bearings, or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts |
| Cylinder valves | Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder |
| | Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder |
| | Starting air valve, complete with casings, seats, springs and other fittings |
| | Cylinder overpressure sentinel valve, complete |
| | Fuel valves of each size and type fitted, complete with all fittings, for one engine |

| | |
|---|---|
| Connecting rod bearings | Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder |
| | Top end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder |
| Piston rings | Piston rings for one cylinder |
| Piston cooling | Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit |
| Fuel injection pumps | Fuel pump complete or, when replacement at sea is practicable, a complete set of working parts for one pump |
| Fuel injection piping | High pressure fuel pipe of each size and shape fitted, compete with couplings |
| Gaskets and packings | Special gaskets and packings of each size and type fitted, for cylinder covers and cylinder liners |

2. Inventories

As important as having a minimum amount of spare parts is, even more important is to have a proper inventory system in place. If spare parts are everywhere, how can the engineer find the one he requires?

On Lady Allison, an inventory system is been put in place. It is a slow process that requires patience and time, but if done properly, it only needs to be done once and the system will be useful for many years to come. Remember that the information provided by the system is only as good as the information entered on it; time and care must be taken to do a thoroughly good job.

The aims to an inventory system are:

- To provide info per part to the user in words and pictures, equivalent to the user having the part in their hand.
- Ensure that all parts are easily identifiable. Be able top pick up any part and find a "spare part number" on it that will take the user back to where it belongs via the system.

- Ensure that parts can be where the system says they are.

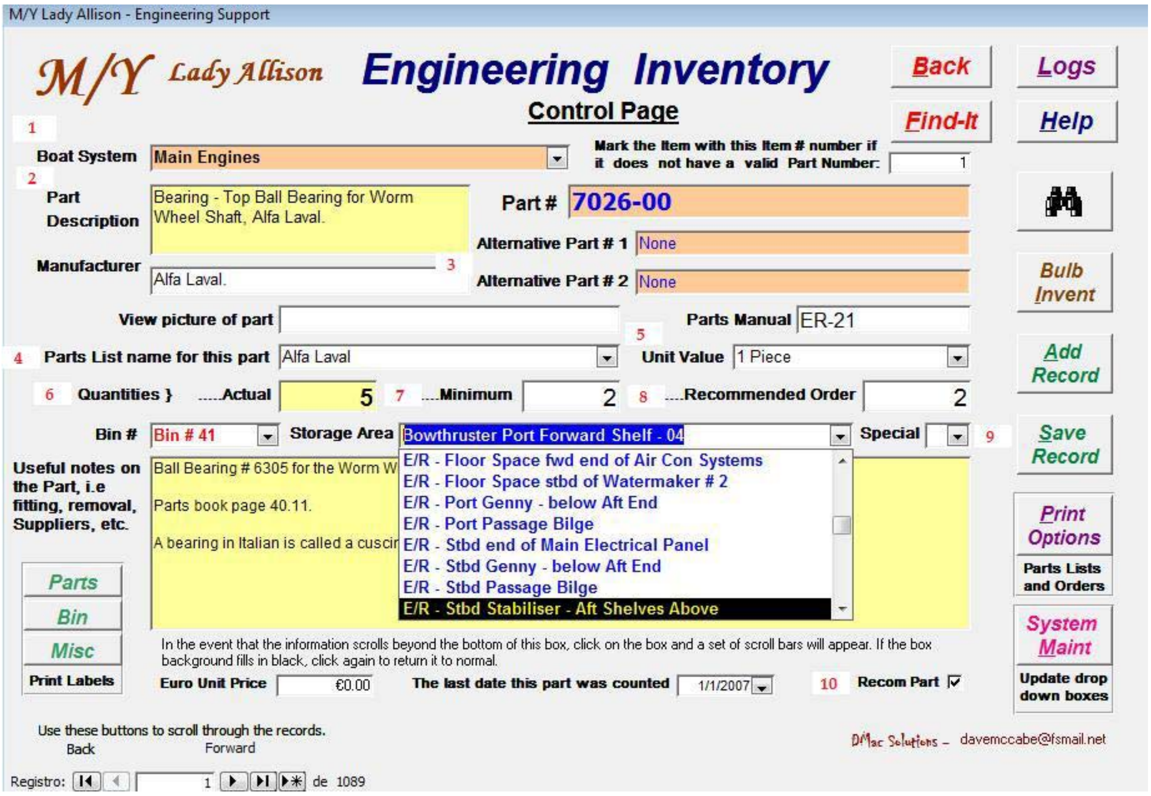

**Figure 29 Lady Allison's view of inventory system**

Above, there is a view of the inventory system used on board Lady Allison. It is a simple program that, if used properly, is of great help finding spare parts on board. Some field explanations as follows:

1- BOAT SYSTEM: The Boat System field provides another search area to help in finding a part when using the computer program. If the user is not sure of the part description or the part number but he/she knows it is a Watermaker part, then it is possible to search this field under Watermaker.

