# A limited RCM analysis of the hydraulic emergency system to an OC-L crane at the jack-up rig Linus

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# Preface

This thesis is a part of the Ocean Technology Bachelor program at the Western Norway University of Applied Sciences (HVL) in Bergen, Norway. The thesis is written in collaboration with Odfjell Technology at Kokstadflaten, Bergen.

The maritime industry is a fast-growing industry that continuously develops and requires new technology. It is a complex and demanding industry and plays a vital role for Norway, and globally. Despite its importance, the maritime industry faces numerous challenges, including overcapacity, competition and being able to adopt and develop sustainable practices.

A special thank you to Lars Garen and Alexander Hatland for providing us with all documents needed and guidance. Hatland and Garen have shared knowledge and experience that have provided a perspective on the industry. We appreciate the trust from Garen and Hatland to write for Odfjell Technology, as well as being our supervisors. We are grateful for the opportunity to join the office at Odfjell Technology at Kokstadflaten for six months and ask necessary questions, meet the rest of the team, and being offered jobs after finished bachelor's degree.

We would also like to thank our supervisor, Professor Maneesh Singh, for the academic guidance making us successful to write this Bachelor thesis, with thorough explanation regarding Reliability Centered Maintenance (RCM).

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Western Norway University of Applied Sciences

odfjell technology

# Abstract

Odfjell Technology has recently taken over the management at the jack-up rig, Linus. There is a need to review and improve maintenance programs to secure safe and cost-effective procedures. The most important aspect is safety. By having an updated and detailed maintenance plan, the occurrence of accidents and injuries will be minimized for the employees at the jack-up rig.

The project will focus on offshore crane operations regarding the jack-up rig, Linus, which utilizes Offshore Cargo Lattice Boom (OC-L) cranes. As cranes are exceedingly involved in the daily activity and operation on the jack-up rig, it is vital that the cranes perform as desired. The consequence of the cranes being inoperable will result in downtime, financial losses and safety risk.

The project will include:

- An example of a way to systemize a hierarchy that is made up from tags provided by Odfjell Technology.
- A limited RCM analysis for a specific system that will identify failure modes (FM) from ISO14224:2016 for the critical items in the given system.
- Identify and compare Odfjell Technology's current maintenance procedures to the maintenance plan from the RCM analysis. The analysis follows recommendations from standards such as Det Norske Veritas (DNV), Norwegian Socket Competitive Position (NORSOK), National Oilwell Varco (NOV), and Norwegian Maritime Authority (NMA). All of the above is based on applicable rules and regulations from Petroleum Safety Authority (PSA).

# Sammendrag

Odfjell Technology har nylig overtatt driften av jack-up riggen Linus. Det er behov for å gjennomgå og forbedre vedlikeholdsprogram for å sikre trygge og kostnadseffektive prosedyrer. Det viktigste aspektet er sikkerhet. Ved å ha en oppdatert og detaljert vedlikeholdsplan vil forekomsten av ulykker og skader bli minimalisert for de ansatte på jack-up riggen.

Prosjektet har fokusert på offshore kranoperasjoner knyttet til jack-up riggen Linus, som benytter Offshore Cargo Lattice Boom (OC-L) kraner. Ettersom kraner spiller en svært viktig rolle i daglig aktivitet og drift på jack-up-riggen, er det avgjørende at kranene fungerer som ønsket. Konsekvensen av at kranene ikke er operative vil føre til nedetid og økonomiske tap.

Prosjektet inneholder:

- Ett eksempel på en måte å systematisere et hierarki, basert på tags som ble levert av Odfjell Technology.
- En begrenset RCM-analyse for et spesifikt system som identifiserer feilmoduser (FM) i samsvar med ISO14224:2016 for de kritiske delene i det gitte systemet.
- Identifikasjon og sammenligning av Odfjell Technologys nåværende vedlikeholds prosedyrer med vedlikeholdsplanen fra RCM-analysen. Analysen følger anbefalinger fra standarder som Det Norske Veritas (DNV), Norsk Sokkel Konkurranseposisjon (NORSOK), National Oilwell Varco (NOV) og Sjøfartsdirektoratet. Alt dette er basert på krav fra Petroleumstilsynet.

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# 1. Introduction

This chapter provides an overview of the thesis, encompassing relevant background information, present the authors, as well as elucidating the overarching aim and scope of the analysis. Additionally, limitations that may constrain the scope, as well as any pertinent abbreviations and definitions will be clarified.

## 1.1 About the authors

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## 1.2 Odfjell Technology

Odfjell Drilling was in 2021 divided into two companies: Odfjell Drilling and Odfjell Technology. The last mentioned consist of three divisions: Odfjell Well Services (OWS), Project and Engineering (P&E), and Operation. With more than 50 years of experience in the industry, Odfjell Technology has become an integrated supplier of offshore operations, well services technology and engineering solutions. With the aim of delivering safe, efficient, and sustainable operations and in addition reducing time, cost, and carbon emissions [1].

## 1.3 Background

Linus is a jack-up rig constructed at Jurong Shipyard in Singapore and was delivered in 2014 to the company Seadrill [2]. The rig has operated on the Norwegian Continental Shelf since 2014, drilling and completing production and injection wells [2]. The jack-up rig has been owned and driven by Seadrill until 2022, as Odfjell Drilling took over the management.

Linus uses and operates three OC3550L deck cranes, produced by NOV [2]. This type of crane participates in the OC-L series. NOV describes the OC-L series cranes as “your partner for a lifetime of lifting” [3] and states that “The OC-L series offers some of the of the safest, most precise cranes on the market today. The cranes state-of–the art technology makes them market leaders when it comes to reliability” [3].

Many deficiencies have been found that are associated with maintenance at Linus. A new set of maintenance procedures will be sat for the jack-up rig Linus, by Odfjell Technology. Odfjell Technology has asked for an assignment with a development of a technical hierarchy for the items of the OC3550L Starboard (STBD) crane, along with an RCM analysis based on qualitative data for a specific system at the OC-L crane. For this to profit Odfjell Technology, will the results be compared to Odfjell Technology’s current maintenance plan. This will help the company get an overview of the maintenance plan according to law regulations.


*Figure 1 - Linus, Reference: Alexander Hatland*

Linus has a “sister rig” called Elara. Elara was managed by Seadrill, as well as Linus. The two jack-ups have had the same maintenance management. Petroleum Safety Authority (PSA) has previously done audit on Elara. The reason for this audit was to make sure that Seadrill complies with the regulations, for example regarding maintenance procedures with respect to environment and safety. The results from the audit can be assumed to be identical to what PSA would report on Linus as the two jack-ups follow the same maintenance program and were owned by the same company. As Odfjell technology has taken over the management at Linus this would give an indication of what to include in the computerized maintenance management program.

After PSA audit at Elara, PSA published an official report that includes where Elara deviates from law regulations, specific within maintenance and maintenance program. The points where Elara did not meet the PSA requirements and regulations are listed below.

- Every facility, system and equipment have a tag number. The reason for this to make safe operations and proper maintenance according to that. The tag number should then be found in the control system. The number should be easy to find and have no wearing or dirt. The facilities regulation § 72 *Marking of equipment and cargo* says that: Cargo and equipment that is transported or used for transport to or from facilities or vessels that participate in the petroleum activities shall be clearly marked with the name of the owner, facility or vessel [4].
- In the activity regulation *§46 Classification* is it stated that equipment must be classified with regard to the health, environmental and safety consequences of potential function failures […] [5]. This process is used to find where PM is needed for the components due to criticality within safety, environment, and economy.
- The activity regulation *§30 Safety-clearance of activities* says that planned activities shall be cleared as regards safety before they are carried out [6]. As well as *§11 Basis for making decisions and decision criteria* from PSA management regulations says that before decisions are made, the responsible party shall ensure that issues relating to health, safety and the environment have been comprehensively and adequately considered [7].
- The responsible party shall ensure that facilities or parts thereof are maintained, so that they can carry out their required functions in all phases of their lifetime is stated in the activity regulation *§45 Maintenance* [8].
- An overall plan shall be prepared for conducting the maintenance program and corrective maintenance activities [9]. This is important to maintain acceptable risk within safety for the workers as well as the other employees at the location, environment, and cost. It is legislated in the activity regulation § 48 Planning and prioritization.
- Failure modes that may constitute a health, safety or environment risk shall be systematically prevented through a maintenance program in the activity regulation *§ 47 Maintenance program* is it specified that the program also shall include activities for monitoring performance and technical condition, identification and correction of failure modes that are under development or have occurred and activities for monitoring and control of failure mechanisms that can lead to such failure modes [10].
- The maintenance effectiveness shall be systematically evaluated based on registered performance and technical condition data for facilities or parts thereof. The evaluation shall be used for continuous improvement of the maintenance program [11]. This benefits the company in the category’s safety, environment and cost since the maintenance plan is optimized as new information is available.

## 1.4 Aim of the project

The aim of the project is to make a systemized technical hierarchy for the tags from the NOV OC3500L Crane and perform a limited RCM analysis for its hydraulic emergency system. The RCM results, combined with maintenance demands, will be compared to Odfjell Technology's current maintenance plan for OC-L cranes.

## 1.5 Scope

The scope of the project is to develop a limited RCM analysis for the cranes hydraulic emergency system at the jack-up rig Linus. The analysis is conducted by following the applicable demands and standards used for offshore cranes and maintenance. The critical item selection will focus on the consequence of safety for personnel, economic cost, and environmental costs.

RCM results will be compared to Odfjell Technology's existing procedures. PSA activity regulation and framework regulation is referred, to substantiate the RCM process to in the analysis. These regulations are also a part of what PSA examines when inspecting a rig.

## 1.6 Limitations

The hierarchy is limited to the tags of the OC35000L crane provided by Odfjell Technology. The RCM analysis is limited to the hydraulic emergency drive system (figure 10) of the crane described in the background. Due to lack of documentation of previous maintenance procedures and failure data for each item at the crane, the assignment is based on law regulations, standards, and qualitative data. The report will not present a plan for corrective maintenance (CM), calculation of mean time to failure (MTTF), mean time between failure (MTBF) or work description.

## 1.7 Structure

The thesis is divided into 7 chapters and 2 appendixes. Under is an overview of the chapters and their containment.

- Chapter 1 – The introduction introduces the assignment and the background with a brief description of RCM, background information about Odfjell Technology, scope, limitations, structure, abbreviations, and definitions.
- Chapter 2 – The theory chapter presents the crane and its build-up, development of a technical hierarchy, RCM bullet points as FFA, critical item selection FMECA, maintenance actions and intervals. This is to ensure reliability and validity for the analysis.
- Chapter 3 – Methodology includes how the analysis is carried out, including the applied methods and tools. This is also where the philosophical groundwork for the research is explained.
- Chapter 4 – Definition of the system, development of tags, tag number build-up and technical hierarchy. Also, result from RCM analysis is presented, including FMECA.
- Chapter 5 – The result from chapter 4 is compared to Odfjell Technology's current maintenance procedures.
- Chapter 6 – Discussion chapter where key points in the analysis are discussed.
- Chapter 7 – Conclusion.

In the end of the assignment, the two appendixes are listed:

1. Pipe and instrumentation diagram (P&ID) of the hydraulic system, with and without categorization.
2. Technical hierarchy, tag catalogue, FMECA, Route example, and PoF/CoF (Probability of Failure/Consequence of Failure) matrix from Professor Maneesh Singh.

## 1.8 Abbreviations

- CM Corrective Maintenance
- CMMS Company Maintenance Management System
- CoF Consequence of Failure
- DNV Det Norske Veritas
- FFA Function Failure Analysis
- FM Failure mode
- FMECA Failure mode, effects, and criticality analysis
- FSI Functional Significant Items
- IEC International Electrotechnical Commission
- ISO International Organization for Standardization
- MCSI Maintenance Cost Significant Items
- MF Main function
- MLC – control Audit for working and living conditions.
- MOU Mobile offshore unit
- MSI Maintenance Significant Items
- MTTF Mean Time To Failure
- MTBF Mean Time Between Failure
- NMA Norwegian Maritime Authority
- NORSOK Norwegian Socket Competitive Position
- NOV National Oilwell Varco
- OC-L Offshore cargo (handling), lattice boom
- OEM Original equipment manufacturer
- P&ID Piping and Instrumentation diagram
- PMS Planned Maintenance Service
- PM Preventive Maintenance
- PoF Probability of Failure
- PSA Petroleum Safety Authority
- RCM Reliability Centered Maintenance
- SF Sub-function
- SFI Senter for Forskningsdrevet Innovasjon (Norwegian Ship Research Institute)
- STBD Starboard side
- VGS Videregående skole (High school)

## 1.9 Definitions

| | |
|---|---|
| Analysis item | Analysis items are the lowest part of the RCM hierarchy and is an item that can perform at least one significant function, such as pumps, valves, etc. [11] page 83. |
| CM | Maintenance carried out after fault detection to affect restoration [12] page 4. |
| Criticality | Numerical index of the severity of a failure or a fault combined with the probability or frequency of its occurrence [13] page 10. |
| Demands | Applicable recommendations from DNV, NMA, and NOV, additional to applicable rules from PSA, will be referred to as demands. Maintenance demands is activities that are expected to be done in the given interval. |
| Dummy tag | Items that are not seen in the P&ID but have an important function. For example, a bolt. |
| Equipment class | Class of similar type of equipment units (e.g., all pumps) [14] page 5. |
| Equipment type | Particular feature of the design which is significantly different from the other design(s) within the same equipment class [14] page 5. |
| Equipment unit | Specific equipment within an equipment class as defined by its boundary [14] page 5. |
| Failure cause | Set of circumstances that leads to failure [14] page 6. |
| Failure mechanism | Process that leads to failure [14] page 7. |
| Failure mode | Manner in which the inability of an item to perform a required function occurs [13] page 9. |
| Functional failure | Reduction in function performance below desired level [15] page 8. |
| Hidden failure | Failure which is not detected during normal operation [13] page 10. |
| Technical hierarchy | Tag number system [11] page 82. |
| Inspection | Examination for conformity by measuring, observing, or testing the relevant characteristics of an item [13] page 14. |

| | |
|---|---|
| Item | Part, component, device, subsystem, functional unit, equipment or system that can be individually described and considered [13] page 6.<br><br>NOTE 1 A number of items e.g., a population of items, or a sample, may itself be considered as an item [13] page 6.<br><br>NOTE 2 An item may consist of hardware, software or both [13] page 6.<br><br>NOTE 3 Software consists of programs, procedures, rules, documentation and data of an information processing [13] page 6. |
| Jack-up | A type of rig with floating installation. A self-elevating mobile unit, which stands steady when in operation [16]. |
| Likelihood | The chance of something happening [14] page 5.<br><br>Note 1 In risk management terminology, the word “likelihood” is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically (such as a probability or a frequency over a given time period) [14] page 5. |
| Maintenance | Combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function [13] page 5. |
| Maintenance program | List of all the maintenance tasks developed for a system for a given operating context and maintenance concept [15] page 10. |
| Mobile offshore unit | By MOU class company is meant a recognized class company with which an additional agreement has been entered into to supervise mobile devices, and this includes the American Bureau of Shipping (ABS); DNV; and Lloyd's Register of Shipping (LR) [17]. |
| Offshore Crane | Lifting appliances on board vessels (including wind turbine installations) intended for load handling outside vessels while at open sea [18] page 7. |
| Qualified personnel | Persons with applicable experience and training regarding the relevant standards, directives, accident prevention regulations and operating conditions and have authorization by responsible persons for the safety of the machine to |

carry out the particular task required and able to recognize and avoid potential hazards. Knowledge of first aid and local rescue equipment is essential. According to regulations, unqualified personnel are forbidden to work on i.e., power installations and equipment [19] page 11.

SFI — Classification system for the maritime and offshore industry worldwide. Provides a functional subdivision of technical and financial ship/rig information [20].

System — A logical grouping of subsystems that will perform a series of key functions, which often can be summarized as one main function, that is required of a plant (e.g., feed water, steam supply, and water injection) [11] page 82.

This includes the American Bureau of Shipping (ABS); DNV; and Lloyd's Register of Shipping (LR) [17].

Tag number — Unique code that identifies the equipment function and its physical location for use in maintenance systems [14] page 17.

PM — Maintenance carried out to mitigate degradation and reduce the probability of failure [14] page 15. A Preventive Maintenance (PM) task may include inspections, lubrication, and replacement of worn components etc.

# 2. Theory

The theory chapter contains theory about the crane and the methods used to achieve the optimal maintenance plan, maintenance activities and maintenance interval.

## 2.1 The crane – Technical specifications

The OC3550L Crane is designed to perform deck-to-deck lifting, as well as loading and unloading to and from supply vessels [3] page 2. The OC3550L crane was developed out of desire to understand visibility, weight efficiencies, time to market and cost competitiveness [3] page 1. An OC-L crane is developed by metal beams, interconnected to form a lattice. The cranes are typically used to lift heavy loads.

The jack-up rig Linus was constructed at Jurong Shipyard in Singapore and delivered in 2014 to the company Seadrill [2]. Linus uses and operates three OC3550L cranes, produced by NOV [2]. NOV is a multinational company that provides technology-driven solutions, equipment and operational support to empower the global energy industry, drilling industry and more. The main drive system of the crane is electric/hydraulic [3].

## 2.2 Crane structure

The crane is mounted on a fixed pedestal with a pedestal adapter. The crane is structured in a A-frame consisting of a lattice boom, hoist, whip hoist and boom hoist winches as pictured below [19] page 16.

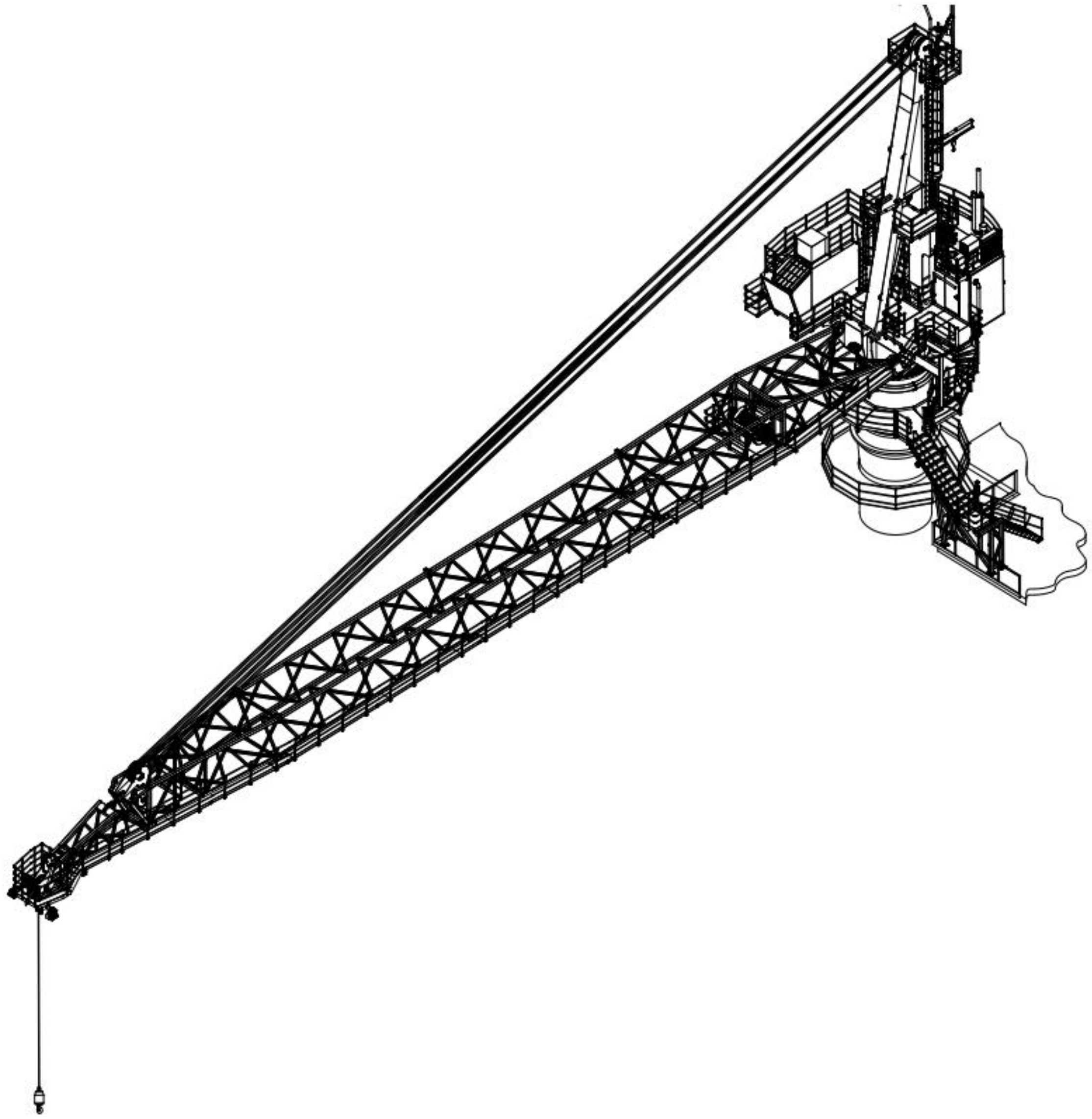

*Figure 2 - Crane, general arrangement. Reference: [11] page 16.*

### 2.2.1 Pedestal adapter

The pedestal consists of steel tubular on the top. A heavy flange is welded to the tubular onto which the slewing bearing is bolted. A circular platform is fitted on the outside of the pedestal. The platform provides access to maintain the slewing bearing and is also the regular access route for the crane operator [19] page 17.

### 2.2.2 Crane base frame

The crane base frame consists of a strong flange onto which the slewing ring is bolted. Over the flange, the frame consists of a welded cylinder structure [19] page 17.

### 2.2.3 A-frame

The A-frame consists of a two-legged structure made of plates and forms a box-profile. The boom hoist steel rope sheaves are located in a sheave house at the top of the A-frame. A hydraulic boom backstop cylinder is fitted in the A-frame to help pushing out the boom. Two boom buffers are also fitted in the A-frame [19] page 17.

### 2.2.4 Machinery House

The machinery house is made of steel plates and is mounted on the crane frame. It consists of one access door. The roof is provided with hatches dimensioned to allow the largest components in the machinery house to be lifted up by the service crane in the A-frame [19] page 17.

### 2.2.5 Boom

The boom is of a welded lattice design, made of square hollow sections (RHS). The boom is made up of three sections, which are bolted together. On the upper side of the boom there is a supporting plate for the boom buffers and the boom backstop cylinder [19] page 17.

### 2.2.6 Ladders and Platforms

The crane is equipped with ladders and platforms in order to provide access to all points that require regular maintenance without any special procedures [19] page 17.

## 2.3 Development of tags

To ensure common coding for all system equipment, tags are used. The wish is to enable and ensure efficient and standardized communication within the company and associated suppliers. Tags are used to support a functional breakdown of systems, subsystems, and equipment items. Consequently, the application of tags simplifies the management of maintenance [21] page 19.

"The Tag Code is used to identify a function and its logical location within a system" [21] page 20. Odfjell Technology uses a specific tag type for main equipment as shown below [21] page 21.

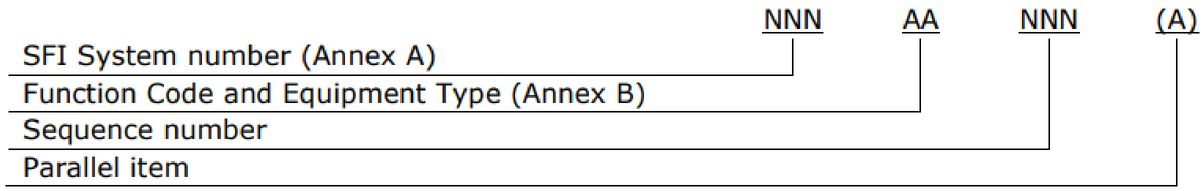


*Figure 3 – Example: Tag code build-up, Reference [21]*

This type of tag code build-up will be used when making the technical hierarchy.

The coherence between tag number and Norwegian Ship Research Institute (SFI) code lies in their common purpose of identifying and classifying equipment in a systematic manner. Tag numbers are used for identifying and tracking individual items, whereas SFI code are used when identifying and classifying systems and their functions.

### 2.3.1 Technical Hierarchy / System breakdown

A technical hierarchy based on item tags, gives a systematic overview and understanding of the whole maintenance process, and therefore provides access to find the tag number of the item that needs maintaining. System breakdown will determine the functionality of each subsystem, making sure that not any key-components are missed and being able to disclose if there are important "dummy tags" that should be taken into consideration.

The technical hierarchy organizes the main system into multiple subsystems. These subsystems are then organized within groups of main equipment. Afterwards, the main equipment can be further divided into subequipment, each comprising groups of main components. These main components will again be divided to subcomponents. While some equipment can be readily "broken down" without requiring unit or component categorization, other equipment may require a more complex deconstruction process to isolate specific items.

The establishment of a clear and precise technical hierarchy provides the company with several advantages, such as facilitating access to the condition of each individual item in the system. This technical hierarchy permits easy access of a digital maintenance record for any given item, thereby streamlining the maintenance process and enhancing the company's overall maintenance efficiency.