2- DESCRIPTION: The amount of information on a normal sized printed list will never equal the amount of information on the Inventory Control Page. However, careful structure of information when completing fields like Description can optimize the printed list's information. With the Description Field the first word to enter is the name of what the item is: O-ring, Motor, Washer, Gasket, etc. then follow with a description of what the part is for. In this way the printed parts lists will have all the same items listed together, making them easy to find on a long list and the reader will know what they are used on just one field. Example: a raw water pump for the Generator # 2 would be entered as 'Pump – Raw Water Pump for Genny # 2'.

3- ALTERNATIVE PART #'S: Some items can be sourced from other makers. The Alternative Part # field allows the recording of such other numbers.

4- PART LIST NAME: It is not practical to have too many printed lists or orders. That is why 12 part lists/orders that can be printed have been pre-set. This field needs to be used to choose which of the 12 lists the user would like the part to appear on, e.g. Engine parts on the Engine List.

The pre-set lists are: A/C-Fridge/Freezer/Icemaker; Alfa Laval; Domestic Appliance; Electrical/Electronic; Evac Toilet – Sewage; Generators; Main Engine & Drive; Misc Pumps; Miscellaneous; Racor Filters; Tools & Test Equipment; Watermaker/Fresh water.

5- UNIT VALUE: The Unit Value field provides the means for the user to know the smallest amount or quantity that the listed part is held in.

6- ACTUAL QTY: This is the quantity that exists on the boat. Keeping an accurate record of this quantity is important regardless of which Inventory system is used. When using a computer system it is generally easier to carry a specific note book for recording daily information that can then be entered into the computer at one time at the end of the day.

7- MINIMUM QTY: This is the quantity value that the user would prefer never to fall below. The figure for this quantity is based on experience. This quantity generally remains constant and possible only for a long passage it may be preferred to carry more. The program uses this quantity to compare with the Actual Qty and to flag the fact that the actual stock quantity is getting low. This quantity mustn't be set to less than 1 unless the user no longer wishes the part to be ordered, in which case can be set to zero.

8- RECOMMENDED ORDER QTY: This is the quantity that would normally be ordered if the Actual Qty should fall below the Minimum. This quantity generally remains constant and possible only for a long passage it may be preferred to order more. Deciding on the value of this quantity when the part is first entered into the stock saves wrestling with it every time an order needs to be placed. This is the order quantity that will be automatically printed on the Recommended Order. Not to be confused with the recommended parts mentioned below.

9- SPECIAL: This is a Special Parts List option. Place an X in this field for each part the user wished to appear on the Special Parts List, e.g. a list of parts only used on Genny 2. The X's must be erased after printing the list in preparation should the user need another list of different parts.

10- RECOMMENDED PARTS: Parts which the manufacturer recommends that should be stocked. Ideally the majority of stocked parts should be manufacturer recommended.

### 2.1. Bins: locations or storage areas

For spare parts in many boats 'Locations' or 'Storage Areas' are generally odd areas of the boat left empty by others because the access is difficult. Sometimes a larger area may be made available. Either way, the space awarded to the storage of spare parts rarely changes from the day the boat is first launched.

On boats it seems that the general dogma infers that the system for spare parts control is to have all items for one system in the same bin or set of bins with a big label on the bin or bins – 'Engine Parts'. Dare an 'Air Con' part to find its way into one of these bins then it will be lost and gone for ever.

With this system, an individual looking for an engine spare part will rummage around known storage areas for the bin marked 'Engine Parts'. Then the rummaging will continue through the bin until, hopefully, the part is found. Such rummaging generally includes the opening of protective wrappings to expose the naked part. The wrappings are never replaced as new with the result that after several such rummaging excursions expensive parts are no longer protected and worse still, the parts required may never have been in the bin to start with.