The NORSOK Z-008:2017 standard *Criticality analysis for maintenance purposes* describes technical hierarchy as:

> *"The technical hierarchy is a cornerstone in maintenance management. It describes the technical structure of the installation by giving physical items unique identifiers. The technical hierarchy provides an overview of equipment units that belong together technically, and shows the physical relationship between main equipment, instruments, valves, etc. The technical hierarchy should be established at an early phase to give an overview of all the tags/equipment and how they are related. The purpose of the technical hierarchy is as follows:*
>
> - *show technical interdependencies of the installation.*
> - *retrieval of tags, equipment, and spare parts.*
> - *retrieval of documents and drawings.*
> - *retrieval of historical maintenance data from Company Maintenance Management System (CMMS).*
> - *planning of operations (e.g., relationships due to shutdown etc.);*
> - *cost allocation and retrieval.*
> - *planning and organization of the maintenance program.*
> - *planning of corrective work.*
>
> *The level on which the maintenance objects are established is governed by practical execution and the individual need to monitor and control the different maintenance programmes. The technical breakdown of an installation shall as a minimum be broken down to a level were requirements and history can be linked to the individual technical barrier elements, and that the performance of the technical barrier elements can be reported and verified"* [12] *page 20.*

The technical hierarchy gives a structure to the CMMS. This gives a systematic approach to structure the components into groups.

The ISO14224:2016 standard presents a structured approach for classifying the various subsystems comprising a crane as outlined in table 1, illustrated below. This table is used as inspiration for making the technical hierarchy. The crane is categorized into seven subsystems, namely the crane structure, boom system, hoist system, swing system, power system, control and monitoring system, and miscellaneous. Each subsystem is further broken down into categorized units, which are listed under their respective subsystem columns.

**Table A.30 — Equipment subdivision — Cranes**

| **Equipment unit** | **Cranes** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Subunit** | **Crane structure** | **Boom system** | **Hoist system** | **Swing system** | **Power system** | **Control and monitoring** | **Miscellaneous** |
| Maintainable items | A-frame/king<br>Drivers cabin<br>Engine room<br>Pedestal<br>Crane frame | Boom<br>Boom bearing<br>Hydraulic cylinder<br>Luffing winch<br>Luffing wire<br>Luffing sheaves<br>Boom stop cylinder | Hoist winch<br>Hoist sheaves<br>Hook<br>Lifting wire<br>Shock damper | Slew bearing<br>Slew ring<br>Slew motor<br>Slew pinion | Hydraulic pumps<br>Electric engine<br>Diesel engine<br>Proportional valves<br>Hydraulic tank<br>Hydraulic filters<br>Hydraulic oil | PC/PLS<br>Control valves<br>Internal power supply<br>Amplifiers<br>Joysticks<br>Load indicator | Others |

*Table 1 - Equipment subdivision - Cranes. Reference: [7] page 81.*

## 2.4 RCM

RCM is a method to identify and select failure management policies to achieve the required safety regulations, availability, and economy of operation efficiently and effectively [15] page 6. It is a method for maintenance planning and has an important role for overall system safety management [11] page 79.

### 2.4.1 RCM (Rausand & Vatn)

Marvin Rausand, Professor in safety and reliability has together with Jørn Vatn, Professor in safety, reliability, and maintenance, both at Norwegian University of Science and technology (NTNU), written the book *Reliability Centered Maintenance* [11]. The book describes the structure and containment of a complete RCM analysis. According to Rausand & Vatn, 12 main step is followed, as presented below.

1. Study preparation
    a. Define and clarify the objectives and the scope of the analysis [11] page 80.
    b. Requirements, policies, and acceptance criteria with respect to safety and environmental protection should be made visible as boundary conditions for the RCM analysis [11] page 81.
2. System selection and definition
    a. Define the system and at what level of assembly (plant, system, subsystem) the analysis should be conducted [11] page 82.
3. Functional failure analysis (FFA)
    a. Identify and describe the systems' required functions [11] page 84.
    b. Describe input interfaces required for the system to operate [11] page 84.
    c. Identify the ways in which the system might fail to function [11] page 84.
    d. Described in chapter 2.6 *FFA.*
4. Critical item selection
    a. Identify the analysis items that are potentially critical with respect to the functional failures identified in FFA [11] page 88.
    b. Described in chapter 2.6.3 *Critical Item Selection*
5. Data collection and analysis
    a. Establish a basis for both the qualitative analysis (relevant FMs and failure causes), and the quantitative analysis (reliability parameters such as MTTF, PF-intervals, and so on) [11] page 88.

6. FMECA
    a. Identify the dominant FMs of the Maintenance Significant Items (MSI) identified in step 4 – critical item selection [11] page 90.
    b. Described in chapter 2.5 *FMECA.*
7. Selection of maintenance actions
    a. Described in chapter 2.7.1 *Determination of maintenance actions*.
8. Determination of maintenance intervals
    a. Described in chapter 2.7.2 *Determination of maintenance intervals*.
9. PM comparison analysis
    a. Analyse if the maintenance tasks comply with the criteria:
        i. Applicable – the task is applicable in relation to our reliability knowledge and in relation to the consequences of failure [11] page 98.
        ii. Effective – the task does not cost more than the failure(s) it is going to prevent [11] page 98.
10. Treatment on non-critical items
    a. Described in chapter 2.7.5 *Treatment Of Non-Critical Items.*
11. Implementation
    a. Described in chapter 2.7.3.1 *Implementation*.
12. In-service data collection and updating
    a. Operation and maintenance experience is fed back into the analysis process. The information should be concentrated on three major time perspectives:
        i. Short term interval adjustments [11] page 99.
        ii. Medium term task evaluation [11] page 99.
        iii. Long term revision of the initial strategy [11] page 99.

### 2.4.2 RCM (IEC60030-3-11)

The European standard, International Electrotechnical Commission (IEC) 60030 divides the overall RCM process into five steps [15] page 12, as follows:

1. Initiation and planning
    a. Determine the boundaries and objectives of the analysis.
    b. Determine the content of the analysis.
    c. Identify the specialist knowledge and experience available, responsibilities, the need for outside expertise and any training requirements.
    d. Develop operating context for item(s).

2. Functional failure analysis
    a. Collect and analyse any field data and available test data.
    b. Perform functional partitioning.
    c. Identify functions, functional failures, FM, effects, and criticality.
    d. Described in chapter 2.6 *FFA* and chapter 2.6.3 *Critical Item Selection*
3. Task selection
    a. Evaluate failure consequences.
    b. Select the most appropriate and effective failure management policy.
    c. Determine task interval, if appropriate.
    d. Described in chapter 2.6.3 *Critical Item Selection*, chapter 2.5 *FMECA*, chapter 2.7.1 Determination of maintenance actions and chapter 2.7.2 Determination of maintenance intervals.
4. Implementation
    a. Identify maintenance task details.
    b. Prioritize and implement other actions.
    c. Rationalize task intervals.
    d. Initial age exploration.
    e. Described in chapter 2.7.3.1 *Implementation.*
5. Continuous improvement
    a. Monitor maintenance effectiveness.
    b. Monitor against safety, operational and economic targets.
    c. Perform age exploration.

## 2.5 FFA

The FFA process begins when a system is selected and defined. For a successful maintenance program to be developed, it "requires a clear understanding of item functions, failures and consequences" [15] page 20.

The wish for FFA is "to identify the ways in which the systems might fail to function", and "to identify and describe the system's required functions and performance criteria" [11] page 84.

### *Identification of functions*

*A system will often contain several separate functions [11] page 84. It is important to identify functions so the RCM analysis can develop targeted maintenance strategies for each FM.*

### *Function failure*

*A functional failure is a decrease in performance at the required level. Functional failures can be placed in four different categories of failure. First one is total loss of function. Second is failure to satisfy the performance required. Third one is periodically function and last one is functions when not required [15] page 21.*

### *Failure cause*

*The failure cause can be correlated to the root cause leading up to the failure. The different failure causes can be categorized into five categories. The first one is design related. Examples of design-related causes are improper capacity or material. The next one is fabrication/installation-related causes. This is manufacturing, installation, or assembly failures. The third one is failure related to operation/maintenance. This can be off-design service and operating or maintenance errors like human mistakes and oversights. The next one is failure related to management, examples here are human errors when it comes to procedures, drawings, specifications, planning and organization etc. The last category is miscellaneous, this can be any other failure cause not listed in the categories above [14] page 180.*

*Failure mechanism*

*Failure mechanism is the seemingly observed cause of the failure. It is the physical/chemical process or combination of processes that leads to the failure. There are six main categories for determining the failure type. These are mechanical, material, instrumentation, and electrical failures, and external influence. Last is miscellaneous where the failure mechanisms not represented in the categories above end up in* [14] page 178.

Each FM will also be marked hidden or evident. "Hidden FM whose effects do not become apparent to the operator under normal circumstances" [15] page 9.

### 2.5.1 FM

FMs are used to categorize the different failure mechanisms and are an important tool to develop a maintenance plan for each maintainable item. This includes identifying the symptoms that may indicate that a failure is imminent. This report will use the FMs from ISO 14224:2016. A FM can lead to a system function failure.

ISO 14224:2016 categorizes FMs in nine different areas for different equipment:

- Rotating (table B6) [14] page 187.
- Mechanical (table B7) [14] page 188-189.
- Electrical (table B8) [14] page 190-191.
- Safety and control (table B9) [14] page 192-194.
- Subsea (table B10) [14] page 195-196.
- Well completion (table B11) [14] page 197-198.
- Drilling (table B12) [14] page 199-200.
- Well intervention (table B13) [14] page 201.
- Marine (table B14) [14] page 202.

## 2.6 Critical Item Selection

In this part of the analysis, the intention is to identify the items that are critical regarding function failures identified in the FFA. The analysis identifies critical items to decide which preventative maintenance the item requires or if it is practical to "run to failure".

In the critical item selection, the criticality is divided into two groups of significant items in. These two groups are "Functional Significant Items" (FSI) and "Maintenance Cost Significant Items" (MCSI). FSIs are items where the failure has a consequence of medium or high for one of the consequence categories listed within the FFA (S,E,A,M) [11] page 88. MCSIs are items where the failure rate and repair costs are high [11] page 98.

Consequence classification is a part of the critical item selection. It categorizes the different risk aspects due to safety, environment, and cost. Additional to likelihood class, this provides a guidance on what items that are critical. "Consequence classification expresses what effect loss of function can have on health, safety and environment, production and cost/other" [22] page 20. All items shall be assigned a function and have a consequence classification [22] page 21. Consequence classification is done to identify critical equipment.

### 2.6.1 Treatment of Non-critical Items (Non-MSIs)

Maintenance significant Items (MSI) are the combination of FSI and MCSI. "… the selection of critical items is important in order to mitigate the potential loss of both time and financial resources" [11] page 88.

This measure is implemented to see if the existing maintenance cost for the non-MSIs is high or whether it can be surpassed. Maintenance should be carried out according to vendor specifications if they exist, else no maintenance should be performed [11] page 98. The analysis can continue without analyzing the items further.

## 2.7 FMECA

FMECA is one of the key aspects of the RCM. FMECA is a systematic procedure to identify FMs, their causes and effects on the system performance. The analysis will also contain a critical item selection based on the function failures found in FFA. The goal is to remove or mitigate FMs in the most cost-effective way [23], page 3.

Each maintainable item is analysed with respect to any impact on the various functional failures [11] page 92.

Items can have multiple functions, each of which may entail different types of risks. The potential for an item to cause damage can vary depending on its specific function, as it may have little to no impact in certain areas, while posing a significant risk in others. The application of a FMECA sheet can provide a systematic overview of various scenarios, ultimately leading to an RCM outcome that in advance addresses potential function failures within the system.

## 2.8 Maintenance

Maintenance is carried out to maintain the equipment and system functions. Maintenance will benefit the company in many sections. Economic, safety and environment are key sections that are taken under consideration when deciding maintenance strategies and developing a maintenance plan, also when implementing a work description with details about how the activities should be executed. It will often be beneficial to combine different types of experience and background/education when developing a maintenance plan. Too few maintenance activities on a critical item, can result in fatality. As well as too frequently dismantling or testing, can in worst case lead to considerable wear and tear.

### 2.8.1 Maintenance program

A maintenance programme includes maintenance tasks, when and how to execute the tasks. A maintenance program is made for each maintainable item. To make the maintenance programme, the RCM analysis is used to determine potential failures. The technical hierarchy is the first step to determine what components are critical. A maintenance programme is used to mitigate the risk of degradation of components. It should also include the intervals for the maintenance activities. The maintenance programme should always be updated continuously. Reasons for updating it could be that expected failure rate is different than first anticipated. Other reasons are cost or environmental changes [12] page 31, 32, 35.


*Figure 4 - Development of maintenance program. Reference [13], page 6.*

An effective maintenance plan will reduce the likelihood of failure. It is important to have a determined maintenance interval to have sufficient control on the items [12] and to utilize the lifespan of the item, subsystem, or system. This will benefit the company economically.

*Implementation*

According to Rausand & Vatn, implementation is associated with the maintenance plan and how to prevent accidents. Maintenance packages are developed as part of the maintenance plan, and these will list what actions need to be taken, and when they should be carried out. A checklist can be used to identify potential risks. [11] page 99.

According to IEC 60300-3-11 standard, implementation is the second to last step where the maintenance strategy is made. Different task details are taken into consideration before the results can be implemented. This is in regard to health and safety, time it takes to do the task, hazardous materials, and tools and test equipment [15] page 30.

### 2.8.2 Selection of Maintenance Activities

A decision logic is used to guide the analysis through a question–and–answer process. The input to the RCM decision logic is the dominant FMs from the FMECA. [11] page 94. There are generally three reasons for doing a preventive maintenance task: prevent a failure, detect the onset of a failure and to reveal a hidden failure [11] page 94. This is to determine if each FM needs preventative maintenance task.

Rausand & Vatn describes the different maintenance activities as listed below:

1. Continuous on-condition task (CCT)
   Continuous monitoring of an item, to find any potential failures [11] page 95.
2. Scheduled on-condition task (SCT)
   Scheduled inspection of an item at regular intervals [11] page 95.
3. Scheduled overhaul (SOH)
   Scheduled overhaul of an item at or before some specified age limit [11] page 96.
4. Scheduled replacement (SRP)
   Scheduled discard of an item at or before some specified age limit [11] page 96.
5. Scheduled function test (SFT)
   Scheduled inspection of a hidden function to identify any failure [11] page 96.

6. Run to failure (RTF)

   Run to failure because the other tasks are not possible, or the economic benefits are low [11] page 96.

ISO14224:2016 describes maintenance activities in the picture below.

**ISO 14224:2016(E)** NS-EN ISO 14224:2016

**Table B.5 — Maintenance activity**

| Code Number | Activity | Description | Examples | Use [a] |
|---|---|---|---|---|
| 1 | Replace | Replacement of the item by a new or refurbished item of the same type and make | Replacement of a worn-out bearing | C, P |
| 2 | Repair | Manual maintenance action performed to restore an item to its original appearance or state | Repack, weld, plug, reconnect, remake, etc. | C |
| 3 | Modify [b] | Replace, renew or change the item, or a part of it, with an item/part of a different type, make, material or design | Install a filter with smaller mesh diameter, replace a lubrication oil pump with another type, reconfiguration etc. | C, P |
| 4 | Adjust | Bringing any out-of-tolerance condition into tolerance | Align, set and reset, calibrate, balance | C, P |
| 5 | Refit | Minor repair/servicing activity to bring back an item to an acceptable appearance, internal and external | Polish, clean, grind, paint, coat, lube, oil change, etc. | C, P |
| 6 | Check [c] | The cause of the failure is investigated, but no maintenance action performed, or action is deferred. Able to regain function by simple actions, e.g. restart or resetting. | Restart, resetting, no maintenance action, etc. Particularly relevant for functional failures, e.g. fire and gas detectors, subsea equipment | C |
| 7 | Service | Periodic service tasks: Normally no dismantling of the item | e.g. cleaning, replenishment of consumables, adjustments and calibrations | P |
| 8 | Test | Periodic test of function or performance | Function test of gas detector, accuracy test of flow meter | P |
| 9 | Inspection | Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses | All types of general check. Includes minor servicing as part of the inspection task | P |
| 10 | Overhaul | Major overhaul | Comprehensive inspection/overhaul with extensive disassembly and replacement of items as specified or required | C, P |
| 11 | Combination | Several of the above activities are included | If one activity dominates, this may alternatively be recorded | C, P |
| 12 | Other | Maintenance activity other than specified above | e.g. protection activities | C, P |

[a] C: used typically in corrective maintenance; P: used typically in preventive maintenance.

[b] Modification is not defined as a maintenance category, but is often performed by persons trained in the maintenance disciplines. Modification to a major extent can have influence on the operation and reliability of an equipment unit.

[c] "Check" includes the both where a failure cause was revealed but maintenance action was considered either not necessary or not possible to carry out and where no failure cause circumstances could be found.

*Table 2 - Maintenance activity. Reference [7] page 184.*

### *PM*

PM is maintenance carried out to mitigate degradation and reduce the probability of failure [22] page 9. PM are done to prolong the lifetime of the equipment. How often the maintenance should be done is dependent on how critical the item is.

Two overriding criteria for the selection of maintenance tasks in an RCM are its applicability and its cost effectiveness [11] page 97. A PM task is applicable if it can eliminate a failure or reduce it to an acceptable level. It is cost effective if the task does not cost more than the failure [11] page 98. Reliability data is necessary to decide the criticality, to mathematically describe the failure process and to optimize the time between PM-task [11] page 89.

Identification of critical items consists of a consequence classification, and the results shall be used as an input to the PM program task selection process [12] page 25, as Figure 5 below illustrates.

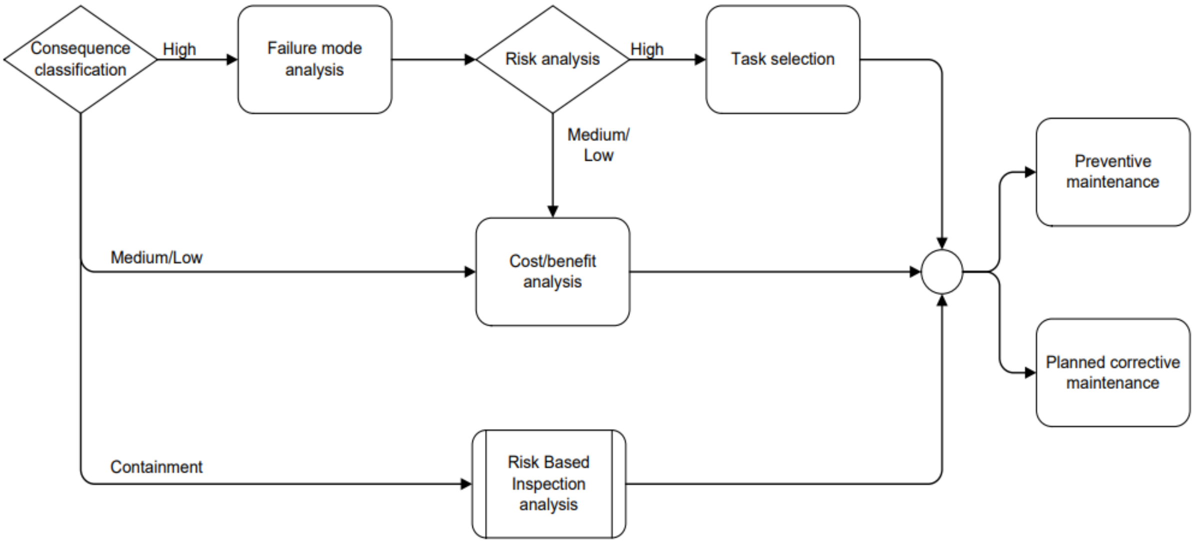


*Figure 5 – Task selection process. Reference [12] page 25.*

*CM*

CM is used when a PM task shows to not be applicable and effective [11] 94. CM aims to reinstate the functionality of an item when it fails or fails to meet performance standards. However, some failures are acceptable if the CoF regarding safety, economics, and environment, are tolerable compared to the cost of PM and the loss due to down-time resulting from failure. [15] page 14.

MTTF

MTTF are the expected time before the item fails [14] page 12. As mentioned earlier, the need to see if the cost of PM and loss from failure are tolerable compared to the CoF. A calculation of MTTF on a system can be done to see if it is feasible to let a component "run-to-failure".

This report will not consist of a MTTF-calculation as it is mainly a part of the CM, and the report has no data for the calculations. For a thorough and specific plan, this is recommended to calculate.

*Run to failure*

It is desirable to have best possible performance regarding safety, environment, and cost. To optimize the performance of the system with respect to environmental, cost, and safety, it is imperative to determine which items require maintenance. There will be some items where maintenance will not profit the company due to high cost, and therefore be beneficial to let the part "run to failure". The approach implies with no maintenance for the item. This can be implemented because the criticality if the item failed, is low in all categories. The item can be used until failure or broken. Then it can be replaced.

### 2.8.3 Determination of Maintenance Intervals

The analysis determines the maintenance interval after deciding the PM task.

The optimal interval can be difficult to find and is based on feedback information from the maintainable items such as the effective failure rate with respect to a specific failure mode [11] page 101. To calculate the intervals needed, tools such as Component Model, System Model or a program "OptiRCM". These are alldescribed in Rausand & Vatn, 2008, chapter 4.4 – Modelling and Optimizing Maintenance Intervals [11] page 101.

According to IEC 60300-3-11, there are different task details to take into consideration before the results can be implemented. This is in regard to health, safety, time it takes to do the task, hazardous materials, and tools and test equipment [15] page 30.

## 2.9 Object type/Equipment class

Object type is a two-digit code which is used to categorize and describe a part in a system. The object type of a part is defined with equipment classes and/or equipment types to give additional details about the part. Equipment class is a classification system used specifically for equipment based on similar characteristics such as functionality. Therefore, the use of object type for maintenance management systems will help organize and manage maintenance activities.

For each equipment category in ISO 14224:2016 you have different equipment class codes for each class [14] page 52. The equipment categories for the crane are rotating, mechanical, electrical and safety and control. In this report we use the same codes as presented in ISO 14224:2016 which are as following:

**Rotating** [14] page 52.

- Electric Motors: EM
- Pumps: PU

**Mechanical** [14] page 53.

- Cranes: CR

**Safety and control** [14] page 56-57.

- Valves: VA

### 2.9.1 Route

A route is a system of numbering that links together multiple items with a shared function, which requires maintenance at the same time. Object types are often utilized to achieve an optimized route. Categorizing maintainable items into routes can be advantageous for the company, particularly for maintenance activities that require specialized expertise. A route can consist of multiple items with unique object codes. A detailed object code makes it easy to develop routes to connect the maintainable items with the same maintenance plan. Implementing routes can help save time, reduce costs, and provide a clear and well-organized maintenance system.

# 3. Methodology

This chapter describes the methods used to complete the assignment. Methodology is described by the Norwegian author and Professor in social science Dag Ingvar Jacobsen as "the purpose of research is to produce valid and reliable knowledge about reality. To explain this, the researcher must have a strategy for how he or she must step forward. This strategy is method" [24], page 21.

## 3.1 Qualitative and quantitative method

The assignment is based on qualitative data. Qualitative method uses information gathering and personal assessment. Analysis categories as FFA and critical item selection is based on personal experience and tuition from HVL. This is essential to the assignment considering for example the evaluation of FMs, and their consequence can be individual, due to variety of experience.

Quantitative method is based on statistics and facts. This can be data collection of function failure from items, and other past failure data. The quantitative analysis is not included in the assignment. Data such as MTTF and Potential Failure Intervals is not available.

## 3.2 Theoretical approach

The analysis in this report is mostly arranged in Microsoft Excel. Microsoft Excel is the industry leading spreadsheet software program, a powerful data visualization and analysis tool [25]. The Excel analysis sheets is included later in the methodology chapter.

Professor in Operations and Maintenance Engineering, Maneesh Singh, has provided a worksheet inspired from a risk matrix developed by DNV. DNV report "Risk based inspection off Offshore Topsides Static Mechanical Equipment, 2010" contains a risk matrix [26] page 16, that Professor Singh has modified and further developed from years of experience. This is used to calculate accepted risk criteria, also to determine the inspection time for calculated critical items. These worksheets are attached in appendix 2, sheet 5 as "PoF/CoF Matrix – Professor Maneesh Singh".

PSA states that "*when developing the maintenance program, the standards NORSOK Z-008:2017, […] and IEC 60300-3-11 can be used in the areas of health, occupational safety and security"* [10]. The assignment is based on Rausand & Vatn RCM methodology, as well as IEC60300-3-11 – application guide - Reliability centered maintenance. Other standards that have been used in the assignment is listed below.

- **NS-EN ISO 14224:2016** is an International Standard that provides a comprehensive basis for the collection of reliability and maintenance data in a standard format for equipment in all facilities and operations within the petroleum, natural gas and petrochemical industries during the operational life cycle of equipment [14].
- **NORSOK Z-008:2017** standard is providing requirements and guidelines for establishment of technical hierarchy, consequence classification of equipment, how to use consequence classification in maintenance management, maintenance management of technical barrier elements, how to use risk and reliability analysis to establish and update PM programmes, how to aid decisions related to maintenance using the underlying risk analysis and to spare part evaluations [22].
- **NS-EN 13306** Maintenance terminology. The standard PSA uses for definitions of terms.
- **NORSOK R-002** Lifting equipment **-** Edition 2, Sept. 2012 [27]. This NORSOK standard is valid for technical requirements to lifting appliances and lifting accessories on all fixed and floating installations, mobile offshore units, barges and vessels, as well as on land-based plants where petroleum activities are performed. [28].
- **NORSOK R-003** Safe use of lifting equipment. This NORSOK standard embraces the safe use of lifting equipment used in connection with lifting operations in the petroleum activities. It does not include the use of lifts and fall protection equipment. [29].

## 3.3 The methods used in the assignment

This chapter describes methods used in the assignment: study preparation, RCM, and comparison.

### 3.3.1 Study preparation

Study preparation is based on information gathering, defining the assignment, and establishing limitations. Exploring standards, RCM approaches, information about the crane and the P&ID system is investigated during study preparation.

### 3.3.2 RCM

RCM is an accepted methodology used in a wide range of industries. RCM provides a decision process to identify applicable and effective PM requirements, or management actions, for equipment in accordance with the safety, operational and economic consequences of identifiable failures, and the degradation mechanism responsible for those failures [15] page 6. It is a method for systematic analysis of system functions, FM, establish maintenance program considering safety, availability, and costs.

The assignment follows Rausand & Vatn's twelve steps, with some changes. For example, the step "in service data" is not applied because of missing information.

The technical hierarchy is attached in appendix 2, sheet 1. How the tags are categorized in the technical hierarchy is attached in appendix 2, sheet 2.

The worksheet used for FMECA will consist of a FFA, critical item selection, risk evaluation, and maintenance activities and planning.

#### FFA

The FFA used in the assignment is inspired by both Rausand & Vatn, and IEC 60300-3-11. Beneath is a hierarchy over how the FFA is built up in this assignment.

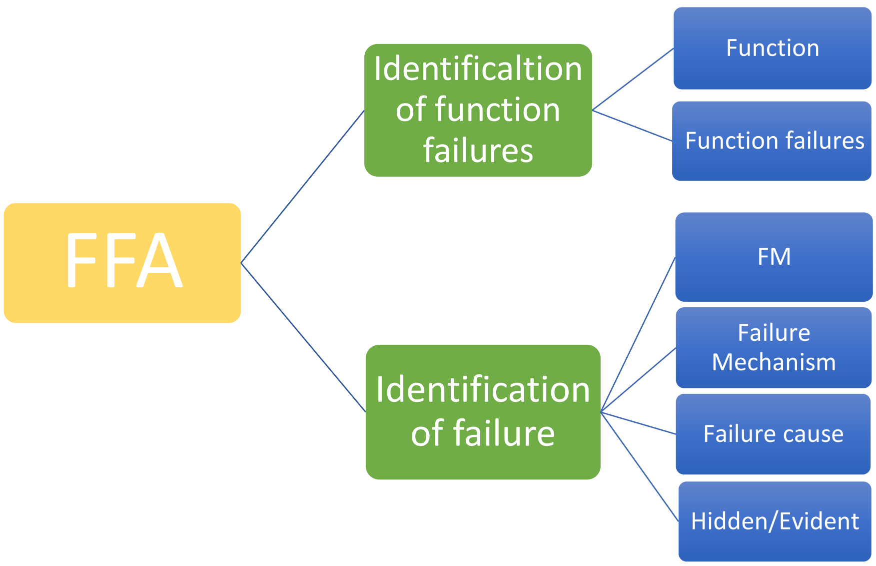


*Figure 6 - FFA build-up*

This is both a quantitative and qualitative analysis, information is taken from the standard ISO14224:2016, and is further categorized out of own experience and knowledge.

The table below shows the FFA excel sheet. The FFA sheet is attached in appendix 2, sheet 3.

| **Function Failure Analysis (FFA)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Main Function | Main Function Failure | Secondary Function | Secondary Function Failure | Tertiary Function | Tertiary Functional Failure | Quaternary Function | Quaternary Function Failure | Failure Mode (ISO14224) | Failure Mechanism (ISO14224) | Failure Cause | Hidden / Evident Failure |
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*Table 3 - FFA work sheet*

## *Critical item selection and risk evaluation*

The likelihood and consequence are assessed and selected on a scale from 1-5, based of educated guess.

To assess risk, the risk matrix depicted below is used, with likelihood and consequence serving as key determining factors. Specifically, when evaluating risk associated with safety, the consequence of safety is considered, and this approach is similarly applied in assessing economic and environmental risk. Risks are assigned a value on a scale ranging from 1 to 3, with 1 denoting the lowest risk and 3 representing the highest. The maximum risk is determined by identifying the highest risk factor among the three key factors: safety, economic, and environment.

| PoF Ranking | PoF Description | A | B | C | D | E |
|---|---|---|---|---|---|---|
| 5 | (1) In a small population, one or more failures can be expected annually.<br>(2) Failure has occurred several times a year in the location. | YELLOW | RED | RED | RED | RED |
| 4 | (1) In a large population, one or more failures can be expected annually.<br>(2) Failure has occurred several times a year in operating company. | YELLOW | YELLOW | RED | RED | RED |
| 3 | (1) Several failures may occur during the life of the installation for a system comprising a small number of components.<br>(2) Failure has occurred in the operating company. | GREEN | YELLOW | YELLOW | RED | RED |
| 2 | (1) Several failures may occur during the life of the installation for a system comprising a large number of components.<br>(2) Failure has occurred in industry. | GREEN | GREEN | YELLOW | YELLOW | RED |
| 1 | (1) Several failures may occur during the life of the installation for a system comprising a large number of components.<br>(2) Failure has occurred in industry. | GREEN | GREEN | GREEN | YELLOW | YELLOW |
| CoF Types | Safety | No Injury | Minor Injury Absence < 2 days | Major Injury Absence > 2 days | Single Fatality | Multiple Fatalities |
| | Environment | No pollution | Minor local effect. Can be cleaned up easily. | Significant local effect. Will take more than 1 man week to remove. | Pollution has significant effect upon the surrounding ecosystem (e.g. population of birds or fish). | Pollution that can cause massive and irreparable damage to ecosystem. |
| | Business | No downtime or asset damage | < € 10.000 damage or downtime < one shift | < € 100.000 damage or downtime < 4 shifts | < € 1.000.000 damage or downtime < one month | < € 10.000.000 damage or downtime one year |
| CoF Ranking | | A | B | C | D | E |

Table 4 - Risk matrix. Reference [16] page 16

The matrix above is used when the risk is calculated in the excel work sheet. The colours represent risk factor. Green is "low", yellow is "medium", and red is "high".

The risk status is found with the modified PoF/CoF matrix beneath. The matrix is modified from DNV-RP-G101 and adjusted after Professor Maneesh Singhs work experience. When finding the risk status, the highest likelihood and the highest consequence are chosen.

| | | CoF Ranking | | | | |
|---|---|---|---|---|---|---|
| | CoF - Environmenta | A - Slight Pollution | B - Minor Pollution | C - Moderate Pollution | D - Major Pollution | E - Massive Pollution |
| | CoF - Economical | A - Slight Damage | B - Minor Damage | C - Moderate Damage | D - Major Damage | E - Massive Damage |
| | CoF - Economical | A - Slight Loss | B - Minor Loss | C - Moderate Loss | D - Major Loss | E - Massive Loss |
| | CoF - Safety | A - No Injury | B - Minor Injury | C - Major Injury | D - Single Fatality | E - Mulitple Fatality |
| PoF Ranking | 5 - Expected | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail | 3 - Fail | 3 - Fail |
| | 4 - High | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail | 3 - Fail |
| | 3 - Medium | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail |
| | 2 - Low | 1 - Pass | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail |
| | 1 - Negligible | 1 - Pass | 1 - Pass | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) |

Table 5 - Risk matrix. Reference: Professor Maneesh Singh

The risk status on a level 1 – low will be "Pass". Level 2 – medium will translate to "Pass with condition(s)", and level 3 – high means "Fail". See description in the table below.

| | |
|---|---|
| 1 - Pass | The equipment has met the criteria and standards for safe and reliable operations regarding the FM. |
| 2 - Pass with condition(s) | The equipment has met the criteria and standards, but there can be some minor issues that needs to be addressed before it can be considered fully operational. |
| 3 - Fail | The equipment did not meet the criteria and standards for safe and reliable operations. |

*Table 6 - Risk status explained*

Below is the critical item selection sheet among with the risk evaluation used in the assignment. The Critical item selection and Risk Evaluation is attached in appendix 2, sheet 3.

| Critical Item Selection | | | | | | | | | | Risk Evaluation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Functional Significant Item (FSI) | Maintenance cost significant item (MCSI) | Likelihood Class | Consequence Safety | Consequence Economic | Consequence Environment | Risk (Safety) | Risk (Economic) | Risk (Environment) | Risk (Maximum) | Risk Status | Comments |
| | | | | | | | | | | | |
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*Table 7 - Critical item selection work sheet*

## Maintenance activities and interval

Maintenance demands from NOV, PSA, DNV and NMD are found from public regulation and laws, DNV standards and NOV user manual. Recommended maintenance activities are chosen from interpretation of the different authorities.

Below is the table used to list the different maintenance demands, and the FMECA result. The last column collects all the demands, additional to the maintenance activities from the FMECA result. This is attached in appendix 2, sheet 3.

| Maintenance activities | | | | | | |
|---|---|---|---|---|---|---|
| Maintenance demands from government agency (+NOV) | | | | Analysis result | | Maintenance activities merged |
| NOV maintenance demands | PSA maintenance demands | DNV maintenance demands | NMD maintenance demands | Recommended maintenance activities | Recommended maintenance intervals | |
| | | | | | | |
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*Table 8 - Maintenance activities work sheet*

When finding the inspection time, the matrix below will be used. This is developed by Professor Maneesh Singh, with inspiration to DNV risk matrix shown in Table 4 – *Risk matrix*. To decide the maintenance interval, the highest likelihood and highest consequence are chosen, equally to the risk status is found.

| | | CoF Ranking | | | | |
|---|---|---|---|---|---|---|
| CoF - Environmental | | A - Slight Pollution | B - Minor Pollution | C - Moderate Pollution | D - Major Pollution | E - Massive Pollution |
| CoF - Economical | | A - Slight Damage | B - Minor Damage | C - Moderate Damage | D - Major Damage | E - Massive Damage |
| CoF - Economical | | A - Slight Loss | B - Minor Loss | C - Moderate Loss | D - Major Loss | E - Massive Loss |
| CoF - Safety | | A - No Injury | B - Minor Injury | C - Major Injury | D - Single Fatality | E - Mulitple Fatality |
| PoF Ranking | 5 - Expected | 1-year | 6-month | 3-month | 2-month | 1-month |
| | 4 - High | 2-year | 1-year | 6-month | 3-month | 2-month |
| | 3 - Medium | 3-year | 2-year | 1-year | 6-month | 3-month |
| | 2 - Low | Corrective Maintenance | 3-year | 2-year | 1-year | 6-month |
| | 1 - Negligible | Corrective Maintenance | Corrective Maintenance | 3-year | 2-year | 1-year |

*Table 9 - Maintenance intervals matrix. Reference: Professor Maneesh Singh*

### 3.3.3 Comparison

The last method used is comparison. Odfjell Technology's procedures are compared to our results from the RCM analysis.

Comparative method contains searching for similarities and differences in the result. This is presented in chapter 5. Here the similarities and differences are presented with activity description taken from ISO14224:2016 and NOV user manual.

## 3.4 Sources of error

The first part of the RCM analysis contains a critical item selection of each item and assembly that the hydraulic crane emergency system consists of. The evaluation of criticality can deviate from elsewhere due to individual appraisal of the consequences. The Norwegian laws and regulations are rewritten in English, therefor some of them may not be precise as at *Lovdata* (Norwegian law and regulation publisher).

## 3.5 Law regulated authority

**NMA** is a directorate under *the Ministry of Trade and Fisheries and the Ministry of Climate and Environment* with authority responsibility for Norwegian-registered ships and foreign ships entering Norwegian ports [30]. Their responsibilities include high safety for life, health, materiel, and environment on all Norwegian floating vessels at sea.

**PSA** is a state agency subordinate to the ministry. The PSA must set conditions for monitoring that the actors in the petroleum business maintain a high level with regard to safety, health and the working environment, as well as safeguarding [31]. The Norwegian Petroleum Authority is a state audit is subject to *the Ministry of Labor and Inclusion* [31]. The Norwegian Petroleum Authority is a state audit is subject to *the Ministry of Labor and Inclusion.*

**Lovdata** is a foundation that publishes Official announcements of changes in Norwegian laws and regulations [32]. Lovdata is the Norwegian digital law register. The laws that are relevant and important to consider in the RCM analysis are laws established by the Norwegian Petroleum Authority and the Norwegian Maritime Directorate. The laws often refer to standards, as the report also will do.

**DNV** – is the world's leading classification society and a recognized advisor for the maritime industry. The company delivers world-renowned testing, certification and technical advisory services to the energy value chain including renewables, oil and gas, and energy management [8]. Odfjell Technology has a close cooperation with DNV. The classification company's maintenance demands and recommendations are therefor included in the result chapter.

# 4. Result – RCM

In this chapter the following subchapters is introduced with PSA regulation belonging to the subchapter, followed by a proposal of how a company can follow them.

## 4.1 Defining the system

Referring to the *Technical and operational regulation* from PSA*, § 7 Facilities, systems, and equipment;* "[…] Installations, systems and equipment must be marked so as to facilitate safe operation and proper maintenance" [34].

The system that the assignment concerns is the OC3500L Crane described in chapter 2 – *Theory*. There are three cranes of this type at the jack-up rig Linus. The system is limited to OC3500L Crane STBD and will be referred to as 361.100.000 in the technical hierarchy, also in its description.

## 4.2 Development of Tags

Referring to the *Technical and operational regulation* from PSA *§ 7 Facilities, systems, and equipment;* "[…] Installations, systems and equipment must be marked so as to facilitate safe operation and proper maintenance" [34].

In the *Regulations on the execution of work, use of work equipment and associated technical requirement* from PSA, *§ 12-8 Requirements for documentation of control and maintenance*, is it noted in conjunction with maintenance, that it must be clearly stated what has been controlled and who has carried out the control [35]. For this to occur, the company needs a system that contains and systemizes all the maintainable items, and a record of maintenance activities for each maintainable item. There are often multiple items of the same type in a system, thus it must exist an identification number, also called tag number for each individual item in the system.

The tags should be clear and visible in both CMMS and in the field. This will help to provide a common understanding of the maintenance task that are performed.

### 4.2.1 Tag number build-up

The tag number consists of SFI code, equipment type code and serial number. The tag number provided from Odfjell Technology for the OC-L STBD crane is 361-MA-01. As the crane is placed on STBD side and is one of three cranes on the jack-up rig, it has been given the serial number 01.

*SFI code*

All the items the crane uses and operates with, are based on the SFI structure provided from Odfjell Technology. This is why all the system numbers in appendix 2 sheet 1 starts with the code 361. The SFI code is also used when developing tag numbers.

- The first number, 3, relates to cargo equipment.

- The two first numbers together, 36, is code for material handling equipment and systems.

- All the three numbers together, 361, is the code used for cargo cranes.

*Equipment class / Object code*

The tag number 361-MA-01, has the equipment type code MA. This code is used for Pedestal Cranes [21] page 46.

ISO 14224:2016 presents a two-numbered Object Code. These does not give specified information and details about what the equipment is.

Therefore, using an object type with four to six numbers is advised. This is to easily determine the part in question, and therefore save time. An example is using the object type for cranes given below.

**Table A.29 — Type classification — Cranes**

| Equipment class — Level 6 | | Equipment type | |
|---|---|---|---|
| **Description** | **Code** | **Description** | **Code** |
| Cranes | CR | Electro-hydraulic operated | HO |
| | | Diesel hydraulic operated | DO |

*Table 10 - Type classification - Cranes. Reference [7] page 79*

As given in ISO 14224:2016, the equipment class for all types of cranes is *CR*. The OC-L NOV crane on Linus is an electro-hydraulic operated crane, which is given the object type *HO*. To improve the information provided from these two-numbered object types, it is recommended to use four to six numbers. A recommended way of doing this is that instead of *CR* or *HO*, it can be written "*CRHO*" as one object code. To specify the item even more, numbers can be added. As this crane is placed on STBD, the object type could be *CRHO01*, and for the other two locations (Portside Crane and Portside Aft Crane) it would be *CRHO02* and *CRHO03*.

### *Object code – system 630*

- Emergency drive pump – PURE00.

**Table A.20 — Type classification — Pumps**

| Equipment class — Level 6 | | Equipment type | |
|---|---|---|---|
| **Description** | **Code** | **Description** | **Code** |
| Pumps | PU | Centrifugal | CE |
| | | Reciprocating | RE |
| | | Rotary | RO |

*Table 11 - Type classification - Pumps. Reference [7] page 73.*

- Electrical motor – EMDC00

**Table A.14 — Type classification — Electric motors**

| Equipment class — Level 6 | | Equipment type | |
|---|---|---|---|
| **Description** | **Code** | **Description** | **Code** |
| Electric motors | EM | Alternating current | AC |
| | | Direct current | DC |

*Table 12 - Type classification - Electric motors. Reference [7] page 68.*

- Emergency cut-off valve – VAXX00

**Table A.77 — Type classification — Valves**

| Equipment class — Level 6 | | Equipment type | |
|---|---|---|---|
| **Description** | **Code** | **Description** | **Code** |
| Valves | VA | Ball | BA |
| | | Gate | GA |
| | | Globe | GL |
| | | Butterfly | BP |
| | | Plug | PG |
| | | Needle | NE |
| | | Check | CH |
| | | Diaphragm | DI |

NOTE 1 Pilot valves are normally non-tagged components used for self-regulation. PSV solenoid valves are normally a sub-tag of a valve tag used for all ESD/PSD. Quick-exhaust dump valves are specific valves used if quick response is required (e.g. HIPPS function). Relief valves are normally PSV valves.

NOTE 2 Valves of a specific type not defined in this table should be coded as OH (Others) with a comment specifying type description. Example: Clack- or Elastomer-type Deluge valves).

*Table 13 - Type classification - Valves. Reference [7] page 116.*

  - Because the function and structure of the cut-off valve is uncertain, the valve is marked with XX where the equipment type usually is presented. The emergency cut-off valve is not described in the NOV user manual and can be of the various types as listed above.

- Hose (hydraulic) – XXXX00
  - The equipment class and equipment type are not specified in the ISO 14224:2016 standard. A possible suggestion is equipment class is hose (HO), and equipment type is categorized as hydraulic (HY). This results in the object code HOHY00.

### *Route*

A route will connect all items that demand the same maintenance activity at the same interval of time. Object class is used to systemize and connect the items that belong in a route. The company utilizes resources in the best possible way.

Example of route explained below, is provided in appendix 2, sheet 4.

Example of Route (1) – sockets

This route contains all items in the tag list that are sockets. They all have the same object class and are easy to find in a digital system. All sockets require the same maintenance activities at the same interval of time.

Example of Route (2) – Lights.

This route combines two types of object classes: Machine House Light and Light. These two categories of light require the same maintenance activities at the same interval of time. The light is categorized for other purposes than route. Also, for systemizing the technical hierarchy and making it easy to find a tag in a digital system.

## 4.3 Technical Hierarchy

The technical hierarchy is systemized from the tags provided by our supervisor Alexander Hatland. The assignment adds another "hierarchy group" and will change the names accordingly when building the hierarchy, relative to what Rausand & Vatn presents. Rausand & Vatn presents a systemization that includes plant, system, subsystem, analysis item and finally components [11] page 82-83. The assignment was found to have a complex system, containing a lot of tags, and therefore a need for a more advanced system build-up.

The thesis will consist of six technical hierarchy groups. The system is first divided into subsystems. Further, the subsystems are divided into multiple units, and the units are divided into components. At last, the components are divided into individual items. These are items with tag numbers that show their physical localization in the technical hierarchy. The system number for each item, developed in the assignment is a tool for categorization and localization in the digital technical hierarchy. Items can consist of multiple subitems, these will be in the last division. The size of the technical hierarchy is depending on how complex the system is. For this specific system there is six different groups.

Below is an illustration of how the technical hierarchy is systemized.

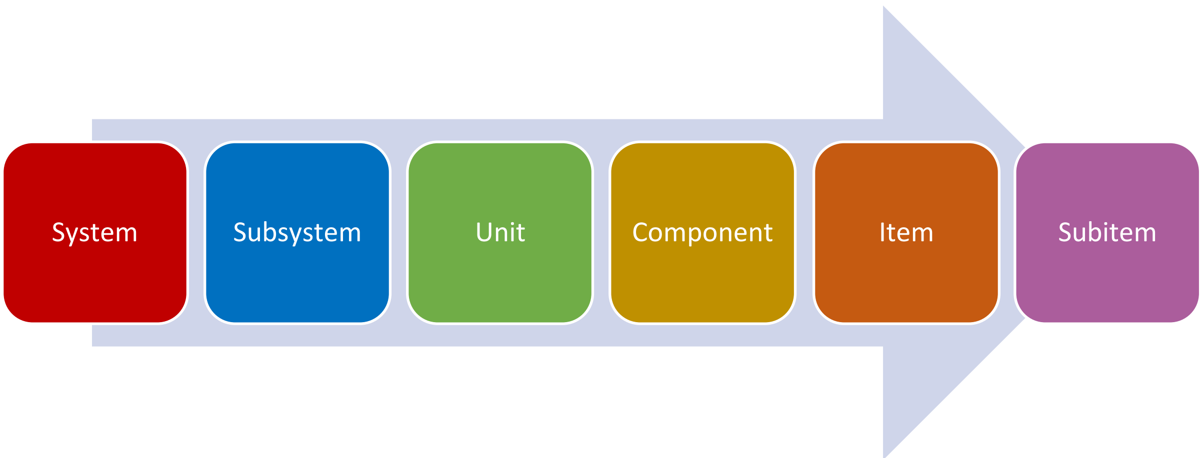



*Figure 7 - Technical Hierarchy division illustration*

The system number consists of nine numbers. The first three of which correspond to the system, specifically "361" for the crane in this instance. The subsequent three digits represents the system, subsystem, and unit. The last three digits describes component, item and subitem. The whole number itself is the finalized system number.

The subsystems are listed below.

**System: 361.100.000**

**Subsystem:**

| | |
|---|---|
| Structure | 361.110.000 |
| Instrumentation | 361.120.000 |
| Operators Cabin | 361.130.000 |
| Hydraulic System | 361.140.000 |
| Hoisting System | 361.150.000 |
| Ventilation, Lights and Sockets | 361.160.000 |

For understanding and description of the subsystems, units, components, items and subitems, this report is based on one of the subsystems. The report will take example in the hydraulic system – 361.140.000. The technical hierarchy is shown appendix 2, sheet 1 and the distribution of items in sheet 2.

The technical hierarchy is illustrated in Figure 8 below.


*Figure 8 - Technical Hierarchy flowchart example*

The hydraulic system is divided into units as listed below.

**Subsystem: 361.140.000**

| | |
|---|---|
| Package electrical motors | 361.140.100 |
| Pump | 361.140.200 |
| Accumulator | 361.140.300 |
| Oil and filtration | 361.140.400 |
| Heater and cooler | 361.140.500 |
| Hose | 361.140.600 |
| Cylinder | 361.140.700 |
| Sensors | 361.140.800 |
| Solenoid valves | 361.140.900 |

The hydraulic system of the crane, shown in figure 9 – P&ID (with categorization), is categorized as one subsystem. For more detailed figure, see the P&ID attached in appendix 1. The figure below describes the hydraulic system of the crane. The P&ID includes valves, motors, pumps, pressure measures and more.

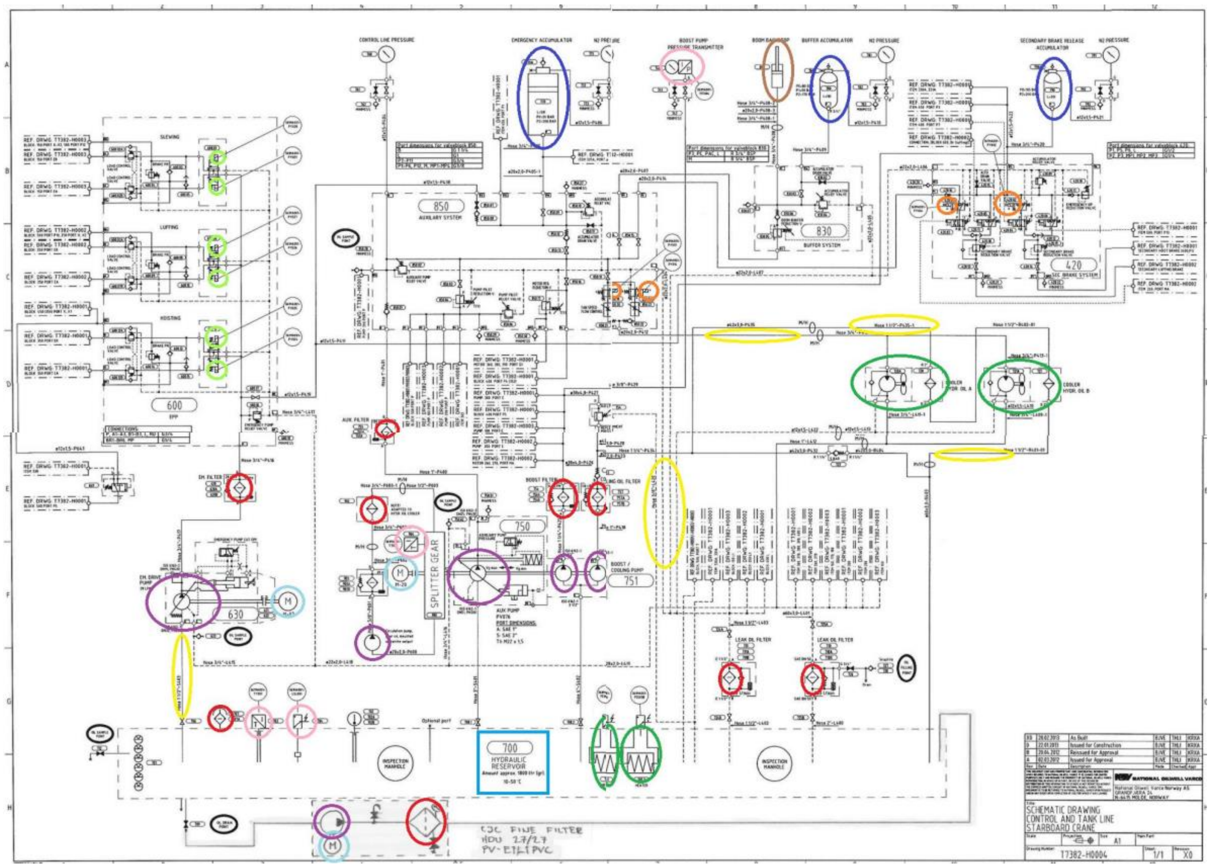



*Figure 9 - P&ID (with categorization)*

Further, the units are divided in components, for example: Package electrical motors – 361.140.100.

| | |
|---|---|
| **<u>Item: 361.140.161</u>** | |
| **Subitem:** | |
| EM drive hoist down | 361.140.161.100 |
| EM drive hoist up | 361.140.161.200 |

| | |
|---|---|
| **<u>Unit: 361.140.100</u>** | |
| **Component:** | |
| Main | 361.140.110 |
| Cooler | 361.140.120 |
| Slewing | 361.140.130 |
| Luffing | 361.140.140 |
| Hoist | 361.140.150 |
| EM drive | 361.140.160 |

The components within EM drive are marked in Figure 9 – *P&ID (with categorization*) as light green. The items that are included in this section is listed below with their belonging tag number.

| | |
|---|---|
| **<u>Component: 361.140.160</u>** | |
| **Item:** | |
| EM drive hoist | 361.140.161 |
| EM drive slew | 361.140.162 |
| EM drive luffing | 361.140.163 |

In addition to dividing units into components, the components are further divided into items if expedient.