Lists are usually made to help in the search but they are more general only breaking down the heading of 'Engine Parts' into individual items they seldom tie a particular part to a particular bin.

With lists and the multiple languages found in the boat business the descriptions end up being vague, and due to the time involved in producing a new list the listed quantities are invariably out of step with the actual quantities.

The best two ways to number bins are either straight (1, 2, 3,…) or preceded with the location initials, like BTR 1 for Bowthruster Room 1.

It is not necessary to have all the parts for one system in the same box and generally they don't all fit in the one box. With a proper parts system, before going to any bin you should know:

- The description of the part you want.
- The part's number.
- The bin number it is in - and if it is a subdivided bag, the bag number within the bin.
- The location on board where the bin should be.

## 2.2. Inventory rules

### General

Always use a Key word for the start of the Description field, e.g. a door lock is not a door but a lock. By doing this it ensures that on a printed list all 'locks' will appear together under 'L' making it easier to work from a printed list in the event that it should be necessary.

Don't short-cut the system by having one page for two or three items. For example, if there is an item X which comes in three sizes, Large, Medium and Small don't use the Quantity field for the 6 large and then use the Notes field to state that there are also 5 medium and 4 small. This defeats the automatic ordering and the printed lists. Items in the Notes field are read only for the user; the system does not see them.

Don't write too much or it will not fit on the Label. Additional info can be put in the Notes field. The Description field is the size it is to help prevent overspill on the label.

**Parts Labels**

Don’t print labels before you are sure that the bin # has not already been used and that the bin will fit in the chosen location.

Try to put everything in a ziploc bag and use two labels – one on the item inside the bag and one on the outside of the bag. The more labels the more secure the system is.

**Bagging Parts**

Avoid having loose parts scattered in a bin.  Keep the same parts together in a bag. If they have sharp corners that can tear a bag tape up the sharp areas before putting them in the bag. If there are many of the same parts use small bags to group them in twos or threes then place the smaller bags in a larger bag marked – bin #. Make sure that all bags used have a label on them.

It is also very important to not overload bags, as they will break and all the parts will end up loose in the bin. That would defeat the purpose of the inventory system.

3. Pictures


To return to the Parts Form, click on the 'Back' button on the far left of the Menu Bar above, if there is one? otherwise click on the 'X' Close button to the right, above.

Item 1 - Part # 337

Item 2 - Part # 446

The view shows the different amount of Offset in the hinge. Number one is approximately 45* and number two is about 20*.

**Figure 30 Example of picture kept on the inventory system**

On the inventory system there is the option of adding pictures to the spare parts to facilitate the user the search of items. It helps on the process of finding what the used is looking for.

Pictures should have names indicating what they are. They should also have the part # on them so that a lost and found picture can be put back where it belongs.

It is important to use a good background and to get as many sides in. There is no need for pictures of common items like nuts and bolts. It is also important to give an idea of the size; thus can be done placing a measuring tape next to the part.

Do not take a picture of the part in a bag unless it is very clear; it wouldn't be of any help when looking at it.

Adding sizes, light pipe diameters, length, O-ring diameters and thickness, is extremely useful to stop rummaging. The user must know for sure that what he is going for is the right thing.

## 4. Procedures for a Rummage Free Inventory System

After the inventory system and its benefits have been explained, it would be of no use if it is not kept in good conditions. It is of a high importance to try and keep rummage out of the inventory. Unnecessary visits to parts bins because the system failed to provide enough information on a desired part is not acceptable.

### Storage Areas and Bins

It is important to keep the Bin # sequence as straight as possible. The following questions should be made before making a decision on where the bin is going to be stored.

Which Storage Area – is it named and is the name in the system?

Which Bin # – will it fit in the storage area selected above?

Figure 31 View of how a bin should be packed and marked

Once both the Bin # and the Storage Area are agreed and both are in the system, the Bin is labeled x 4 with Number and Storage Area. Clean the bin area for the label, stick it on the bin squarely and press it on securely; it is important to make sure the labels won't fall off with time as that will make the inventory system less efficient.

**Parts, Part Numbers – ID's**

Select the parts that will be in the Bin. Look for the part # somewhere on each part. It must be the number that the part is most likely known by. If there is no clue to the part #, use the model number or name.