This shows how subitem 361.140.161.100 can be “found” among the list of tags belonging to the crane. The cranes motion signals are electric driven, and EM drive hoist down is an electromagnet that controls the cranes hoist motion, going down. It is beneficial for the company to use the technical hierarchy to find the maintenance register on the item, to be able to perform maintenance activities on the item or subitem.

## 4.4 FMECA (for 630)

Referring to the activity regulation, established by PSA *§ 46 Classification* – “Facilities' systems and equipment shall be classified as regards the health, safety, and environment consequences of potential functional failures. For functional faults that can lead to serious consequences, the responsible party shall identify the various FMs with associated failure causes and failure mechanisms and predict the likelihood of failure for the individual FM. The classification shall be used as a basis in choosing maintenance activities and maintenance frequencies, in prioritizing between different maintenance activities and in evaluating the need for spare parts” [5].

This regulation is complying by performing FMECA. The FMECA in this assignment consist of chapter 4.5 FFA, 4.6 Critical Item selection, and 4.7 Maintenance Plan.

## 4.5 FFA

The activity regulation *§ 47 Maintenance programme* states that: *FMs that may constitute a health, safety or environment risk, cf. Section 46, shall be systematically prevented through a maintenance program that shall include activities for monitoring performance and technical condition, which ensure identification and correction of FMs that are under development or have occurred. The programme shall also contain activities for monitoring and control of failure mechanisms that can lead to such FMs* [10].

*System 630*

System 630 is an emergency system that uses and operates with a pump that delivers a variable accrual volume, an electrical motor, an emergency cut-off valve and hoses that connect the system together and contains hydraulic oil. Beneath is a picture of the system. The remaining part of the assignment is specified for system 630. System 630 is shown below in the P&ID of the hydraulic system in figure 10 – *P&ID, System 630*.

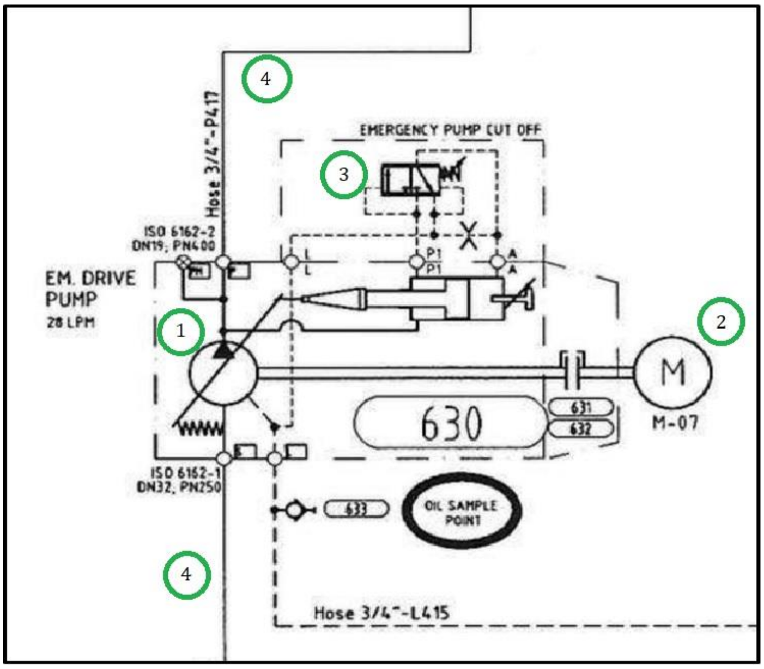



*Figure 10 - P&ID, System 630*

The items from system 630, included further in the analysis is the maintainable items listed below. See figure 10 – *P&ID, system 630.*

- Emergency drive pump (1)
- Electrical motor (2)
- Emergency pump cut-off valve (3)
- Hose(s) (4)

### 4.5.1 Function and function failure

*Pump*

The pump is an axial piston pump with swashplate. The oil flow from the pump can be varied from zero to maximum by varying the pump displacement by swivelling the swashplate [19] page 48.

A hydraulic piston pump is an adjustable pump making it able to deliver high pressure over a long period of time. The pump is regulated by a swashplate with a rotating shaft and cylinder block. When the pump is running, the swashplate and cylindric block are rotating with the shaft. There are several pistons connected to the swashplate that goes in and out of the cylinders on the cylinder block [36]. The pump in the emergency system is activated either automatically or manually by an emergency stop button. The area in the two cylinders changes, the swashplate adjusts accordingly, and the oil flow will go in the intendent direction [36].

Below is a list of the pumps function and function failures.

| **Function** | **Function failure** |
|---|---|
| 1. Initiate and transfer a fluid flow | 1. Unable to transfer fluid flow |
| 2. Produce necessary flow to maintain a certain pressure. | 2. Produces too low flow rate |
| 3. To contain the fluid on the inside of the system | 3. Leakage |
| 4. Start and stop when needed | 4. Does not start/stop |

*Table 14 - Function/function failure for emergency drive pump*

### *Electric motor*

The electric motor converts the electrical energy into rotational mechanical power. This is done through the interaction between a stationary part, known as the stator, and a moving part known as the rotor. The air gap between the stator and rotor is crucial to allow the rotor to spin. They both have an electric and a magnetic circuit [37] page 3.

Below is a list of the electric motor function and FMs.

| **Function** | **Function failure** |
|---|---|
| 1. Convert electrical energy to mechanical energy. | 1. Does not produce mechanical energy |
| 2. Produce the energy to drive the pump. | 2. Does not produce energy to the pump |
| 3. To contain the fluid on the inside of the system | 3. Leakage |
| 4. Start/stop when needed | 4. Does not start/stop |

*Table 15 - Function/function failure for electric motor*

### *Cut-off valve*

The valve is an Emergency Pump Cut-off Valve (3/2). It has three gates for inlet, output, vents, and two flow paths, and two boxes. The cut-off valve controls the flow direction. It can be controlled automatically, electric, mechanically, pneumatically, electric, or manually. The cut-off valve has an overload safety function, so the valve will prevent the crane from functioning when the systems pressure reaches a given value [19] page 46.

Below is a list of the cut-off valve function and FMs.

| **Function** | **Function failure** |
|---|---|
| 1. Flow direction control | 1. Does not control the direction of the flow |
| 2. Prevents excess pressure by regulating the actuators output | 2. High pressure can cause hoses to burst, leading to leaks |

*Table 16 - Function/function failure for emergency cut-off valve*

### *Hose*

Below is a list of the function and FMs to the hoses.

| **Function** | **Function failure** |
|---|---|
| 1. Transports viscose fluid inside the system. | 1. Does not transport the fluid |
| 2. To contain the fluid on the inside of the system | 2. Leakage |

*Table 17 - Function/function failure for hose*

### 4.5.2 FM Codes

Below is a list of the FMs that can, or at some point will occur to the items. These are carried out from the standard ISO 14224:2016, table B.6 and B.7 [14] page 187-189. Each FM has a FM code, which is included in the list.

| | |
|---|---|
| AIR | Abnormal instrument reading |
| BRD | Breakdown |
| DOP | Delayed operation |
| ERO | Erratic output |
| ELP | External leakage – process medium |
| ELU | External leakage – utility medium |
| FRO | Failure to rotate |
| FTC | Failure to close on demand |
| FTO | Failure to open on demand |
| FTS | Failure to start on demand |
| HIO | High output |
| INL | Internal leakage |
| LCP | Leakage in closed position |
| LOO | Low output |
| NOI | Noise |
| OHE | Overheating |
| OTH | Other |
| PDE | Parameter deviation |
| PLU | Plugged / choked |
| PTF | Power/signal transmission failure |
| SER | Minor in – service problems |
| SPO | Spurious operation |
| STD | Structural deficiency |
| STP | Failure to stop on demand |
| UNK | Unknown |
| UST | Spurious stop |
| VIB | Vibration |

### *Failure Mechanisms and failure cause*

Failure mechanism is a following consequence from failure cause. The failure mechanisms are listed in appendix 2, sheet 3. The failure mechanisms used from ISO 14224:2016 are mechanical failure such as leakage and vibration, material failure such as overheating and wear, instrument failure such as faulty signal and control failure, electrical failure such as no power and faulty power, external failure such as plugged and miscellaneous failures [14] page 179-180.

The listed failure mechanisms in appendix 2, sheet 3, originate from the same failure cause: failure related to operation/maintenance.

### *Detection method*

This is the method or activity where a failure is discovered. This information is vitally important when evaluating the effect of maintenance, e.g., to distinguish between failures discovered by a planned action (inspection, PM) or by chance (casual, observation) [14] page 182-183.

How the failure is detected indicates if the failure is hidden or evident, or both. For example, if a failure is detected by casual observation is it an evident failure. If a failure is detected by a periodic maintenance activity as functional testing, when no prior sign of function failure, is the failure categorized as hidden. A failure can also be categorized as both hidden and evident.

*Analysis result*

| FM | Failure mechanism | Failure cause | Maintainable item |
|---|---|---|---|
| AIR | Instrument failure | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve |
| BRD | Miscellaneous | Failure related to operation/ maintenance | Pump, electrical motor |
| DOP | Miscellaneous | Failure related to operation/ maintenance | Cut-off valve |
| ELP | Mechanical failure (leakage) | Failure related to operation/ maintenance | Pump, hose |
| ELU | Mechanical failure (vibration) | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve |
| ERO | Instrument failure/ mechanical failure | Failure related to operation/ maintenance | Pump, electrical motor |
| FRO | Material failure/ mechanical failure | Failure related to operation/ maintenance | Pump |
| FTC | Instrument failure | Failure related to operation/ maintenance | Cut-off valve |
| FTO | Instrument failure | Failure related to operation/ maintenance | Cut-off valve |
| FTS | Instrument failure/ electric failure | Failure related to operation/ maintenance | Pump, electrical motor |
| HIO | Instrument failure | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve |

| | | | |
|---|---|---|---|
| INL | Mechanical failure (leakage) | Failure related to operation/ maintenance | Pump, cut-off valve |
| LCP | Mechanical failure | Failure related to operation/ maintenance | Cut-off valve |
| LOO | Electrical failure (general) | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve |
| NOI | Material failure/ mechanical failure | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve, |
| OHE | Material failure | Failure related to operation/ maintenance | Pump, electrical motor, hose |
| OTH | Miscellaneous | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve, hose |
| PDE | Instrument failure | Failure related to operation/ maintenance | Pump, electrical motor |
| PLU | External influence (plugged) | Failure related to operation/ maintenance | Pump, cut-off valve, hose |
| PTF | Instrument failure | Failure related to operation/ maintenance | Hose |
| SER | Instrument failure/ electric failure | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve, hose |
| SPO | Miscellaneous | Failure related to operation/ maintenance | Cut-off valve |
| STD | Mechanical failure (vibration) | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve, hose |
| STP | Instrument failure/ electric failure | Failure related to operation/ maintenance | Electrical motor |

| | | | |
|---|---|---|---|
| UNK | Miscellaneous | Failure related to operation/ maintenance | Pump, electrical motor, cut-off valve, hose |
| UST | Miscellaneous | Failure related to operation/ maintenance | Pump, electrical motor |
| VIB | Mechanical failure (vibration) | Failure related to operation/ maintenance | Pump, electrical motor, hose |

*Table 18 - FFA results*

## 4.6 Critical Item Selection

All the parts in the system 630 – *Emergency system* have been assessed to be an FSI. The emergency drive pump and electrical motor have been assessed to be a MCSI as well. As the emergency system is composed solely of critical items, there will be no treatment of non-MSI included in results.

Below is an extract from the analysis done in excel, displaying the three risk statuses possible.

**630 - Emergency Drive Pump, example:**

S (safety), Eco (economic), Env (environment), Max (maximum)

| FFA | Critical Item Selection | | | | | | | | Evaluation |
|---|---|---|---|---|---|---|---|---|---|
| **FM** | **PoF** | **CoF (S)** | **CoF (Eco)** | **CoF (Env)** | **Risk (S)** | **Risk (Eco)** | **Risk (Env)** | **Risk (Max)** | **Status** |
| ERO | 1 | 3 | 3 | 1 | 1 - Low | 1 - Low | 1 - Low | 1 - Low | 1 - Pass |
| ELU | 3 | 2 | 2 | 2 | 2 - Medium | 2 - Medium | 2 - Medium | 2 - Medium | 2 - Pass with condition (s) |
| NOI | 4 | 2 | 1 | 3 | 2 - Medium | 2 - Medium | 3 - High | 3 - High | 3 - Fail |

*Table 19 - Critical item selection result*

Beneath is a table explaining why the FMs has been given “1- Pass” and “2 - Pass with condition(s)” for the Emergency Drive Pump. The FMs with risk status “3 - Fail” for the complete system 630 – *Emergency System*, will be explained later.

| FM | Status | Comments |
|---|---|---|
| ERO | 1 - Pass | Low Risk (Safety) - Not likely to affect workers<br><br>Low Risk (Economic) - Affordable to change sensor<br><br>Low risk (Environment) - Does not affect the environment |
| ELU | 2 – Pass with condition(s) | Medium Risk (Safety) - Workers can get in eye or slip<br><br>Medium Risk (Economic) - Change of part can lead to down-time<br><br>Medium Risk (Environment) - Fluid can leak into the sea and affect marine life |

*Table 20 - FM status, with comments*

### 4.6.1 Risk evaluation

Below is a table of the critical FMs, that has been given the risk status “3 -fail” for the 630 – Emergency Drive System.

| FM | Risk evaluation (Status) | Maintainable item | Comments |
|---|---|---|---|
| FTS | 3 – Fail | Emergency Drive Pump | High risk (Safety) - If failed: Emergency pump will not work.<br><br>High risk (Economic) - Will result in downtime and change of pump.<br><br>Low risk (Environment) - Little to no effect on environment. |
| | | Electrical Motor | High risk (Safety) - If failed: Emergency system will not start.<br><br>High risk (Economic) - Result in downtime and change/reparation.<br><br>Low risk (Environment) - Little to no effect on environment. |
| FRO | 3 – Fail | Emergency Drive Pump | High risk (Safety) - If failed: Emergency pump will not work.<br><br>Medium risk (Economic) - May result in downtime and change/reparation.<br><br>Low risk (Environment) - Little to no effect on environment. |
| NOI | 3 – Fail | Emergency Drive Pump | Medium risk (Safety) - High noise can affect workers close to the pump.<br><br>Medium risk (Economic) - noise indicates that there is something wrong with the pump.<br><br>High risk (Environment) - Due to wildlife, noise can be harmful. |

| | | | |
|---|---|---|---|
| PLU | 3 – Fail | Cut-off valve | High risk (Safety) – Valve being choked can cause high pressure and stop flow.<br><br>Low risk (Economic) – Affordable to change valve.<br><br>Low risk (Environment) – Will not affect the environment. |
| | | Hose | Medium risk (Safety) – Can burst and cause workers to get in eye or slip on the fluid.<br><br>High risk (Economic) – Reduce flow and change of part will cause downtime.<br><br>Medium risk (Environment) – Fluid can leek to the sea and affect marine life. |

*Table 21 - Risk evaluation result*

### 4.6.2 FMECA result

The FMECA result is consisting of a close visual inspection for the emergency pump, electric motor, cut-off valve and hose every 6th month.

The table below shows FMs with high risk, the critical items that are exposed for them, the risk evaluation, recommended maintenance activities and intervals for the items.

| FM | Risk evaluation (Status) | Maintainable Items | Recommended maintenance activities | Recommended maintenance intervals |
|---|---|---|---|---|
| FTS | 3 – Fail | - Emergency pump<br>- Electrical motor | Close visual inspection | 6 months |
| FRO | 3 – Fail | - Emergency pump | Close visual inspection | 6 months |
| NOI | 3 – Fail | - Emergency pump | Close visual inspection | 6 months |
| PLU | 3 – Fail | - Cut-off valve<br>- Hose | Close visual inspection | 6 months |

*Table 22 - FMECA result*

Close visual inspection will be described in the work description. The work description can refer to other work descriptions, for example if any damage, dirt, or abnormalities are found during an inspection, and actions must be taken.

## 4.7 Maintenance plan

There are seven different maintenance activities in the PSA regulations which are recommended to follow when the maintenance plan is being made. The activity regulation § 47 *Maintenance program* describes that:

> *The program shall include activities for monitoring performance and technical condition, which ensure identification and correction of FMs that are under development or have occurred. The program shall also contain activities for monitoring and control of failure mechanisms that can lead to such FMs* [10].

An overall plan shall be prepared for conducting the maintenance program and corrective maintenance activities, cf. Section 12 of the Management Regulations [9].

### 4.7.1 Maintenance demands

Maintenance demands from PSA (law regulation authority), NMA (law regulation authority), DNV (MOU classifications company) and NOV (manufacturer).

| | PSA | NMA | DNV | NOV |
|---|---|---|---|---|
| **Offshore crane** | The responsible party shall ensure that facilities or parts are maintained, so that they are capable of carrying out their required functions in all phases of their lifetime.<br><br>Criteria shall be available for setting priorities with associated deadlines for carrying out the individual maintenance activities. | Five-year inspection<br><br>The inspector must assess the complete dismantling and dismantling of devices and equipment, even if the guidelines from the crane supplier do not require it. The assessment must take account of age, use, lifetime calculations, experience history and possibly condition monitoring to detect stretching, wear, corrosion and the formation of fractures and cracks. | Annual inspection of emergency stop function. | Testing of the emergency system every 12 months<br><br>Filter changes every 12 months. |
| **Emergency pump** | | Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Annual inspection of emergency stop function. | Test of emergency system every 12 months.<br><br>Filter changes every 12 months.<br><br>Replacement 12 000-15 000 running hours. |

| | | | | |
|---|---|---|---|---|
| **Electrical motor** | | Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Annual inspection of emergency stop function. | Test of emergency system every 12 months.<br><br>Inspection/draining every year.<br><br>Lubrication every second year.<br><br>Replacement after 20 000 running hours. |
| **Cut-off valve** | | Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Annual inspection of emergency stop function. | Test of emergency system every 12 months.<br><br>Testing every 12 months<br><br>Replacement every 5 years. |
| **Hose** | | Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Annual inspection of emergency stop function. | Test of emergency system every 12 months.<br><br>Inspection every 6 months.<br><br>Replacement every 5 years. |

*Table 23 - Maintenance demands from PSA, NMA, DNV and NOV*

### *NMA*

Based on the Ship Safety Act, regulation No. 2381 of 21 December 2017 is implemented on cranes and lifting on mobile devices. Offshore cranes must be constructed with a safety level that corresponds to:

a) EN 13852-1:2013 "Part 1: Offshore cranes for general use", or b) DNV GL-ST-0378 "Standard for offshore and platform lifting appliances". Alternatively, a standard with an equivalent security level from another MOU class company can be used.

For alternative b, annual and five-yearly inspection of offshore cranes must be carried out by the MOU class company that owns the standard, cf. § 19. There are also provisions in § 20 about inspection of offshore cranes after overloading or damage, where this must be carried out by the MOU class company [38].

The statutory inspections and test must be carried out in accordance with the crane supplier's guidelines. NMA has legislated that mobile facilities must have a request for inspection when it has been built, when there is a need for an issued certificate, audit for working and living conditions, inspection, in the event of an accident or damage, if the facility is to be transferred to the Norwegian ship register, and in several cases. This process takes place through NMA, unless the company chooses an MOU company. For example, DNV [39].

The company is responsible to meet DNV's requirements to be approved by the NMA and can start/continue normal operation.

### *PSA*

The requirements and demands from PSA, do not give specific timing when to replace and inspect different equipment.

The activity regulation *§ 48 Planning and prioritisation* says that an overall plan shall be prepared for conducting the maintenance programme and corrective maintenance activities, cf. section 12 of the Management regulations [9].

The paragraph adds that criteria shall be available for setting priorities with associated deadlines for carrying out the individual maintenance activities [9].

The demands provided by PSA means that the company is responsible for developing a maintenance plan that specifies when and what to perform the calculated maintenance activities. PSA does not have any suggestions for a maintenance plan. It is up to the company to make a feasible and approved maintenance plan for all maintainable items.

### *DNV*

NMA states that the 5-year inspection is done according to the MOU company's guidelines. DNV writes on their homepage that as an alternative to the traditional 5-year inspection approach, maintenance is performed in accordance with recommendations made by the Original Equipment Manufacturer (OEM).

"Performing inspection and maintenance at 5 yearly intervals will in many cases not be an optimal solution. This type of maintenance is usually not adjusted according to operational conditions and experience and will in some cases result in too much or insufficient maintenance" [40].

The classification company is referring to the maintenance demands established by the producer company. These demands are more accurate and covers specific equipment at an item level.

"Drill planned maintenance service (PMS) and Machinery PMS are survey arrangements for drilling equipment and machinery equipment respectively as an alternative to more traditional survey arrangements with 5 yearly inspections. The survey arrangements are based on a PM approach with a planned maintenance system containing predetermined maintenance tasks, acceptance criteria and intervals in accordance with OEM" [40].

The benefits with this approach are that it is cost efficient, the company develops and keeps relevant maintenance competence on board, it promotes cooperation and experience exchange between the company and OEM, the company and OEM, there are no requirement for 5 year inspection, the company and OEM shares maintenance functions and it is a tool for documenting sufficient maintenance effort and competence [40].

NORSOK R-003 states that control of the crane and its equipment should be carried out according to manufactures recommendations at least every 12$^{th}$ month or more often depending on the operational mode and environmental factors [41] page 17.

Further, the standard states that the control may be extended to a longer period when justified by the enterprise of competence. The control may also be shorter than 12 months due to environmental conditions [41] page 18.

According to DNV-ST-0378, the emergency stop function at the crane shall be surveyed during annual survey [18] page 114.

*NOV*

According to NOV recommendations, the replacement of components should be carried out by qualified personnel based on either running hours or yearly intervals. Only components that have high criticality are included in the replacement list. Hoses, for example, are recommended for replacement every five years, while the replacement of other selected components is based on running hours rather than yearly intervals.

Electrical motors are recommended for replacement once they have surpassed 20,000 running hours, whereas pumps should be replaced between 12,000 to 15,000 running hours.

### 4.7.2 Maintenance activities and interval based on demands

The maintenance demands provided by the agencies, classification company and manufacturer company are not comprehensive. It is stated in the standard NS-EN 14492-2:2019 *Cranes: Power driven winches and hoists, part 2: power driven hoists* that methods to be used to verify conformity with the safety requirements for an emergency stop function would be the general verification methods: functional check and visual inspection [43] page 52.

Below is a list of the maintenance demands from PSA, NOV, NMD and DNV merged. Additionally, to the result from the FMECA, this is attached in appendix 2, sheet 3.

| | |
|---|---|
| The offshore crane | |
| ○ Test and inspection of the offshore crane | (12 months) |
| ○ Test and inspection of the offshore crane | (5 years) |
| ○ Filter change | (12 months) |
| Emergency drive system | |
| ○ Test and inspection of emergency system | (12 months) |
| Emergency drive piston pump | |
| ○ Replace | (12 000 – 15 000 running hours) |
| ○ Close visual inspection | (6 months) |
| Electrical motor | |
| ○ Inspection and/or draining | (12 months or 2000 running hours) |
| ○ Lubrication | (24 months or 4000 running hours) |
| ○ Replace | (20 000 running hours) |
| ○ Close visual inspection | (6 months) |
| Emergency cutoff valve | |
| ○ Test | (12 months) |
| ○ Replace | (5 years) |
| ○ Close visual inspection | (6 months) |
| Hose | |
| ○ Replace | (5 years) |
| ○ Close visual inspection | (6 months) |

*Table 24 - FMECA results combined with demands from PSA, NMA, DNV and NOV*

### *Activity description*

Description of the maintenance activities is described in NOV user manual and the standard NS-EN ISO 14224:2016 as listed below.

- Filter change – Change of filter elements [42] page 27.
- Replacement – Replacement of the item by a new or refurbished item of the same type [14] page 184.
- Close visual inspection – Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Lubrication – Apply grease with grease gun or brush [42] page 27.
- Inspection and/or draining – Combination: Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [NOV] Draining of oil/fluid [42] page 27.
- Test – Periodic test of function or performance [14] page 184.
- Test and inspection of offshore crane – Combination: several of the above activities are included [14] page 184.

For descriptions and interpretation of the adjusted maintenance activities, the activities are divided into three levels.

1. First-hand maintenance – activities that do not require any physical work. Such as inspection and visualization.

2. Second hand maintenance – activities that requires qualified personnel such as testing of equipment, draining, lubrication, cleaning, adjusting etc.

3. Third hand maintenance – replacement or partly replacement of equipment.

Activities for monitoring and control of failure mechanisms is interpreted as visual inspections, documentation routines for logging activities, failure mechanisms and operation time.

From NOV Linus, Starboard Crane user manual, it is stated that visual inspection of a hydraulic hose is the easiest way to prevent hose breakage and discover damages on the hose. (NOV, 5.8.2) A close visual inspection is a first-hand maintenance activity.

### *Operation time*

The emergency system of a crane, like all other systems, undergoes wear and tear over time due to factors such as usage, aging, material load, weather, and operation time. To comply with the maintenance requirements set forth by NOV, the electrical motor and hydraulic pumps of the emergency system should be replaced after a specified number of running hours. However, to optimize the lifespan of these components, an assessment must be made of how the equipment has been used during its operation time. It should be noted that electrical motors and hydraulic pumps experience less wear and tear when used continuously for an extended period than when frequently used over the same duration. This can lead to significant economic benefits for the company, such as being able to use the electrical motor at an optimal operating level for a longer duration than recommended based on its previous lifespan.

The NMA demands that companies operating offshore cranes follow the guidelines for maintenance set forth by MOU classification companies. Additionally, DNV recommends that companies adhere to the manufacturers' recommendations for the maintenance of the crane equipment. However, DNV also acknowledges that companies may deviate from the manufacturers' recommendations if such deviations can be justified by their competence. Therefore, a thorough and carefully considered analysis is required to determine if it is appropriate to extend the manufacturers' maintenance specifications.

### *Documentation*

Maintenance is properly documented to help the company establish an information base on failure data such as MTBF. This can indicate if there are missing needed maintenance activities for an item if something can be wrongly maintained or produced. The data includes tag number, drawings, past maintenance data, design details and task descriptions. Documentation of previous work can be used when making a new and improved maintenance plan. If one objects continuously fails or have problems, it can be replaced. PSAs activity regulation *§ 48 Planning and prioritisation* states: “An overall plan shall be prepared for conducting the maintenance programme and corrective maintenance activities”.

According to IEC, in-service feedback is important for the maintenance programme to evolve each time it is revised. The process involves the accumulation of experience through the operation of equipment, coupled with the identification and analysis of in-service failures. Information like, failure times and dates, causes of failure, maintenance times, inspections efficiency should be collected to make the revisions.

*Feedback*

The maintenance programme from the RCM analysis is continuously updated. This is one of the advantages of doing the RCM analysis. The updated process can be implemented and revised to make an even better plan [11] page 99. Therefore, updated information must be accessible to all employees to ensure communication between all shifts working. This is done by documenting it in writing to a system used by the operators.

### 4.7.3 Execution of maintenance plan

For execution of the maintenance plan, an individual risk analysis is needed for the calculated maintenance activities from this report. This chapter highlights the importance of the requirement of a risk analysis due to safety, environment, and economics. Often accidents occur either during maintenance or because of inadequate maintenance. Risks must be considered regarding the different maintenance tasks and conditions such as weather and temperature.

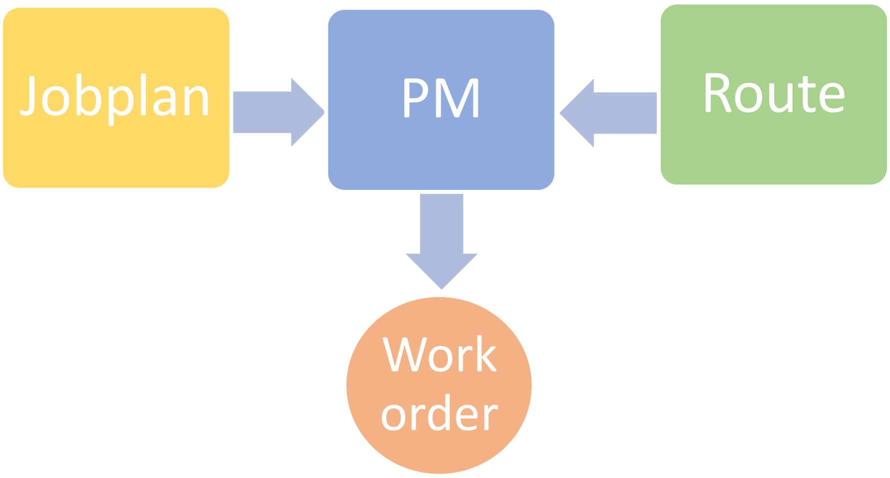



*Figure 11 - Relation between job plan, PM, route, and work order*

Incorrect crane operation or faulty work on the crane could cause dangerous situations and result in serious injury or death [43] page 8. Due to safety, following jobs should only be carried out by qualified personnel, trained, and approved by NOV, dept. Molde. Including opening of the hydraulic system, adjustment of the hydraulic system, adjustment or changes to the control system or PLC, adjustment or changes to critical components and systems involving safety [43] page 8.

NOV user manual for OC-L STBD crane has attached job definitions for their demanded maintenance activities. Work description from NOV user manual specifies that service personnel, personnel with the required competence who are trained to operate and/or maintain the crane can, for example, replace hydraulic oil filter [42] page 146.

### *Work description*

A work plan includes a detailed description of how to implement the given maintenance task, and the measures that need to be carried out before the task can be done. The maintenance shall be planned with the priority; 1. Safety, 2. Reliability, 3. Availability [27] page 15.

The maintenance engineer has the responsibility to schedule, inspect and conduct maintenance for the equipment. A maintenance activity generated as a result of the RCM analysis need additional details before they can be implemented in line with the maintenance concept [15] page 30, according to the standard IEC60300-3-11, the details might include:

a) time to undertake the task,

b) skills and minimum number of people required at each maintenance echelon,

c) procedures,

d) health and safety considerations,

e) hazardous materials,

f) spares at each maintenance echelon,

g) tools and test equipment,

h) packaging, handling, storage and transportation [15] page 30.

The manufacturers company makes the work description for maintenance on their equipment. This is combined with a risk analysis from the operating company. Risk analysis is made in advance of the work and is individually for each time, place, and job task. If the operating company performs activities that are not demanded by the manufacturer company, an individual and specified work description is made.

Work description can be carried out by personnel that have the required knowledge and are trained to operate and/or maintain the crane, where it is not necessary to have special and detailed expertise in the various systems and /or the need for certified personnel [19] page 11.

# 5. Odfjell Technology's procedures in line with RCM result

This chapter will highlight Odfjell Technology's ongoing maintenance procedures, with activity description taken from the ISO 14224:2016 standard and NOV user manual. The procedures are compared with the RCM result described in table 24 – *FMECA results combined with demands from PSA, NMA, DNV and NOV*. Similarities and differences are listed. The chapter also contains a brief description of Odfjell Technology's maintenance philosophy.

## 5.1 Odfjell Technology's PM procedures

**Deck crane:**

| | |
|---|---|
| 1M | DECK CRANE MARINE INSPECTION |
| 3 M | DECK CRANE MECHANICAL INSPECTION |
| 3 M | CRANE ELECTRICAL INSPECTION |
| 6 M | DECK CRANE MECHANICAL INSPECTION |
| 12 M | DECK CRANE MARINE INSPECTION |
| 12 M | CRANE ELECTRICAL INSPECTION |
| 60 M | DECK CRANE MARINE SURVEY & LOAD TEST |
| 12 M | INTEGRITYCHECK DECK CRANE 1 |
| 12 M | EX BARRIER DECK CRANE 1 |

*Table 25 – Odfjell Technology's procedures - Deck crane*

**Emergency drive system:**

| | |
|---|---|
| 1 M | CRANE EMERGENCY STOP FUNCTION TEST |

*Table 26 – Odfjell Technology's procedures - Emergency drive system*

**Electrical motor (Route):**

| | |
|---|---|
| 12 M | EL MOTOR CHECK DECK CRANES |
| 12 M | EL MOTOR CHECK DECK CRANES |

*Table 27 – Odfjell Technology's procedures - Electrical motor*

**Hose:**

| | |
|---|---|
| 6 M | HIGH PRESSURE HOSE PERIODIC INSPECTION - HOSE INSPECTION STDB CRANE |
| 6 M | HOSE INSPECTION STDB CRANE |

*Table 28 – Odfjell Technology's procedures – Hose*

**Emergency Drive Pump:**

| | |
|---|---|
| 12 M | PISTON PUMP - CHECK OF PUMPS PIPECRANE |

*Table 29 – Odfjell Technology's procedures - Emergency drive pump*

**Emergency Pump Cut-off Valve (3/2):**

| | |
|---|---|
| Run-to-failure (CM) | Cut-Off Valve |

*Table 30 – Odfjell Technology's procedures - Emergency cut-off valve*

## 5.2 Activity description (NOV user manual and ISO 14224:2016)

- Marine inspection – Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Mechanical inspection – Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Electrical inspection - Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Marine survey & load test – Periodic test of function or performance [14] page 184.
- Integrity check – The cause of the failure is investigated, but no maintenance action performed, or action is deferred. Able to regain function by simple actions, e.g., restart or resetting [14] page 184.
- Function test - Periodic test of function or performance [14] page 184.
- Check - The cause of the failure is investigated, but no maintenance action performed, or action is deferred. Able to regain function by simple actions, e.g., restart or resetting [14] page 184.
- High pressure inspection - Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Inspection – Periodic inspection/check: a careful scrutiny of an item carried out with or without dismantling, normally by use of senses [14] page 184.
- Inspection of oil levels, limits, pressure, temperatures, bolt torques, hoses, of high stress components, welding etc. [42] page 27.
- Ex barrier deck crane test – the crane is used for emergencies, for example fire where it is used as an evacuation equipment and for that reason it is critical to always work. The test is to check that the crane works as intended.
- Integrity check – A general inspection where the crane gets checked for damage and defects and that it operates as intended.

Referring to the results presented in chapter 4.7.2 – *Maintenance activities and interval based on demand*, additional to the procedures presented in 5.1 – *Odfjell Technology's PM procedures*. The differences between the two maintenance plans can be summarized as:

### Similarities:

- Test and inspection of offshore crane each 12 months
- Test and inspection of offshore crane each 5 years
- Test and inspection of emergency system each 12 months
- Electrical inspection/electric motor close visual inspection each 6 months
- Mechanical inspection/emergency drive piston pump close visual inspection each 6 months
- Electrical motor check each 12 months
- Hose inspection each 6 months

### Differences:

- Maintenance activities from the analysis result that are not listed in Odfjell's procedures.
    - Filter changes each 12 months
    - Emergency drive piston pump replacement each 12000-15000 running hours
    - Electrical motor lubrication each 4000 running hours
    - Electrical motor replacement each 20000 running hours
    - Emergency cut-off valve inspection each 6 months
    - Emergency cut-off valve replacement each 5 years
    - Hose replacement each 5 years

- Maintenance activities in Odfjell's procedures that are not listed in the result of the analysis.
    - Marine inspection of deck crane each month
    - Marine inspection of deck crane each 12 months
    - Mechanical inspection each 3 months
    - Electrical inspection each 3 months
    - Emergency drive piston pipe check each 12 months
    - Ex barrier deck crane each year
    - Emergency stop function test each month
    - High pressure hose inspection each 6 months

Some maintenance activities have different names, but the actions are alike. These are described below.

Odfjell Technology and Odfjell Drilling has experience and historic failure data in all fields they operate in. The knowledge can, in many cases, compensate the recommendation from the standards. Special periodic survey (SAP) is a five-year survey where the jack-up is inspected, components are replaced, and equipment disassembled and inspected further. The survey is a downtime period. This is done by Odfjell in cooperation with DNV and are listed as one single maintenance activity in their procedures. This is reason for some of the differences in the maintenance activities between Odfjell and the results from the analysis. In conversation with Odfjell, the survey is found to include the maintenance activities *emergency cut-off valve* – and *hose replacement, each 5 years.*

Further, in conversation with Odfjell Technology (ref. Alexander Hatland and Lars Garen) the maintenance activities such as electrical and mechanical inspection each 3 months is done to maintain the electrical motor at best possible way. According to the analysis result, is the motor supposed to be replaced after 20 000 running hours, and lubrication after 4000 running hours. Electrical and mechanical inspection is implemented to make sure that the electrical motor is in good shape. An inspection will cover multiple stages, this is specified in the work order, among other things: lubrication.

The Emergency drive piston pump replacement each 12000-15000 running hours is covered by Odfjell Technology in the same way as electrical motor. In their procedures is it listed mechanical inspection each 3 months, as well as emergency drive piston pipe check each 12 months.

The ex-barrier deck crane test each year does not deviate from the analysis result. Although, it is not considered in the analysis of the assignment. Therefore, it is not included in differences between the analysis results and Odfjell Technology’s procedures. The final differences in the procedures are listed below:

- Maintenance activities from the analysis result that are not listed in Odfjell Technology’s procedures.
    - Filter changes each 12 months
    - Emergency cut-off valve inspection each 6 months

- Maintenance activities in Odfjell Technology’s procedures that are not listed in the result of the analysis.
    - Marine inspection of deck crane each month
    - Marine inspection of deck crane each 12 months
    - Emergency stop function test each month
    - High pressure hose inspection each 6 months

### *Maintenance – Odfjell Technology*

The main objective within Odfjell Technology for maintenance analytics is to increase reliability, operability and reduce life cycle cost of the jack-ups and systems by monitoring potential FMs by means of data collection, evaluation and presentation e.g., connect data sources to the identified functional objects associated with identified FMs, monitor performance and initiate maintenance when required [44] page 15.

### *Odfjell Technology maintenance management analysis*

Odfjell Technology's maintenance management analysis approach can be interpreted in five steps, as described below.


*Figure 12 - llustration of Odfjell Technology's maintenance management analysis approach*

The first step – global standard contains the location of main functions, sub functions and performance standard. Odfjell Technology shall strive to maintain the generic approach defined as global standard to allow verifications and analysis across fleet [44] page 6. Consequence classification is a qualitative approach established to evaluate the potential risk related to loss of systems and to identify safety – and environmental critical elements. It is based on functional hierarchy where the identified function is broken down into main functions and further into sub functions in such way that all necessary parts of the system is described for the system to obtain its intention [44] page 6.

The table below shows one of Odfjell Technology's consequence classification matrixes. It contains specific examples of the different consequence classification to the different scenarios.

| Criticality | H&S | Environment | Production | Cost |
|---|---|---|---|---|
| High | Fatality Disability | Black>0 Red>1 Yellow>10 Green>100 | Jack-up > 1 day | > US$ 200k |
| Medium | Lost time caused by injury or ill health | Red 0.01 Yellow/Green 1-10 | Jack-up > 12h | > US$ 50k |
| Low | Medical treatment caused by injury or ill health. First aid caused by injury or ill health | Red < 0.01 Yellow/Green < 1 | Jack-up U > 6h | > US$ 10k |
| No Consequence | Near miss or no personnel injury | No environmental spill | No stop on work | No effect on the equipment |

*Table 31 – Odfjell Technology's Procedures, Consequence Classification Matrix. Reference [37] page 7.*

Second step – consequence classification, is used as a basis for FMECA, priority and due date setting of corrective work orders, maintenance strategies and spare part evaluations. Below is attached a risk acceptance criteria matrix that involves different scenarios and a guideline to what classification they belong to.

| CONSEQUENCE (SEVERITY IMPACT)[1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Personnel injury | Human rights (To be combined with personnel injury) | Environment[2] | Assets[3] | Operations[3] | Security | Reputation | Project: cost and schedule | Project: design and performance |
| 5 Critical (75) | Fatality | Impact to all people in the group, impossible to restore | Ecosystem degradation, widespread effect | Major or total loss | Cancellation of contract, stop of operation | Disruption to ops. at corp. level – wide-spread effect | International public or media attention | Major impact to cost and schedule | Major impact to design, system or performance |
| 4 Significant (25) | Disability | Impact to most people in the group, long term mitigation required | Ecosystem degradation, off-site effect | Significant loss | Severe disruptions | Significant disruption to ops. locally/ regionally | National public or media attention | Significant impact to cost and schedule | Significant impact to design, system or performance |
| 3 Moderate (10) | Lost time or restricted work case | Impact to few people in the group, short term mitigation possible | Moderate impact, on-site/local effect | Some loss | Delays | Short-term disruption to ops. locally (country level) | Client/local public or media attention | Moderate impact to cost and schedule | Moderate impact to design, system or performance |
| 2 Minor (5) | Medical treatment | Impact at individual level, can be mitigated immediately | Minor impact, limited to immediate vicinity of the source | Possible damage or loss | Limited delays | No disruption to ops., minor consequence locally | Company level attention | Minor impact to cost and schedule | Minor impact to design, system or performance |
| 1 In-significant (1) | First aid | Potential impact for right-holders, existing measures apply | Little or no impact, effect limited to the source | Minor damage | Minor disruptions | No direct conse-quence, but risk potential | Business area level attention | Minimal impact to cost and schedule | Negligible impact to design, system or performance |

*Table 32 – Odfjell Technology's Procedures, Risk acceptance criteria. Reference [39] page 1.*

Consequence classification within Odfjell Technology also contains a spare part evaluation consequence classification. This is a case-by-case risk assessments for capital and insurance spares where the different spare parts are evaluated due to criticality. A description of execution and participating personnel is the last step of the consequence classification step.

Third step – FMECA, is an analytical model where the rig specific design is taken into consideration to identify the potential FMs. FMECA can be executed by two different models, functional approach, or design. FMECA should be performed by a team with different skills and be led by a facilitator with skills within risk/maintenance analysis [44] page 11. Odfjell Technology uses a standard library for FMs based on ISO 14224:2016 [44] page 12. The effect of the outcome of a FM is divided into system effects and rig effects that both shall be described for each FM and based on the worst, but realistic case. MTTF shall be assessed based on manufacturers information, maintenance history, reliability data and own experience [44] page 12. This in turn is input to the "probability" evaluation of a FM. For the calculation, a matrix attached below is used, among other matrixes in Odfjell Technology's procedures [44] page 12.

| Category | Probability class | | | | |
|---|---|---|---|---|---|
| Class name | Unlikely | Rare | Moderate | Likely | Very Likely |
| Probability | < 0.1 % | 0.1-1% | 1-10% | 10-63% | > 63% |
| Frequency | <0.001 | 0.001-0.01 | 0.01-0.1 | 0.1-1 | > 1 |
| Frequency per 100 year | <0.05 | 0.05-0.5 | 0.5-5 | 5-15 | > 15 |
| "Definition" | Never heard of in the industry | An incident has occurred in industry | Has been experienced by most Operators | Occurs several times per year per Operator | Occurs several times per year per facility |

*Table 33 – Odfjell Technology's Procedures, Probability Matrix. Reference [37] page 12.*

Fourth step – Barrier analysis, is a systematic approach to review the performance standards to verify that all sub functions related to safety critical elements are considered during the consequence classification and assigned FMECA and Safety – and environmental critical equipment [44] page 13.

Fifth step – The RCM process. It is divided in three main parts:

- Maintenance analysis contains consequence, FMECA and barrier analysis, along with identified Main function (MF) / Sub-function (SF) with allocated criticality, system and rig effects as basis including considerations with regard to safety critical element and barrier element [44] page 14.
- Maintenance strategies is based on the maintenance analysis, and appropriate maintenance strategies are chosen [44] page 14.
- Continuous improvement is a review of the results with respect to required availability, PM versus CM, and cost [44] page 14.

As the FMs and failure effects is identified, next step is to evaluate maintenance strategy to be used based on Mean Time Between Failure (MTBF), Criticality and Effects [44] page 14.

1. Generic Maintenance Concepts
2. Condition Based Maintenance
3. Risk Based Inspections
4. Run to Failure
5. Performance Monitoring

It is important for Odfjell Technology to gather quality assured data, measure against assurance criteria based on identified FMs and failure impact, either continuously (real time) or by set intervals [44] page 15. For all systems where analytics is used as a tool for maintenance optimization, assurance- or performance monitoring within maintenance management, the data flow shall be traceable, identifiable including sensor's position in field and the data input and model quality assured [44] page 16.

# 6. Discussion

The aim of this chapter is to describe the technical hierarchy build-up, the RCM analysis result, the comparison of the result versus Odfjell Technology's procedures, and possibly how and why it differs from each other.

The build-up of the technical hierarchy has been determined by what the equipment is, rather than by its physical location. It may be established and changed according to the preferences of workers, rather than a fixed organizational structure.

There could exist additional regulations and exceptions, such as the mandatory 5-year survey, that have not been identified. Additionally, some standards may have been excluded from the research, and our interpretation of standards may be misinterpreted. Furthermore, the FM and critical item selection has been based on practical experience and education.

To achieve the most optimum maintenance plan from the RCM analysis, constant feedback on failure data and periodically improvement is needed to maximize the analysis benefits. To review maintenance plans on Linus, one can continue the work already done in this thesis and include quantitative data such as MTTF for a more specified result. The method used in this thesis to create technical hierarchy, FMECA, a detailed object type, comparison, etc. can be used to develop maintenance plans for all the systems on the jack-up rig.

Spare part analysis is a part of Odfjell Technology's RCM analysis. This thesis does not conduct a spare part analysis as it primarily follows the RCM steps of Rausand & Vatn and IEC60300-3-11. It also lacks data and background information to determine which spare parts are critical. This leads to different results compared to Odfjell Technology.

The comparison illuminates the differences and similarities in the maintenance procedures. To evaluate further what maintenance activities to that provides the best maintenance based on the risk categories safety, economics and environment is not included in the assignment because of limited competence and experience.

The information used in this assignment, such as risk matrix and FMs are developed by acknowledged national and international standards. The matrixes used for critical item selection and maintenance interval are developed by our Professor Maneesh Singh. The risk categories are divided into three (Safety, environment, and economics). The risk matrix Odfjell Technology uses is divided into 9 categories (Personal injury, human rights, environmental, assets, operations, security, reputation, project cost and schedule, project: design and performance). This is essential for a detailed result and for specification of maintenance activities.

The reason for the differences in results could occur from our comparative lack of expertise in contrast to the extensive knowledge and experience preserved by Odfjell Technology. Additionally, the unavailability of certain documentation and data for our analytical purposes may contribute to differences.

# 7. Conclusion

The technical hierarchy was developed in a systemized way to easily find maintainable items, specifically for the NOV OC3500L Crane. The results obtained from the RCM analysis, was first hand inspection every 6 months for all the four items in the emergency system. The RCM result along with the Norwegian authority regulations, are compared with the procedures Odfjell Technology performs today.

The comparison revealed both similarities and differences between Odfjell Technology's RCM analysis and the analysis presented in this thesis. Overall, the project aimed to highlight Norwegian statutory regulations and standards for maintenance on the crane and make a proposed maintenance plan by utilizing a systematic technical hierarchy, RCM analysis and comparison.

# 8. References

[1] «What we do», *Odfjell Technology*. https://www.odfjelltechnology.com/what-we-do/ (åpnet 25. april[ 2023).