Figure 32 Parts labeled and ready to be stored in a bin

If there is absolutely no form of ID and inquires have been made without success, then a computer generated number must be used. Mark it in the notes field that this is a temporary computer number. It is important that this part also has a clear picture.

TIP: for finding parts in the system, a) search with the part #, if no Finds, b) search the description. If a part with the same name is been found, hopefully there is a good clear picture to identify it or very good notes in the 'Notes' field.

If the same name items have no picture and no good notes then the user's last option, which amounts to a system failure, is to go to the Bin and rummage in the parts to see if the part is really the same.

This highlights the need for standardization in descriptions, using the same words with correct spellings for all similar parts. Standardization is best for most field, brief entries using the 'Notes' field for the longer detailed explanation. Remember, rummage is failure.

**Enter the data on the system**

Before entering any data, user needs to search the Part # field for the part in case there is already one of the same.

When the part is in the users hand and getting prepared, enter the Description (brief), the Notes (as much as you like) and maybe include a picture. Exact sizes, lengths, widths, diameters, capacities, volumes, temperatures, rotation direction, thread sizes, voltages, watts, amps, RPM, HZ, # of contacts, materials, color, wiring diagrams and more, depending on the item, must be added on the Notes to facilitate the search of items in the future.

If the part is a common everyday part like a Nut, Bolt, Bearing, etc where all that is needed are the sizes then a picture or a parts book reference is not needed. If the part is not so common and there is no reference to a parts book page showing a picture of the part, then a good picture is necessary.

One other exception to a picture is if the part has a common name and can only be used in one place like a main engine piston.

**Package the part – Bags & Labels.**

Now all pervious listed have been binned and all that are left are first time listings. Sort out the small parts for sub division bags

Every single part, big or small, needs to be put into at least one bag. If the part is already in a box or well packaged one bag will do. If the part is loose then two bags will be needed. If the part is loose and has sharp edges then three bags and maybe four will be needed.

**Figure 33 Example of proper wrapping of items**

It is important to never put more than one label on one bag.

The parts have to be protected and they should be as well wrapped as items for the postal service, they will probably have to endure a harsher environment on the boat than with the postal service. With good part #'s, good pictures and good notes the parts should never be opened unless they are going to be used. If not properly packaged the bags will tear, get lost and the system will again become like the older parts today.

# Chapter 7: Conclusions

After the writing of this thesis, it comes to light how dynamic a maintenance plan is. It will constantly be submitted to changes. Tasks will be added, removed, or even modified. It is continuously evolving thanks to the experience of its users.

A good maintenance plan is extremely important on board a yacht, as well as any other boat. It brings the amount of unexpected repairs to a minimum and when the yacht finds herself far from land, engineers do not want to have any surprises. Having a broken engine in the middle of the Atlantic Ocean could be a major problem. A good maintenance schedule is not only important to make the daily work go easier, but is also a question of safety for both the boat and the crew.

With my personal experience I have noticed that when jobs are properly scheduled, less equipment will break down unexpectedly. That has a direct positive influence on the atmosphere of the engine room. Engineers have a better planning and the psychological impact of this can be noticed; better work conditions, happier crew, more efficiency and desire of improvement of oneself performance.

It is clearly easier to work when the tasks are programmed, especially when the yacht has a busy season with many trips and little time in the port. Having the maintenance up to date will avoid repairs that could compromise the ship's trips, with the economic lost that this could represent; many yachts are charter and make their profits when they sail.

Although there will be some differences between the manufacturer's recommendations and the real needs of the machinery, once the maintenance system is in place, it is easy to change the intervals on which to perform the tasks. Only with the experience of the engineers, will the system be modified to the real needs of the yacht; this will be made over time.

Setting up a proper maintenance program is a long and hard task that required many hours of organization and planning. But once this has been done, the benefits can be seen in a short period of time.

On the other hand, it will always be better from the economic point of view if the maintenance is up to date. Preventive maintenance will reduce the costs enormously and that has been noticed after implementing the system on board Lady Allison.

Lastly, there is no good maintenance if a proper inventory system is not in place; they are both linked to each other. And if the inventory system needs to be helpful, then special care needs to be taken when creating such. It can be a task even harder than organizing the maintenance schedule. But yet again, the more time it gets invested on implementing the system, the easier will be for the engineers to do their job satisfactorily.

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# Figures Appendix

*Figure* *Page*

# Tables' Appendix