[2] Seadrill, *West-Linus*. 2014. Åpnet: 25. januar 2023. [Table]. Tilgjengelig på: https://www.seadrill.com/application/files/4915/7288/7950/west-linus.pdf

[3] NOV, *OC3550L Lattice Boom Offshore Cranes*. Åpnet: 25. januar 2023. [Table]. Tilgjengelig på: https://www.nov.com/-/media/nov/files/products/rig/marine-and-construction/offshore-cranes/oc3550l-lattice-boom-crane.pdf

[4] Petroleumsloven, *Innretningsforskriften § 72 Marking of equipment and cargo*. 2011. Åpnet: 5. april 2023. [Online]. Tilgjengelig på: https://www.ptil.no/regelverk/alle-forskrifter/innretningsforskriften/XIV/72/

[5] Arbeidsmiljøloven, *The activity regulation § 46 Classification*. Lovdata, 2017. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-activities-regulations3/IX/46/

[6] Arbeidsmiljøloven, *Activity regulation § 30 Safety-clearance of activities*. Lovdata, 2011. Åpnet: 8. mai 2023. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-activities-regulations3/VII/30/

[7] Arbeidsmiljøloven, *The management regulation § 11 Basis for making decisions and decision criteria*. Lovdata, 2011. Åpnet: 8. mai 2023. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-management-regulations3/III/11/

[8] Arbeidsmiljøloven § 45 Maintenance, *The activity regulation*. 2017. Åpnet: 8. mai 2023. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-activities-regulations3/IX/45/

[9] Arbeidsmiljøloven, *The activity regulatin § 48 Planning and prioritisation*. Lovdata, 2011.[Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-activities-regulations3/IX/48/

[10] Arbeidsmiljøloven, *The activity regulation § 47 Maintenance programme*. 2017. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/the-activities-regulations3/IX/47/

[11] M. Rausand og J. Vatn, «Reliability Centred Maintenance», i *Complex System Maintenance Handbook*, i Springer Series in Reliability Engineering. London: Springer London, 2008, s. 79–108. Åpnet: 2. februar 2023. [Online]. Tilgjengelig på: https://link.springer.com/chapter/10.1007/978-1-84800-011-7_4

[12] NORSOK, «Risk based maintenance and consequence classification», Standard Norge, Standard NORSOK Z-008:2017, 2017. [Online]. Tilgjengelig på: https://www.standard.no/no/Nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=956000

[13] The British standard Institution, «Maintenance - Maintenance terminology», Standard NS-EN 13306:2010. Åpnet: 1. februar 2023. [Online]. Tilgjengelig på: https://www.standard.no/no/nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=451419

[14] ISO, «Petroleumsindustri, petrokjemisk industri og naturgassindustri - Innsamling og utveksling av pålitelighets- og vedlikeholdsdata for utstyr (ISO 14224:2016, korrigert versjon 2016-10-01)», Standard NS-EN ISO14224:2016, 2016. Åpnet: 1. februar 2023. [Online]. Tilgjengelig på: https://standard.no/no/Nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=871037

[15] IEC, «Dependability management - Part 3-11: Application guide - Reliability centered maintenance», Standard IEC 60300-3-11, jun. 2009. Åpnet: 2. februar 2023. [Online]. Tilgjengelig på: https://www.standard.no/no/nettbutikk/produktkatalogen/produktpresentasjon/?ProductID=387586

[16] B. Harestad og S. Paaske, «Jackup». NDLA, 31. august 2021. Åpnet: 1. februar 2023. [Online]. Tilgjengelig på: https://ndla.no/nb/subject:1:98cbb757-a718-4275-b87a-2248cde4b58d/topic:c046a6d8-1067-4bdb-a85f-c2bab8df2f96/resource:1:150066

[17] Skipssikkerhetsloven, *Forskrift om kran og løft på flyttbare innretninger, § 2. Definitions*. Lovdata, 2018. Åpnet: 1. mars 2023. [Online]. Tilgjengelig på: https://lovdata.no/forskrift/2017-12-21-2381/§2

[18] DNV, «Standard for offshore and platform lifting appliances», Standard DNVGL-ST-0378, mai 2016. Åpnet: 8. mai 2023. [Online]. Tilgjengelig på: https://www.contractsfinder.service.gov.uk/Notice/Attachment/cac582dd-1a52-4390-919d-75b9672b32c4

[19] «User manual - Final Documentation - Lattice Boom Crane - Starboard - T7382. Chapter 3 - Technical description.», NOV, User manual T7382-Z-MA-001, mar. 2014.

[20] «About: SFI Coding and Classification System». DBpedia. Åpnet: 15. mai 2023. [Online]. Tilgjengelig på: https://dbpedia.org/page/SFI_Coding_and_Classification_System

[23] IEC, «IEC 60812 Analysis techniques for system reliability - procedures for FMEA». Åpnet: 31. januar 2023. [Online]. Tilgjengelig på: https://webstore.iec.ch/preview/info_iec60812%7Bed2.0%7Den_d.pdf

[24] D. I. Jacobsen, «Hvordan gjennomføre undersøkelser? : innføring i samfunnsvitenskapelig metode». Cappelen Damm akademisk, Oslo, 2022.

[25] «Microsoft Excel Spreadsheet Software | Microsoft 365», *Microsoft Excel*. https://www.microsoft.com/en-ww/microsoft-365/excel (åpnet 25. januar 2023).

[26] DNV, «Risk based inspection off Offshore Topsides Static Mechanical Equipment», DNV, Standard DNV-RP-G101, okt. 2010. Åpnet: 1. mars 2023. [Online]. Tilgjengelig på: https://rules.dnv.com/docs/pdf/dnvpm/codes/docs/2017-07/RP-G101.pdf

[27] NORSOK, «Lifting Equipment», Standard Norge, Standard NORSOK R-002:2012, sep. 2012. Åpnet: 1. februar 2023. [Online]. Tilgjengelig på: https://www.standard.no/no/nettbutikk/produktkatalogen/produktpresentasjon/?ProductID=589202

[28] «NORSOK R-002:2012». https://www.standard.no/no/nettbutikk/produktkatalogen/produktpresentasjon/?ProductID=589202 (åpnet 31. januar 2023).

[29] Standard Norge, «NORSOK R-003». https://www.standard.no/no/nettbutikk/produktkatalogen/produktpresentasjon/?ProductID=132382 (åpnet 31. januar 2023).

[30] N. handelsdepartementet, «Sjøfartsdirektoratet», *Regjeringen.no*, 28. november 2006. https://www.regjeringen.no/no/dep/nfd/org/etater-og-virksomheter-under-narings--og-fiskeridepartementet/Subordinate-agencies-and-institutions/sjofartsdirektoratet/id435117/ (åpnet 24. januar 2023).

[31] A. inkluderingsdepartementet, «Petroleumstilsynet», *Regjeringen.no*, 28. juli 2006. https://www.regjeringen.no/no/dep/aid/om-arbeids-og-inkluderingsdepartementet/etatstyring/underliggende-etater/petroleumstilsynet/id85809/ (åpnet 24. januar 2023).

[32] «Forsiden - Lovdata». https://lovdata.no/ (åpnet 24. januar 2023).

[33] «About DNV», *DNV*. https://www.dnv.com/Default (åpnet 25. januar 2023).

[34] Brann- og eksplosjonsvernloven, *Teknisk og operasjonell forskrift § 7 Installations, systems and equipment*. Lovdata, 2011. Åpnet: 2. april 2023. [Online]. Tilgjengelig på: https://www.ptil.no/en/regulations/all-acts/technical-and-operational-regulations3/II/7/

[35] Arbeidsmiljøloven, *Forskrift om utførelse av arbeid § 12-8.Krav om dokumentasjon av kontroll og vedlikehold*. 2012. Åpnet: 1. april 2023. [Online]. Tilgjengelig på: https://lovdata.no/forskrift/2011-12-06-1357/§12-8

[36] D. O. Lereim, «Aksialstempelpumpe», S. Trageton, Red., NDLA, 2020. Åpnet: 10. mars 2023. [Online]. Tilgjengelig på: https://ndla.no/nb/subject:1:5a5cac3f-46ff-4f4d-ba95-b256a706ec48/topic:5d631e43-f324-41ad-9cb2-16a26fc391ac/topic:a322c488-0fef-4a61-8128-cfee23b95dc4/resource:f1ab2eb4-aadc-4364-834f-715c581103a8

[37] S.-H. Kim, *Electric Motor Control: DC, AC, and BLDC Motors*. Saint Louis: Elsevier Science & Technology, 2017. [Online]. Tilgjengelig på: https://bibsys-almaprimo.hosted.exlibrisgroup.com/primo-explore/fulldisplay?docid=TN_cdi_scopus_primary_624208290&context=PC&vid=HIB&lang=nn_NO&search_scope=default_scope&adaptor=primo_central_multiple_fe&tab=default_tab&query=any,contains,Electric%20Motor%20Control%20:%20DC,%20AC,%20and%20BLDC%20Motors&offset=0&searchInFulltext=false

[38] Skipssikkerhetsloven, *Regulations on cranes and lifting on mobile devices § 20. Inspection after overloading or damage to cranes*. Lovdata, 2017.

[39] NMA, «Begjæring om tilsyn», [Online]. Tilgjengelig på: https://www.sdir.no/sjofart/fartoy/tilsyn/begjaring-om-tilsyn/#Flyttbar_innretning

[40] DNV, «PMS (Planned Maintenance System)», DNV. Åpnet: 2. mars 2023. [Online]. Tilgjengelig på: https://www.dnv.com/services/pms-planned-maintenance-system--113450?fbclid=IwAR0jyC2AOfdx-sZfPVxfVKregql515c7WkhLSLc18ZjWwChIMuBhFA3hxkg#top

[41] NORSOK, «Lifting Equipment Operation», Standard Norge, NORSOK R-003:1997, 1997. Åpnet: 25. mars 2023. [Online]. Tilgjengelig på: https://www.standard.no/pagefiles/1099/r-003.pdf

[42] «User manual - Final Documentation - Lattice Boom Crane - Starboard - T7382. Chapter 6 - Maintenance Instructions», NOV, User manual T7382-Z-MA-005, mar. 2014.

[43] «User manual - Final Documentation - Lattice Boom Crane - Starboard - T7382. Chapter 5 - Operating instructions», NOV, User manual T7382-Z-MA-007, mar. 2014.

[44] Odfjell Technology. Company Management System, «Maintenance Management Analysis and analytics», Odfjell Technology, Document L3-JU-ALL-TO-PR-001.

[45] Odfjell Technology. Company Management System, «Maintenance Philosophy (Self-Elevation Unit/Jack-Up)», Odfjell Technology, Document L3-JU-ALL-TO-PR-018.

# Figurelist



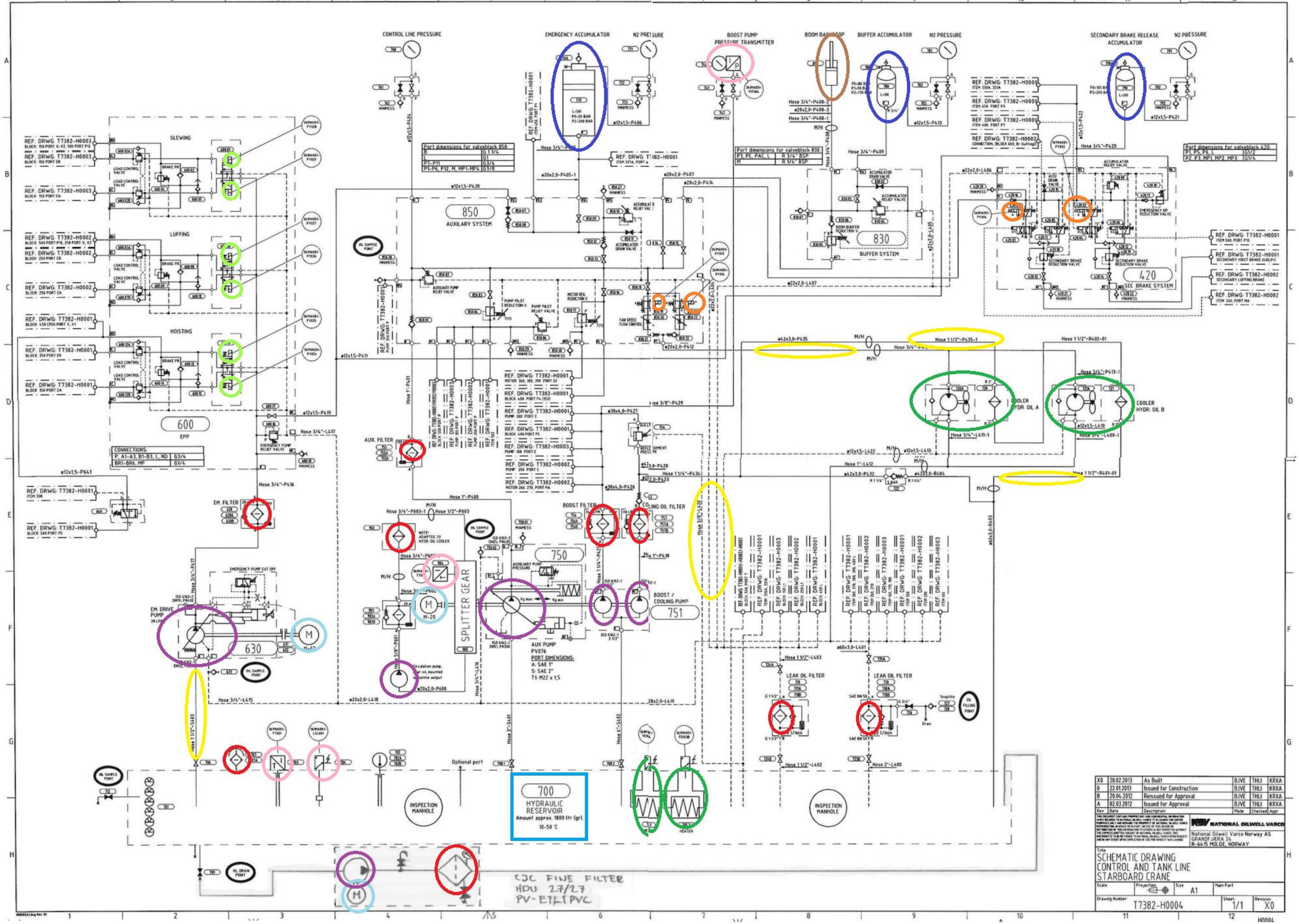
# Table list

# Appendix

1. *P&ID* – P&ID of the cranes hydraulic system with, and without categorization.

2. Excel file: *Technical Hierarchy, FMECA*

   - Sheet 1: Technical Hierarchy
   - Sheet 2: Tag catalogue
   - Sheet 3: FMECA
   - Sheet 4: Route example
   - Sheet 5: PoF/CoF – Professor Maneesh Singh


CONTROL LINE PRESSURE
EMERGENCY ACCUMULATOR
N2 PRESSURE
BOOST PUMP PRESSURE TRANSMITTER
BOOM BACKSTOP
BUFFER ACCUMULATOR
SECONDARY BRAKE RELEASE ACCUMULATOR
SLEWING
LUFFING
HOISTING
600
EPP
850
AUXILARY SYSTEM
830
BUFFER SYSTEM
420
SEC BRAKE SYSTEM
Port dimensions for valveblock 850
Port dimensions for valveblock 830
Port dimensions for valveblock 420
CONNECTIONS:
P, A1-A3, B1-B3, L, ND G3/4
BR1-BR6, MP G1/4
AUX. FILTER
EM. FILTER
BOOST FILTER
COOLING OIL FILTER
COOLER HYDR. OIL A
COOLER HYDR. OIL B
EMERGENCY PUMP CUT OFF
EM. DRIVE PUMP
630
SPLITTER GEAR
750
751
BOOST / COOLING PUMP
AUX PUMP PV076
PORT DIMENSIONS:
A: SAE 1"
S: SAE 2"
T1: M22 x 1,5
LEAK OIL FILTER
OIL SAMPLE POINT
OIL FILLING POINT
OIL DRAIN POINT
INSPECTION MANHOLE
700
HYDRAULIC RESERVOIR
Amount approx. 1800 ltr (gr).
10-50 °C
HEATER
Optional port
CJC FINE FILTER
HDU 27/27
PV-E1/1 PVC
X0 28.02.2013 As Built BJVE THLI KRXA
0 22.01.2013 Issued for Construction BJVE THLI KRXA
B 20.04.2012 Reissued for Approval BJVE THLI KRXA
A 02.03.2012 Issued for Approval BJVE THLI KRXA
NATIONAL OILWELL VARCO
National Oilwell Varco Norway AS
GRANDFJÆRA 24
N-6415 MOLDE, NORWAY
SCHEMATIC DRAWING
CONTROL AND TANK LINE
STARBOARD CRANE
Size A1
Drawing Number: T7382-H0004
Sheet 1/1
Revision X0

MOTOR

PUMP

ACCUMULATOR

HOSE

FILTER

HEATER

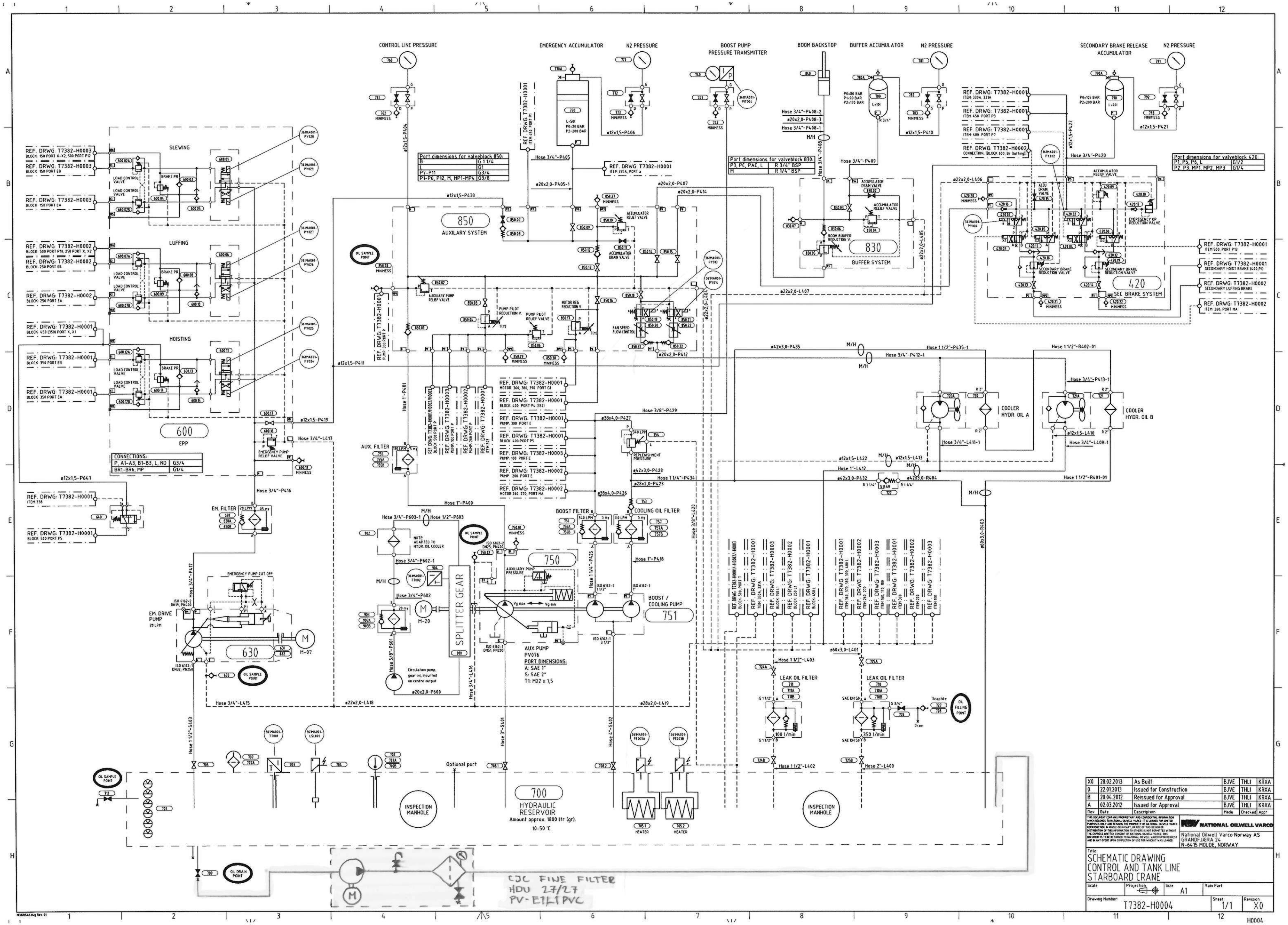
COOLER

CYLINDER

EM DRIVE

SOLENOIDS

LEVEL, TEMPRATURE & PRESSURE FEELER




| Rev | Date | Description | Made | Checked | Appr |
|---|---|---|---|---|---|
| X0 | 28.02.2013 | As Built | BJVE | THLI | KRXA |
| 0 | 22.01.2013 | Issued for Construction | BJVE | THLI | KRXA |
| B | 20.04.2012 | Reissued for Approval | BJVE | THLI | KRXA |
| A | 02.03.2012 | Issued for Approval | BJVE | THLI | KRXA |

NATIONAL OILWELL VARCO

National Oilwell Varco Norway AS
GRANDFJÆRA 24
N-6415 MOLDE, NORWAY

Title
SCHEMATIC DRAWING
CONTROL AND TANK LINE
STARBOARD CRANE

Scale | Projection | Size A1 | Main Part

Drawing Number: T7382-H0004 | Sheet 1/1 | Revision X0

H0004

Sheet 1 – *Hierarchy*

| assetnum | description | Tag number (location) | Kolonne | _361.160.000 | Kolonne24 | Component | Item | Tagnumber | status | otlsfi | otlobj | otlmodelnum | serialnum | siteid | pluscphyloc | total_rec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1049536 | CRANE,OFFSHORE PEDESTAL,DECK STBD | 361-MA-001 | _361 | _361.110.000 | _361.110.100_ | | | | OPERATING | 361 | MA | NOV OCL SERI | T7382 | LIN01 | M-MD-13-01 | 264 |
| C10684777 | SHEAVES PACKAGE STBD DECK CRANE | 361-MA-001-A-001 | _361 | _361.150.000 | _361.150.400 | _361.150.430 | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C10684857 | PACKAGE LIGHTS | 361-MA-001-A-002 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C10684787 | PACKAGE JUNCTION BOXES | 361-MA-001-A-003 | _361 | _361.120.000 | _361.120.200 | | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C10684866 | PACKAGE SOLENOID VALVES | 361-MA-001-A-004 | _361 | _361.140.000 | _361.140.900 | | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C10684849 | PACKAGE ELECTRICAL MOTORS | 361-MA-001-A-005 | _361 | _361.140.000 | _361.140.100 | | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C10685000 | HYDRAULIC HOSE PACKAGE CRANE STBD | 361-MA-001-A-006 | _361 | _361.140.000 | _361.140.600 | _361.140.610 | | | OPERATING | 361 | AD | | | LIN01 | - | 264 |
| C11104330 | ACCUMULATOR BOOST HOIST WHIP WINCH | 361-MA-001-BT358 | _361 | _361.150.000 | _361.150.200 | _361.150.230 | | | OPERATING | 361 | VW | | | LIN01 | 361.DCR1-VV | 264 |
| C11104331 | ACCUMULATOR BOOST HOIST MAIN WINCH | 361-MA-001-BT395 | _361 | _361.150.000 | _361.150.100 | _361.150.110 | | | OPERATING | 361 | VW | | | LIN01 | 361.DCR1-VV | 264 |
| C11104332 | ACCUMULATOR EMERGENCY | 361-MA-001-BT770 | _361 | _361.140.000 | _361.140.300 | _361.140.310 | | | OPERATING | 361 | VW | | | LIN01 | 361.DCR1-VV | 264 |
| C11104333 | ACCUMULATOR BUFFER | 361-MA-001-BT780 | _361 | _361.140.000 | _361.140.300 | _361.140.320 | | | OPERATING | 361 | VW | | | LIN01 | 361.DCR1-VV | 264 |
| C11104334 | ACCUMULATOR SEC. BRAKE RELEASE | 361-MA-001-BT790 | _361 | _361.140.000 | _361.140.300 | _361.140.330 | | | OPERATING | 361 | VW | | | LIN01 | 361.DCR1-VV | 264 |
| C10685116 | BOOM CYLINDER BACKSTOP | 361-MA-001-CT501 | _361 | _361.140.000 | _361.140.700 | _361.140.710 | | | OPERATING | 361 | QG | | | LIN01 | M-MD-13-01 | 264 |
| C10685143 | TK HYDR OIL | 361-MA-001-CT601 | _361 | _361.140.000 | _361.140.400 | _361.140.420 | | | OPERATING | 361 | TH | | | LIN01 | M-MD-13-01 | 264 |
| C10685145 | FILTER UNIT CJC FOR HPU | 361-MA-001-CW001 | _361 | _361.140.000 | _361.140.400 | _361.140.410 | | | OPERATING | 361 | CW | | | LIN01 | M-MD-13-01 | 264 |
| C11104335 | BEARING SLEW | 361-MA-001-CX001 | _361 | _361.150.000 | _361.150.500 | _361.150.540 | _361.150.541 | | OPERATING | 361 | CX | | | LIN01 | 361.DCR1-CX | 264 |
| C11104336 | BOLTS SLEW BEARING | 361-MA-001-CX002 | _361 | _361.150.000 | _361.150.500 | _361.150.540 | _361.150.542 | | OPERATING | 361 | CX | | | LIN01 | 361.DCR1-CX | 264 |
| C11104337 | A-FRAME, OFFSHORE CRANE STBD | 361-MA-001-CZ01 | _361 | _361.110.000 | _361.110.100_ | _361.110.120_ | _361.110.121 | | OPERATING | 361 | YE | | | LIN01 | 361.DCR1-YE | 264 |
| C11104338 | BOOM, OFFSHORE CRANE STBD | 361-MA-001-CZ02 | _361 | _361.110.000 | _361.110.100_ | _361.110.110_ | _361.110.111 | | OPERATING | 361 | YE | | | LIN01 | 361.DCR1-YE | 264 |
| C10684940 | GEAR WINCH HOIST | 361-MA-001-DB101 | _361 | _361.150.000 | _361.150.200 | _361.150.260 | _361.150.261 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684792 | GEAR WINCH WHIP HOIST | 361-MA-001-DB201 | _361 | _361.150.000 | _361.150.200 | _361.150.260 | _361.150.262 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684926 | GEAR WINCH LUFFING | 361-MA-001-DB301 | _361 | _361.150.000 | _361.150.400 | _361.150.420 | | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684854 | GEAR A SLEWING | 361-MA-001-DB401 | _361 | _361.150.000 | _361.150.500 | _361.150.510 | _361.150.511 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684782 | GEAR B SLEWING | 361-MA-001-DB402 | _361 | _361.150.000 | _361.150.500 | _361.150.510 | _361.150.512 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685117 | GEAR C SLEWING | 361-MA-001-DB403 | _361 | _361.150.000 | _361.150.500 | _361.150.510 | _361.150.513 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685005 | GEAR SPLITTER | 361-MA-001-DB601 | _361 | _361.150.000 | _361.150.500 | _361.150.510 | | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685144 | MOTOR MAIN 690V 60HZ | 361-MA-001-DE001 | _361 | _361.140.000 | _361.140.100 | _361.140.110 | _361.140.111 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10685146 | EMERGENCY POWER PACK 690V 60HZ | 361-MA-001-DE002 | _361 | _361.120.000 | _361.120.100 | _361.120.110 | _361.120.111 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684870 | CRANE VENT. FAN 230V 60HZ | 361-MA-001-DE003 | _361 | _361.130.000 | _361.130.500 | _361.130.520 | _361.130.521 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684798 | CRANE CAB.VENT. FAN 230V 60HZ | 361-MA-001-DE004 | _361 | _361.130.000 | _361.130.500 | _361.130.520 | _361.130.522 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684946 | MOTOR ROOF WIPER 24VDC | 361-MA-001-DE005 | _361 | _361.130.000 | _361.130.400 | _361.130.420 | _361.130.421 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10685134 | MOTOR F-O.NT WIPER 24VDC | 361-MA-001-DE006 | _361 | _361.130.000 | _361.130.400 | _361.130.420 | _361.130.422 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684947 | MOTOR F-O.NT WIPER 24VDC | 361-MA-001-DE007 | _361 | _361.130.000 | _361.130.400 | _361.130.420 | _361.130.423 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10685133 | MOTOR SIDE WIPER 24VDC | 361-MA-001-DE008 | _361 | _361.130.000 | _361.130.400 | _361.130.420 | _361.130.424 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684872 | MOTOR SIDE WIPER 24VDC | 361-MA-001-DE009 | _361 | _361.130.000 | _361.130.400 | _361.130.420 | _361.130.425 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684797 | MOTOR WASHER F-O.NT WINDOW 24VDC | 361-MA-001-DE010 | _361 | _361.130.000 | _361.130.400 | _361.130.410 | _361.130.411 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10685014 | MOTOR WASHER SIDE WINDOWS 24VDC | 361-MA-001-DE011 | _361 | _361.130.000 | _361.130.400 | _361.130.410 | _361.130.412 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684871 | MOTOR WASHER ROOF WINDOW 24VDC | 361-MA-001-DE012 | _361 | _361.130.000 | _361.130.400 | _361.130.410 | _361.130.413 | | OPERATING | 361 | EF | | | LIN01 | M-MD-13-01 | 264 |
| C10684788 | DAMPER ACTUATOR AIR INLET CABIN | 361-MA-001-DE013 | _361 | _361.160.000 | _361.160.100 | _361.160.110 | _361.160.111 | | OPERATING | 361 | GM | | | LIN01 | M-MD-13-01 | 264 |
| C10685130 | DAMPER ACTUATOR AIR INLET MACH.H. | 361-MA-001-DE015 | _361 | _361.160.000 | _361.160.100 | _361.160.110 | _361.160.112 | | OPERATING | 361 | GM | | | LIN01 | M-MD-13-01 | 264 |
| C10685112 | DAMPER ACTUATOR AIR OUTLET MACH.H. | 361-MA-001-DE016 | _361 | _361.160.000 | _361.160.100 | _361.160.110 | _361.160.113 | | OPERATING | 361 | GM | | | LIN01 | M-MD-13-01 | 264 |
| C10684931 | BRAKE PRIMARY MAIN WINCH HOIST A | 361-MA-001-DX101 | _361 | _361.150.000 | _361.150.100 | _361.150.120 | _361.150.121 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685121 | BRAKE PRIMARY MAIN WINCH HOIST B | 361-MA-001-DX102 | _361 | _361.150.000 | _361.150.100 | _361.150.120 | _361.150.122 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685008 | BRAKE PRIMARY WHIP WINCH HOIST A | 361-MA-001-DX201 | _361 | _361.150.000 | _361.150.200 | _361.150.240 | _361.150.241 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684783 | BRAKE PRIMARY WHIP WINCH HOIST B | 361-MA-001-DX202 | _361 | _361.150.000 | _361.150.200 | _361.150.240 | _361.150.242 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684941 | BRAKE SECONDARY WHIP WINCH | 361-MA-001-DX203 | _361 | _361.150.000 | _361.150.200 | _361.150.240 | _361.150.243 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684793 | BRAKE PRIMARY LUFFING WINCH A | 361-MA-001-DX301 | _361 | _361.150.000 | _361.150.400 | _361.150.410 | _361.150.411 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684774 | BRAKE PRIMARY LUFFING WINCH B | 361-MA-001-DX302 | _361 | _361.150.000 | _361.150.400 | _361.150.410 | _361.150.412 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684855 | BRAKE SECONDARY LUFFING | 361-MA-001-DX303 | _361 | _361.150.000 | _361.150.400 | _361.150.410 | _361.150.413 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685006 | BRAKE SLEWING A | 361-MA-001-DX401 | _361 | _361.150.000 | _361.150.500 | _361.150.520 | _361.150.521 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684861 | BRAKE SLEWING B | 361-MA-001-DX402 | _361 | _361.150.000 | _361.150.500 | _361.150.520 | _361.150.522 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10685010 | BRAKE SLEWING C | 361-MA-001-DX403 | _361 | _361.150.000 | _361.150.500 | _361.150.520 | _361.150.523 | | OPERATING | 361 | CA | | | LIN01 | M-MD-13-01 | 264 |
| C10684997 | JB BATTERY BOX | 361-MA-001-EB001 | _361 | _361.120.000 | _361.120.200 | _361.120.230 | _361.120.231 | | OPERATING | 361 | EB | | | LIN01 | M-MD-13-01 | 264 |
| C10685118 | CTRL-P MACHINERY HOUSE | 361-MA-001-ED001 | _361 | _361.120.000 | _361.120.500 | _361.120.510 | | | OPERATING | 361 | IF | | | LIN01 | M-MD-13-01 | 264 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C10684927 | CTRL-P CABIN | 361-MA-001-ED002 | _361 | _361.130.000 | _361.130.300 | _361.130.310 | _361.130.311 | | OPERATING | 361 IF | LIN01 | M-MD-13-01 | 264 |
| C10688933 | AWL CRANE BOOM (RD) | 361-MA-001-EI001 | _361 | _361.110.000 | _361.110.100_ | _361.110.110_ | _361.110.112 | | OPERATING | 427 LQ | LIN01 | M-MD-13-01 | 264 |
| C10688934 | AWL CRANE BOOM (RD) | 361-MA-001-EI002 | _361 | _361.110.000 | _361.110.100_ | _361.110.110_ | _361.110.113 | | OPERATING | 427 LQ | LIN01 | M-MD-13-01 | 264 |
| C10688914 | AWL CRANE BOOM (RD) | 361-MA-001-EI003 | _361 | _361.110.000 | _361.110.100_ | _361.110.110_ | _361.110.114 | | OPERATING | 427 LQ | LIN01 | M-MD-13-01 | 264 |
| C10688931 | WINDSOCK UNIT W/ AWL | 361-MA-001-EI004 | _361 | _361.130.000 | _361.130.600 | _361.130.610 | | | OPERATING | 427 LQ | LIN01 | M-MD-13-01 | 264 |
| C10684850 | SLIP RING UNIT | 361-MA-001-EJ001 | _361 | _361.150.000 | _361.150.400 | _361.150.470 | | | OPERATING | 361 EV | LIN01 | M-MD-13-01 | 264 |
| C10685059 | JB DAMPERS | 361-MA-001-EJ003 | _361 | _361.120.000 | _361.120.200 | _361.120.260 | _361.120.261 | | OPERATING | 361 EJ | LIN01 | M-MD-13-01 | 264 |
| C10684839 | JB INLET MACH.H. | 361-MA-001-EJ004 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.211 | | OPERATING | 361 EJ | LIN01 | M-MD-13-01 | 264 |
| C10684917 | JB OUTLET MACH.H. | 361-MA-001-EJ005 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.212 | | OPERATING | 361 EJ | LIN01 | M-MD-13-01 | 264 |
| C10685104 | JUNCTION BOX DK CRANE STBD UTILITY SUPL | 361-MA-001-EJ01 | _361 | _361.120.000 | _361.120.200 | _361.120.270 | _361.120.271 | | OPERATING | 361 EJ | LIN01 | M-MD-13-01 | 264 |
| C10684932 | PANEL POWER DISTRIBUTION MACHINERY HOUSE | 361-MA-001-EL001 | _361 | _361.120.000 | _361.120.500 | _361.120.520 | | | OPERATING | 361 EH | LIN01 | M-MD-13-01 | 264 |
| C10684936 | SOCKET OUTL.FAN HEATER | 361-MA-001-EL001-F129X02 | _361 | _361.160.000 | _361.160.300 | _361.160.340 | | | OPERATING | 361 ES | LIN01 | M-MD-13-01 | 264 |
| C10684789 | SOCKET OUTL.MACH.HOUSE | 361-MA-001-EL001-F26X01 | _361 | _361.160.000 | _361.160.300 | _361.160.310 | | | OPERATING | 361 ES | LIN01 | M-MD-13-01 | 264 |
| C10684913 | LIGHT MACH. HOUSE RIGHT | 361-MA-001-EL001-F27L01 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 | _361.160.231.100 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684835 | LIGHT MACH. HOUSE MIDDLE | 361-MA-001-EL001-F27L02 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 | _361.160.231.200 | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10685055 | LIGHT MACH. HOUSE BACK | 361-MA-001-EL001-F27L03 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 | _361.160.231.300 | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10684911 | LIGHT MACH. HOUSE LEFT | 361-MA-001-EL001-F27L04 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 | _361.160.231.400 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684982 | LIGHT OUTSIDE MACH. HOUSE BY DOOR | 361-MA-001-EL001-F27L05 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.232 | _361.160.232.100 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10685099 | LIGHT OUTSIDE MACHINERY HOUSE RIGHT | 361-MA-001-EL001-F27L06 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.232 | _361.160.232.200 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10685057 | LIGHT ACCESS CRANE | 361-MA-001-EL001-F27L07 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.214 | | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10685101 | LIGHT UNDER MACH. HOUSE RIGHT | 361-MA-001-EL001-F27L08 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.233 | _361.160.233.200 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10685054 | LIGHT UNDER MACH. HOUSE LEFT | 361-MA-001-EL001-F27L09 | _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.233 | _361.160.233.100 | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684910 | LIGHT SLIPRING AREA UPPER | 361-MA-001-EL001-F27L10 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.211 | | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684836 | LIGHT A-FRAME MIDDLE | 361-MA-001-EL001-F27L11 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.212 | | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684983 | LIGHT A-FRAME TOP | 361-MA-001-EL001-F27L12 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.213 | | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684794 | PANEL POWER DISTRIBUTION CABIN | 361-MA-001-EL002 | _361 | _361.130.000 | _361.130.300 | _361.130.330 | _361.130.331 | | OPERATING | 361 EH | LIN01 | M-MD-13-01 | 264 |
| C10684928 | SOCKET OUTL.AIR CONDITION | 361-MA-001-EL002-F122X01 | _361 | _361.160.000 | _361.160.300 | _361.160.320 | | | OPERATING | 361 ES | LIN01 | M-MD-13-01 | 264 |
| C10685011 | SOCKET OUTL.CABIN CCTV MONITOR | 361-MA-001-EL002-F123X01 | _361 | _361.160.000 | _361.160.300 | _361.160.330 | | | OPERATING | 361 ES | LIN01 | M-MD-13-01 | 264 |
| C10684909 | FLOODLIGHT BOOM | 361-MA-001-EL002-F124L01 | _361 | _361.160.000 | _361.160.200 | _361.160.220 | _361.160.221 | | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10685098 | FLOODLIGHT BOOM | 361-MA-001-EL002-F124L02 | _361 | _361.160.000 | _361.160.200 | _361.160.220 | _361.160.222 | | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10685056 | FLOODLIGHT SLEW. STRUCTURE | 361-MA-001-EL002-F124L03 | _361 | _361.160.000 | _361.160.200 | _361.160.220 | _361.160.223 | | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10684912 | FLOODLIGHT SLEW. STRUCTURE | 361-MA-001-EL002-F124L04 | _361 | _361.160.000 | _361.160.200 | _361.160.220 | _361.160.224 | | OPERATING | 361 EA | LIN01 | M-MD-13-01 | 264 |
| C10684984 | LIGHT CABIN | 361-MA-001-EL002-F125L01 | _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.215 | | OPERATING | 361 EO | LIN01 | M-MD-13-01 | 264 |
| C10684929 | SOCKET OUTL.FAN HEATER | 361-MA-001-EL002-F129X01 | _361 | _361.160.000 | _361.160.300 | _361.160.350 | | | OPERATING | 361 ES | LIN01 | M-MD-13-01 | 264 |
| C10685100 | ESD INDICATION LAMP | 361-MA-001-ELA01 | _361 | _361.120.000 | _361.120.300 | _361.120.350 | _361.120.351 | | OPERATING | 361 LQ | LIN01 | M-MD-13-01 | 264 |
| C10685097 | F&G INDICATION LAMP | 361-MA-001-ELA02 | _361 | _361.120.000 | _361.120.300 | _361.120.350 | _361.120.352 | | OPERATING | 361 LQ | LIN01 | M-MD-13-01 | 264 |
| C10684778 | PANEL POWER DISTRIBUTION MAIN MOTOR STARTE | 361-MA-001-ES001 | _361 | _361.130.000 | _361.130.300 | _361.130.330 | _361.130.332 | | OPERATING | 361 EH | LIN01 | M-MD-13-01 | 264 |
| C10684937 | HEATER FAN CABIN | 361-MA-001-FE001 | _361 | _361.130.000 | _361.130.500 | _361.130.510 | _361.130.511 | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| C10685125 | HEATER CABIN SPACE | 361-MA-001-FE002 | _361 | _361.130.000 | _361.130.500 | _361.130.510 | _361.130.512 | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| C10685001 | HEATER HYDR OIL | 361-MA-001-FE003A | _361 | _361.140.000 | _361.140.500 | _361.140.510 | | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| C10684858 | HEATER HYDR OIL | 361-MA-001-FE003B | _361 | _361.140.000 | _361.140.500 | _361.140.520 | | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| C10684790 | HEATER MACH.HOUSE FAN | 361-MA-001-FE004 | _361 | _361.130.000 | _361.130.500 | _361.130.510 | _361.130.513 | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| C10684867 | HEATER MACH.HOUSE SPACE | 361-MA-001-FE005 | _361 | _361.130.000 | _361.130.500 | _361.130.510 | _361.130.514 | | OPERATING | 361 FE | LIN01 | M-MD-13-01 | 264 |
| R4502024 | DOOR,STEEL,SWING, MACH. HOUSE SB CRANE | 361-MA-001-G001 | _361 | _361.110.000 | _361.110.100_ | _361.110.140_ | _361.110.141 | _361.110.141.100 | OPERATING | 513 YT | LIN01 | | 264 |
| R4502025 | DOOR,STEEL,SWING, CRANE CABIN SB CRANE | 361-MA-001-G002 | _361 | _361.110.000 | _361.110.100_ | _361.110.140_ | _361.110.141 | _361.110.141.200 | OPERATING | 513 YT | LIN01 | | 264 |
| C10684851 | UNIT AIR CONDITION | 361-MA-001-GK001 | _361 | _361.130.000 | _361.130.500 | _361.130.530 | _361.130.531 | | OPERATING | 361 GA | LIN01 | M-MD-13-01 | 264 |
| C10684933 | FAN VENT CRANE | 361-MA-001-GM001 | _361 | _361.160.000 | _361.160.100 | _361.160.120 | _361.160.121 | | OPERATING | 361 KF | LIN01 | M-MD-13-01 | 264 |
| C11104339 | COOLER INCLUDING FAN/HYD. MOTOR A | 361-MA-001-HC720 | _361 | _361.140.000 | _361.140.100 | _361.140.120 | _361.140.121 | | OPERATING | 361 HC | LIN01 | 361.DCR1-HC | 264 |
| C11104340 | COOLER INCLUDING FAN/HYD. MOTOR B | 361-MA-001-HC721 | _361 | _361.140.000 | _361.140.100 | _361.140.120 | _361.140.122 | | OPERATING | 361 HC | LIN01 | 361.DCR1-HC | 264 |
| C10685122 | PUSH BUTTON EMERGENCY STOP PB MUSHRM | 361-MA-001-HS001 | _361 | _361.130.000 | _361.130.300 | _361.130.320 | _361.130.321 | | OPERATING | 361 EP | LIN01 | M-MD-13-01 | 264 |
| C10685009 | MOP ACTIVATE | 361-MA-001-HS002 | _361 | _361.120.000 | _361.120.300 | _361.120.340 | _361.120.343 | | OPERATING | 361 EP | LIN01 | M-MD-13-01 | 264 |
| C10685131 | EMERGENCY LOWERING | 361-MA-001-HS003 | _361 | _361.120.000 | _361.120.100 | _361.120.110 | _361.120.112 | | OPERATING | 361 EP | LIN01 | M-MD-13-01 | 264 |
| C10685113 | PUSH BUTTON EMERGENCY STOP | 361-MA-001-HS004 | _361 | _361.130.000 | _361.130.300 | _361.130.320 | _361.130.322 | | OPERATING | 361 EP | LIN01 | M-MD-13-01 | 264 |
| C11104341 | DATA RECORDING SYSTEM | 361-MA-001-IA001 | _361 | _361.120.000 | _361.120.100 | _361.120.120 | | | OPERATING | 361 IA | LIN01 | 361.DCR1-IA | 264 |
| C11104342 | ANTI-COLLISION SYSTEM | 361-MA-001-IA002 | _361 | _361.120.000 | _361.120.300 | _361.120.380 | _361.120.382 | | OPERATING | 361 IA | LIN01 | 361.DCR1-IA | 264 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C10684840 | JB BOOM ANGLE | 361-MA-001-JB001 | _361 | _361.120.000 | _361.120.200 | _361.120.260 | _361.120.262 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10684837 | JB LUFFING ENCODER | 361-MA-001-JB002 | _361 | _361.120.000 | _361.120.200 | _361.120.250 | _361.120.251 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10684914 | JB LUFFING MOTOR | 361-MA-001-JB003 | _361 | _361.120.000 | _361.120.200 | _361.120.250 | _361.120.252 | OPERATING | 361 EJ | 415175 | LIN01 | M-MD-13-01 | 264 |
| C10684915 | JB SLEW. COUNTER | 361-MA-001-JB004 | _361 | _361.120.000 | _361.120.200 | _361.120.260 | _361.120.263 | OPERATING | 361 EJ | 415179 | LIN01 | M-MD-13-01 | 264 |
| C10684986 | JB WINCHES | 361-MA-001-JB005 | _361 | _361.120.000 | _361.120.200 | _361.120.240 | _361.120.241 | OPERATING | 361 EJ | 415189 | LIN01 | M-MD-13-01 | 264 |
| C10685061 | JB LOAD CELLS | 361-MA-001-JB006 | _361 | _361.120.000 | _361.120.200 | _361.120.280 | _361.120.281 | OPERATING | 361 EJ | 415184 | LIN01 | M-MD-13-01 | 264 |
| C10685058 | JB CCTV BOOM | 361-MA-001-JB007 | _361 | _361.120.000 | _361.120.200 | _361.120.220 | _361.120.221 | OPERATING | 361 EJ | 415208 | LIN01 | M-MD-13-01 | 264 |
| C10685102 | JB CCTV BOOM TIP | 361-MA-001-JB008 | _361 | _361.120.000 | _361.120.200 | _361.120.220 | _361.120.222 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10685103 | JB LC LUFFING/WINDSPEED | 361-MA-001-JB009 | _361 | _361.120.000 | _361.120.200 | _361.120.250 | _361.120.253 | OPERATING | 361 EJ | 415191 | LIN01 | M-MD-13-01 | 264 |
| C10684862 | JOYSTICK BOX LEFT HAND | 361-MA-001-JB010 | _361 | _361.130.000 | _361.130.100 | _361.130.140 | | OPERATING | 361 QH | | LIN01 | M-MD-13-01 | 264 |
| C10684784 | JOYSTICK BOX RIGHT HAND | 361-MA-001-JB011 | _361 | _361.130.000 | _361.130.100 | _361.130.150 | | OPERATING | 361 QH | | LIN01 | M-MD-13-01 | 264 |
| C10684987 | JUNCTION BOX INLET MACH.H. | 361-MA-001-JB012 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.213 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10684988 | JB INLET MACH.H. | 361-MA-001-JB013 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.214 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10684985 | JUNCTION BOX OUTL.MACH.H. | 361-MA-001-JB014 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.215 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10684838 | JB OUTLET MACH.H. | 361-MA-001-JB015 | _361 | _361.120.000 | _361.120.200 | _361.120.210 | _361.120.216 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10685060 | JB WINCH MOTORS | 361-MA-001-JB016A | _361 | _361.120.000 | _361.120.200 | _361.120.240 | _361.120.242 | OPERATING | 361 EJ | 415170 | LIN01 | M-MD-13-01 | 264 |
| C10684916 | JB WINCH MOTORS | 361-MA-001-JB016B | _361 | _361.120.000 | _361.120.200 | _361.120.240 | _361.120.243 | OPERATING | 361 EJ | | LIN01 | M-MD-13-01 | 264 |
| C10685012 | STARTER EMG. POWER PACK | 361-MA-001-JC001 | _361 | _361.120.000 | _361.120.100 | _361.120.110 | _361.120.113 | OPERATING | 361 IA | | LIN01 | M-MD-13-01 | 264 |
| C10684852 | CRANE CONTROL DISPLAY | 361-MA-001-JJ001 | _361 | _361.120.000 | _361.120.200 | _361.120.220 | _361.120.223 | OPERATING | 361 IG | | LIN01 | M-MD-13-01 | 264 |
| C10685119 | EPP START/STOP (CABIN) | 361-MA-001-JP001 | _361 | _361.130.000 | _361.130.300 | _361.130.320 | _361.130.323 | OPERATING | 361 EP | | LIN01 | M-MD-13-01 | 264 |
| C10685114 | JB MOPS/BACKUP BATTERY | 361-MA-001-JX001 | _361 | _361.120.000 | _361.120.200 | _361.120.230 | _361.120.232 | OPERATING | 361 EB | | LIN01 | M-MD-13-01 | 264 |
| C10684779 | LEVEL SENSORSOR HYDR.TK | 361-MA-001-LSL001 | _361 | _361.140.000 | _361.140.800 | _361.140.810 | _361.140.813 | OPERATING | 361 QL | | LIN01 | M-MD-13-01 | 264 |
| C10684938 | HOOK BLOCK | 361-MA-001-MB001 | _361 | _361.150.000 | _361.150.300 | | | OPERATING | 361 MD | RX0900 | LIN01 | M-MD-13-01 | 264 |
| C10685126 | SWIVEL WEIGHT WHIPLINE | 361-MA-001-MB002 | _361 | _361.150.000 | _361.150.200 | _361.150.280 | | OPERATING | 361 MD | RB16565 | LIN01 | M-MD-13-01 | 264 |
| C10685070 | WINCH MAIN HOIST | 361-MA-001-MK101 | _361 | _361.150.000 | _361.150.100 | _361.150.170 | | OPERATING | 361 MW | | LIN01 | M-MD-13-01 | 264 |
| C10684775 | WINCH WHIP HOIST | 361-MA-001-MK201 | _361 | _361.150.000 | _361.150.200 | _361.150.290 | | OPERATING | 361 MW | | LIN01 | M-MD-13-01 | 264 |
| C10685002 | WINCH LUFFING | 361-MA-001-MK301 | _361 | _361.150.000 | _361.150.400 | | | OPERATING | 361 MW | | LIN01 | M-MD-13-01 | 264 |
| C10684799 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101A | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.431 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685017 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101B | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.432 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685018 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101C | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.433 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684948 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101D | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.434 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684949 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101E | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.435 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685136 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101F | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.436 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684802 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101G | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.437 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685015 | SHEAVE LUFFING STBD CRANE | 361-MA-001-MS101H | _361 | _361.150.000 | _361.150.400 | _361.150.430 | _361.150.438 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685019 | SHEAVE MAIN HOIST STBD CRANE | 361-MA-001-MS102A | _361 | _361.150.000 | _361.150.100 | _361.150.130 | _361.150.131 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684801 | SHEAVE MAIN HOIST STBD CRANE | 361-MA-001-MS102B | _361 | _361.150.000 | _361.150.100 | _361.150.130 | _361.150.132 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685021 | SHEAVE MAIN HOIST STBD CRANE | 361-MA-001-MS102C | _361 | _361.150.000 | _361.150.100 | _361.150.130 | _361.150.133 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684800 | SHEAVE MAIN HOIST STBD CRANE | 361-MA-001-MS102D | _361 | _361.150.000 | _361.150.100 | _361.150.130 | _361.150.134 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684951 | SHEAVE MAIN HOIST STBD CRANE | 361-MA-001-MS102E | _361 | _361.150.000 | _361.150.100 | _361.150.130 | _361.150.135 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685016 | SHEAVE WHIP HOIST STBD CRANE | 361-MA-001-MS103A | _361 | _361.150.000 | _361.150.200 | _361.150.250 | _361.150.251 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685135 | SHEAVE WHIP HOIST STBD CRANE | 361-MA-001-MS103B | _361 | _361.150.000 | _361.150.200 | _361.150.250 | _361.150.252 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684950 | SHEAVE WHIP HOIST STBD CRANE | 361-MA-001-MS103C | _361 | _361.150.000 | _361.150.200 | _361.150.250 | _361.150.253 | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10685020 | SHEAVE HOOK BLOCK STBD CRANE | 361-MA-001-MS104A | _361 | _361.150.000 | _361.150.300 | _361.150.310 | | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684875 | SHEAVE HOOK BLOCK STBD CRANE | 361-MA-001-MS104B | _361 | _361.150.000 | _361.150.300 | _361.150.320 | | OPERATING | 361 MS | | LIN01 | M-MD-13-01 | 264 |
| C10684859 | SERV CRANE IN A-FRAME | 361-MA-001-MX101 | _361 | _361.110.000 | _361.110.100_ | _361.110.120_ | _361.110.122 | OPERATING | 361 MX | | LIN01 | M-MD-13-01 | 264 |
| C10684791 | PORTABLE SERV DAVIT | 361-MA-001-MX102 | _361 | _361.110.000 | _361.110.100_ | _361.110.130_ | _361.110.131 | OPERATING | 361 MB | | LIN01 | M-MD-13-01 | 264 |
| C10684925 | WIRE WINCH MAIN HOIST | 361-MA-001-MY001 | _361 | _361.150.000 | _361.150.100 | _361.150.140 | | OPERATING | 361 MY | VD2016-15090-1-1 | LIN01 | M-MD-13-01 | 264 |
| C10684873 | WIRE WINCH WHIP HOIST | 361-MA-001-MY002 | _361 | _361.150.000 | _361.150.200 | _361.150.270 | | OPERATING | 361 MY | VD 2017 21101-1 | LIN01 | M-MD-13-01 | 264 |
| C10685052 | WIRE WINCH LUFFING | 361-MA-001-MY003 | _361 | _361.150.000 | _361.150.400 | _361.150.440 | | OPERATING | 361 MY | VD2016-1590-2-3 | LIN01 | M-MD-13-01 | 264 |
| C11104343 | HYDR. PUMP SLEW SYSTEM | 361-MA-001-PB100 | _361 | _361.140.000 | _361.140.200 | _361.140.210 | | OPERATING | 361 PB | | LIN01 | 361.DCR1-PB | 264 |
| C11104344 | HYDR. MOTOR SLEW A | 361-MA-001-PB160 | _361 | _361.140.000 | _361.140.100 | _361.140.130 | _361.140.131 | OPERATING | 361 PB | | LIN01 | 361.DCR1-PB | 264 |
| C11104345 | HYDR. MOTOR SLEW B | 361-MA-001-PB170 | _361 | _361.140.000 | _361.140.100 | _361.140.130 | _361.140.132 | OPERATING | 361 PB | | LIN01 | 361.DCR1-PB | 264 |
| C11104346 | HYDR. MOTOR SLEW C | 361-MA-001-PB180 | _361 | _361.140.000 | _361.140.100 | _361.140.130 | _361.140.133 | OPERATING | 361 PB | | LIN01 | 361.DCR1-PB | 264 |
| C11104347 | HYDR. PUMP LUFFING SYSTEM | 361-MA-001-PB200 | _361 | _361.140.000 | _361.140.200 | _361.140.220 | | OPERATING | 361 PB | | LIN01 | 361.DCR1-PB | 264 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11104348 | HYDR. MOTOR LUFFING A | 361-MA-001-PB260 | _361 | _361.140.000 | _361.140.100 | _361.140.140 | _361.140.141 | | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104349 | HYDR. MOTOR LUFFING B | 361-MA-001-PB270 | _361 | _361.140.000 | _361.140.100 | _361.140.140 | _361.140.142 | | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104350 | HYDR. PUMP MAIN HOIST SYSTEM | 361-MA-001-PB300 | _361 | _361.140.000 | _361.140.200 | _361.140.230 | | | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104351 | HYDR. MOTOR HOIST MAIN WINCH A | 361-MA-001-PB360 | _361 | _361.140.000 | _361.140.100 | _361.140.150 | _361.140.151 | _361.140.151.100 | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104352 | HYDR. MOTOR HOIST MAIN WINCH B | 361-MA-001-PB370 | _361 | _361.140.000 | _361.140.100 | _361.140.150 | _361.140.151 | _361.140.151.200 | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104353 | HYDR. MOTOR HOIST WHIP WINCH A | 361-MA-001-PB380 | _361 | _361.140.000 | _361.140.100 | _361.140.150 | _361.140.152 | _361.140.152.100 | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104354 | HYDR. MOTOR HOIST WHIP WINCH B | 361-MA-001-PB390 | _361 | _361.140.000 | _361.140.100 | _361.140.150 | _361.140.152 | _361.140.152.200 | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C11104355 | HYDR. PUMP EMERGENCY DRIVE | 361-MA-001-PB630 | _361 | _361.140.000 | _361.140.200 | _361.140.240 | | | OPERATING | 361 PB | LIN01 | 361.DCR1-PB | 264 |
| C10685111 | TRANSM PRS HOIST LINE | 361-MA-001-PIT001 | _361 | _361.120.000 | _361.120.400 | _361.120.450 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10684868 | TRANSM PRS SLEWING LINE | 361-MA-001-PIT002 | _361 | _361.120.000 | _361.120.400 | _361.120.460 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10684998 | TRANSM PRS BOOST P | 361-MA-001-PIT004 | _361 | _361.120.000 | _361.120.400 | _361.120.440 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10684934 | TRANSM PRS HOIST BOOST | 361-MA-001-PIT005 | _361 | _361.120.000 | _361.120.400 | _361.120.420 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10685123 | TRANSM PRS LUFFING BOOST | 361-MA-001-PIT006 | _361 | _361.120.000 | _361.120.400 | _361.120.430 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10684942 | TRANSM PRS MOP ACTIVATED | 361-MA-001-PIT007 | _361 | _361.120.000 | _361.120.400 | _361.120.410 | | | OPERATING | 361 QP | LIN01 | M-MD-13-01 | 264 |
| C10685109 | V/V SOLENOID PRIMARY HOIST BRAKE | 361-MA-001-PY001 | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.921 | _361.140.921.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684841 | V/V SOLENOID SECONDARY HOIST BRAKE | 361-MA-001-PY002 | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.921 | _361.140.921.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684919 | V/V SOLENOID PRIMARY LUFFING BRAKE | 361-MA-001-PY003 | _361 | _361.140.000 | _361.140.900 | _361.140.930 | _361.140.931 | _361.140.931.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684844 | V/V SOLENOID SECONDARY LUFFING BRAKE | 361-MA-001-PY004 | _361 | _361.140.000 | _361.140.900 | _361.140.930 | _361.140.931 | _361.140.931.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685106 | V/V SOLENOID SLEWING BRAKE | 361-MA-001-PY005 | _361 | _361.140.000 | _361.140.900 | _361.140.940 | _361.140.941 | _361.140.941.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685065 | V/V SOLENOID HOIST MOT.R CHANGE OVER | 361-MA-001-PY006 | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.924 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684923 | V/V SOLENOID LUFFING MOT.R CHANGE OVER | 361-MA-001-PY007 | _361 | _361.140.000 | _361.140.900 | _361.140.930 | _361.140.933 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684847 | V/V SOLENOID AOPS HP | 361-MA-001-PY008 | _361 | _361.140.000 | _361.140.900 | _361.140.910 | _361.140.911 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685062 | V/V SOLENOID AOPS LP | 361-MA-001-PY009 | _361 | _361.140.000 | _361.140.900 | _361.140.910 | _361.140.912 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684843 | V/V SOLENOID HOOK PARK | 361-MA-001-PY010 | _361 | _361.140.000 | _361.140.900 | _361.140.990 | _361.140.991 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684993 | V/V SOLENOID MAIN HOIST SELECTION | 361-MA-001-PY011 | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.923 | _361.140.923.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685108 | V/V SOLENOID WHIP HOIST SELECTION | 361-MA-001-PY012 | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.923 | _361.140.923.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685069 | V/V SOLENOID COOLER SPEED LOW | 361-MA-001-PY013 | _361 | _361.140.000 | _361.140.900 | _361.140.950 | _361.140.951 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684989 | V/V SOLENOID COOLER SPEED HIGH | 361-MA-001-PY014 | _361 | _361.140.000 | _361.140.900 | _361.140.950 | _361.140.952 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684995 | V/V SOLENOID AOPS MED.PRS | 361-MA-001-PY015 | _361 | _361.140.000 | _361.140.900 | _361.140.910 | _361.140.913 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684918 | V/V SOLENOID CONSTANT TENSION | 361-MA-001-PY016 | _361 | _361.140.000 | _361.140.900 | _361.140.960 | _361.140.961 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685064 | V/V SOLENOID AOPS BOOST PRS | 361-MA-001-PY017 | _361 | _361.140.000 | _361.140.900 | _361.140.910 | _361.140.914 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685066 | V/V SOLENOID MOP ARM | 361-MA-001-PY018 | _361 | _361.140.000 | _361.140.900 | _361.140.970 | _361.140.971 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684845 | V/V SOLENOID MOP DISARM | 361-MA-001-PY019 | _361 | _361.140.000 | _361.140.900 | _361.140.970 | _361.140.972 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684924 | V/V SOLENOID PROP.A HOIST P | 361-MA-001-PY020A | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.922 | _361.140.922.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685105 | V/V SOLENOID PROP.B HOIST P | 361-MA-001-PY020B | _361 | _361.140.000 | _361.140.900 | _361.140.920 | _361.140.922 | _361.140.922.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684991 | V/V SOLENOID PROP.A LUFFING P | 361-MA-001-PY021A | _361 | _361.140.000 | _361.140.900 | _361.140.930 | _361.140.932 | _361.140.932.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684994 | V/V SOLENOID PROP.B LUFFING P | 361-MA-001-PY021B | _361 | _361.140.000 | _361.140.900 | _361.140.930 | _361.140.932 | _361.140.932.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685067 | V/V SOLENOID PROP.A SLEWING P | 361-MA-001-PY022A | _361 | _361.140.000 | _361.140.900 | _361.140.940 | _361.140.942 | _361.140.942.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684922 | V/V SOLENOID PROP.B SLEWING P | 361-MA-001-PY022B | _361 | _361.140.000 | _361.140.900 | _361.140.940 | _361.140.942 | _361.140.942.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684846 | PROP. VALVE LUFFING MOTOR | 361-MA-001-PY023 | _361 | _361.140.000 | _361.140.100 | _361.140.140 | | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685110 | EM DRIVE HOIST DOWN | 361-MA-001-PY024 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.161 | _361.140.161.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684842 | EM DRIVE HOIST UP | 361-MA-001-PY025 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.161 | _361.140.161.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684920 | EM DRIVE LUFFING DOWN | 361-MA-001-PY026 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.163 | _361.140.163.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685107 | EM DRIVE LUFFING UP | 361-MA-001-PY027 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.163 | _361.140.163.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685068 | EM DRIVE SLEW LEFT | 361-MA-001-PY028 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.162 | _361.140.162.100 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684848 | EM DRIVE SLEW RIGHT | 361-MA-001-PY029 | _361 | _361.140.000 | _361.140.100 | _361.140.160 | _361.140.162 | _361.140.162.200 | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10685063 | V/V SOLENOID MOP ACTIVATE | 361-MA-001-PY030 | _361 | _361.140.000 | _361.140.900 | _361.140.970 | _361.140.973 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684992 | PROP. VALVE MAIN HOIST MOTOR | 361-MA-001-PY031 | _361 | _361.150.000 | _361.150.100 | | | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684990 | PROP. VALVE WHIP HOIST MOTOR | 361-MA-001-PY032 | _361 | _361.150.000 | _361.150.200 | | | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10684921 | V/V SOLENOID EL ACTIVATE | 361-MA-001-PY033 | _361 | _361.140.000 | _361.140.900 | _361.140.980 | _361.140.981 | | OPERATING | 361 QX | LIN01 | M-MD-13-01 | 264 |
| C10688219 | 15W EX-PROOF SPEAKER | 361-MA-001-RA001A | _361 | _361.130.000 | _361.130.200 | _361.130.240 | _361.130.242 | | OPERATING | 425 LO | LIN01 | M-MD-13-04 | 264 |
| C10688467 | 15W EX-PROOF SPEAKER | 361-MA-001-RA001B | _361 | _361.130.000 | _361.130.200 | _361.130.240 | _361.130.243 | | OPERATING | 425 LO | LIN01 | M-MD-13-04 | 264 |
| C10688018 | 15W EX-PROOF SPEAKER | 361-MA-001-RA002A | _361 | _361.130.000 | _361.130.200 | _361.130.240 | _361.130.244 | | OPERATING | 425 LO | LIN01 | M-MD-13-01 | 264 |
| C10688537 | 15W EX-PROOF SPEAKER | 361-MA-001-RA002B | _361 | _361.130.000 | _361.130.200 | _361.130.240 | _361.130.245 | | OPERATING | 425 LO | LIN01 | M-MD-13-01 | 264 |
| C10687909 | YELLOW FLASHING BEACON | 361-MA-001-RA003A | _361 | _361.160.000 | _361.160.200 | _361.160.240 | _361.160.241 | | OPERATING | 425 LQ | LIN01 | M-MD-13-01 | 264 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C10687937 | YELLOW FLASHING BEACON | 361-MA-001-RA003B | _361 | _361.160.000 | _361.160.200 | _361.160.240 | _361.160.242 | OPERATING | 425 LQ | | LIN01 | M-MD-13-01 | 264 |
| C10684863 | CCTV CTRL UNIT | 361-MA-001-RC001 | _361 | _361.130.000 | _361.130.100 | _361.130.110 | | OPERATING | 361 IF | | LIN01 | M-MD-13-01 | 264 |
| C10684795 | CCTV MONITOR | 361-MA-001-RC002 | _361 | _361.130.000 | _361.130.100 | _361.130.120 | | OPERATING | 361 IG | | LIN01 | M-MD-13-01 | 264 |
| C10685127 | CAMERA BOOM TIP | 361-MA-001-RC003 | _361 | _361.130.000 | _361.130.100 | _361.130.130 | | OPERATING | 361 LK | | LIN01 | M-MD-13-01 | 264 |
| C10684981 | RADIO FM | 361-MA-001-RE001 | _361 | _361.130.000 | _361.130.200 | _361.130.210 | _361.130.211 | OPERATING | 361 LC | | LIN01 | M-MD-13-01 | 264 |
| C10684834 | ANTENNA FM | 361-MA-001-RE002 | _361 | _361.130.000 | _361.130.200 | _361.130.220 | _361.130.221 | OPERATING | 361 LN | | LIN01 | M-MD-13-01 | 264 |
| C10684944 | TELEPHONE CABIN | 361-MA-001-RP001 | _361 | _361.130.000 | _361.130.200 | _361.130.230 | _361.130.231 | OPERATING | 361 LT | | LIN01 | M-MD-13-01 | 264 |
| C10688774 | EXPLOSION PROOF TELEPHONE | 361-MA-001-RP003 | _361 | _361.130.000 | _361.130.200 | _361.130.230 | _361.130.232 | OPERATING | 425 LT | | LIN01 | M-MD-13-04 | 264 |
| C10685003 | RADIO UNIT VHF/UHF/FM | 361-MA-001-RU001 | _361 | _361.130.000 | _361.130.200 | _361.130.210 | _361.130.212 | OPERATING | 361 IF | | LIN01 | M-MD-13-01 | 264 |
| C10684907 | RADIO VHF | 361-MA-001-RU002 | _361 | _361.130.000 | _361.130.200 | _361.130.210 | _361.130.213 | OPERATING | 361 LC | | LIN01 | M-MD-13-01 | 264 |
| C10685096 | ANTENNA UHF | 361-MA-001-RU003 | _361 | _361.130.000 | _361.130.200 | _361.130.220 | _361.130.222 | OPERATING | 361 LN | | LIN01 | M-MD-13-01 | 264 |
| C10685053 | RADIO UHF | 361-MA-001-RU004 | _361 | _361.130.000 | _361.130.200 | _361.130.210 | _361.130.214 | OPERATING | 361 LC | | LIN01 | M-MD-13-01 | 264 |
| C10684908 | ANTENNA VHF | 361-MA-001-RU005 | _361 | _361.130.000 | _361.130.200 | _361.130.220 | _361.130.223 | OPERATING | 361 LN | | LIN01 | M-MD-13-01 | 264 |
| C10684785 | LOADHAILER LOUDSPEAKER | 361-MA-001-RX002 | _361 | _361.130.000 | _361.130.200 | _361.130.240 | _361.130.241 | OPERATING | 361 LO | | LIN01 | M-MD-13-01 | 264 |
| C11104356 | HORN ALARM | 361-MA-001-RX004 | _361 | _361.130.000 | _361.130.200 | _361.130.260 | _361.130.261 | OPERATING | 361 LO | | LIN01 | 361.DCR1-LO | 264 |
| C10684943 | SENSOR WINDSPEED | 361-MA-001-ST001 | _361 | _361.120.000 | _361.120.300 | _361.120.370 | _361.120.371 | OPERATING | 361 QM | | LIN01 | M-MD-13-01 | 264 |
| C10685132 | CTRL-P CABIN FAN HEATER | 361-MA-001-TC001 | _361 | _361.130.000 | _361.130.500 | _361.130.510 | _361.130.515 | OPERATING | 361 IF | | LIN01 | M-MD-13-01 | 264 |
| C10685115 | HYDR. TANK TEMPERATURE SENSOR | 361-MA-001-TT001 | _361 | _361.140.000 | _361.140.800 | _361.140.810 | _361.140.811 | OPERATING | 361 QT | | LIN01 | M-MD-13-01 | 264 |
| C10684935 | LUBE OIL SPLITTER GEAR TEMPERATURE SENSOR | 361-MA-001-TT002 | _361 | _361.140.000 | _361.140.800 | _361.140.810 | _361.140.812 | OPERATING | 361 QT | | LIN01 | M-MD-13-01 | 264 |
| C10684776 | MACHINERY HOUSE TEMPERATURE SENSOR | 361-MA-001-TT003 | _361 | _361.120.000 | _361.120.300 | _361.120.310 | _361.120.311 | OPERATING | 361 QT | | LIN01 | M-MD-13-01 | 264 |
| C10684856 | LOAD CELL HOIST WHIP | 361-MA-001-WE001 | _361 | _361.150.000 | _361.150.200 | _361.150.220 | | OPERATING | 361 QW | | LIN01 | M-MD-13-01 | 264 |
| C10685124 | LOAD CELL HOIST MAIN | 361-MA-001-WE002 | _361 | _361.150.000 | _361.150.100 | _361.150.150 | | OPERATING | 361 QW | | LIN01 | M-MD-13-01 | 264 |
| C10684864 | LOAD CELL LUFFING | 361-MA-001-WE003 | _361 | _361.150.000 | _361.150.400 | _361.150.450 | | OPERATING | 361 QW | | LIN01 | M-MD-13-01 | 264 |
| C10684796 | WHIP HOIST SLACKWIRE | 361-MA-001-ZE001 | _361 | _361.150.000 | _361.150.200 | _361.150.210 | | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684999 | MAIN HOIST SLACKWIRE | 361-MA-001-ZE002 | _361 | _361.150.000 | _361.150.100 | _361.150.160 | | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10685120 | LUFFING LIMIT SW. UP ABS. | 361-MA-001-ZE003 | _361 | _361.150.000 | _361.150.400 | _361.150.460 | | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684786 | SLEWING COUNTER A | 361-MA-001-ZE004 | _361 | _361.150.000 | _361.150.500 | _361.150.530 | _361.150.531 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10685128 | SLEWING COUNTER B | 361-MA-001-ZE005 | _361 | _361.150.000 | _361.150.500 | _361.150.530 | _361.150.532 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10685013 | SLEWING COUNTER RESET | 361-MA-001-ZE006 | _361 | _361.150.000 | _361.150.500 | _361.150.530 | _361.150.533 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684865 | SWITCH PROX MOP ARMED | 361-MA-001-ZE007 | _361 | _361.120.000 | _361.120.300 | _361.120.340 | _361.120.341 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684945 | SWITCH PROX MOP DISARMED | 361-MA-001-ZE008 | _361 | _361.120.000 | _361.120.300 | _361.120.340 | _361.120.342 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684930 | SWITCH PROX PARKING F-O.NT WIPER UPPER | 361-MA-001-ZE009 | _361 | _361.120.000 | _361.120.300 | _361.120.360 | _361.120.361 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684780 | SWITCH PROX PARKING F-O.NT WIPER LOWER | 361-MA-001-ZE010 | _361 | _361.120.000 | _361.120.300 | _361.120.360 | _361.120.362 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10685007 | SWITCHES LIMIT MAIN HOIST | 361-MA-001-ZE011 | _361 | _361.120.000 | _361.120.300 | _361.120.320 | _361.120.321 | OPERATING | 361 EP | | LIN01 | M-MD-13-01 | 264 |
| C10685129 | SWITCHES LIMIT WHIP HOIST | 361-MA-001-ZE012 | _361 | _361.120.000 | _361.120.300 | _361.120.330 | _361.120.331 | OPERATING | 361 EP | | LIN01 | M-MD-13-01 | 264 |
| C10684869 | EFGD INLET MACH.H. CLOSED | 361-MA-001-ZE013 | _361 | _361.120.000 | _361.120.500 | _361.120.530 | | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684853 | EFGD OUTLET MACH.H. CLOSED | 361-MA-001-ZE014 | _361 | _361.120.000 | _361.120.500 | _361.120.540 | | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10685004 | HOIST ENCODER WHIP | 361-MA-001-ZT001 | _361 | _361.120.000 | _361.120.300 | _361.120.330 | _361.120.332 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684939 | HOIST ENCODER MAIN | 361-MA-001-ZT002 | _361 | _361.120.000 | _361.120.300 | _361.120.320 | _361.120.322 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684781 | BOOM ANGLE ENCODER | 361-MA-001-ZT003 | _361 | _361.120.000 | _361.120.300 | _361.120.380 | _361.120.383 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10684860 | LUFFING ENCODER | 361-MA-001-ZT004 | _361 | _361.120.000 | _361.120.300 | _361.120.380 | _361.120.381 | OPERATING | 361 QG | | LIN01 | M-MD-13-01 | 264 |
| C10688942 | JB FLOODLIGHTS & AWL BOOM | 361-MA-001EJ002 | _361 | _361.120.000 | _361.120.200 | _361.120.290 | _361.120.291 | OPERATING | 427 EJ | 415168 | LIN01 | M-MD-13-01 | 264 |
| C10688629 | UNIT,TALKBACK | 361-MA-001RD001 | _361 | _361.130.000 | _361.130.200 | _361.130.250 | _361.130.251 | OPERATING | 425 LO | | LIN01 | M-MD-13-01 | 264 |
| C10688614 | LOUDSPEAKER,TALKBACK | 361-MA-001RD002 | _361 | _361.130.000 | _361.130.200 | _361.130.250 | _361.130.252 | OPERATING | 425 LO | | LIN01 | M-MD-13-01 | 264 |
| C10688627 | FOOTSWITCH,TALKBACK | 361-MA-001RD003 | _361 | _361.130.000 | _361.130.200 | _361.130.250 | _361.130.253 | OPERATING | 425 EP | | LIN01 | M-MD-13-01 | 264 |

Sheet 2 – *Tag catalogue*

| Lattice Boom Crane STBD | 361.100.000 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure | _361.110.000 | | | | | | | | | | |
| Instrumentation | _361.120.000 | | | | | | | | | | |
| Operators Cabin | _361.130.000 | | | | | | | | | | |
| Hydraulic System | _361.140.000 | | | | | | | | | | |
| Hoisting System | _361.150.000 | | | | | | | | | | |
| Ventilation, Lights and Sockets | _361.160.000 | | | | | | | | | | |
| **SUBSYSTEM** | | | | | | | | | | | |
| **361.110.000** | | **361.120.000** | | **361.130.000** | | **361.140.000** | | **361.150.000** | | **361.160.000** | |
| Crane, offshore pedestal, deck STBD | 361.110.100 | Power control | 361.120.100 | CCTV | 361.130.100 | PACKAGE ELECTRICAL MOTORS | 361.140.100 | PROP. VALVE MAIN HOIST MOTOR | 361.150.100 | Ventilation | 361.160.100 |
| | | Junction boxes | 361.120.200 | Communication | 361.130.200 | Pump | 361.140.200 | PROP. VALVE WHIP HOIST MOTOR | 361.150.200 | Lights | 361.160.200 |
| | | Sensor/Encoder | 361.120.300 | Control equipment | 361.130.300 | Accumulator | 361.140.300 | HOOK BLOCK | 361.150.300 | Sockets | 361.160.300 |
| | | Transmitter | 361.120.400 | Washer and Wiper | 361.130.400 | Oil and filtration | 361.140.400 | WINCH LUFFING | 361.150.400 | | |
| | | Machinary house | 361.120.500 | Heat, cooling and air condition | 361.130.500 | Heater | 361.140.500 | Slewing | 361.150.500 | | |
| | | | | Equipment | 361.130.600 | Hose | 361.140.600 | | | | |
| | | | | | | Cylinder | 361.140.700 | | | | |
| | | | | | | Sensors | 361.140.800 | | | | |
| | | | | | | Solenoid valves | 361.140.900 | | | | |
| **UNIT** | | | | | | | | | | | |
| **Crane, offshore pedestal, deck STBD:** | | **Power control:** | | **CCTV:** | | **PACKAGE ELECTRICAL MOTORS:** | | **PROP. VALVE MAIN HOIST MOTOR:** | | **VENTILATION:** | |
| Main lattice boom | 361.110.110 | Emergency system | 361.120.110 | CCTV CTRL UNIT | 361.130.110 | Main | 361.140.110 | ACCUMULATOR BOOST HOIST MAIN WINCH | 361.150.110 | Damper actuator | 361.160.110 |
| A-frame | 361.110.120 | Data recording system | 361.120.120 | CCTV MONITOR | 361.130.120 | Cooler | 361.140.120 | Brake | 361.150.120 | Fan | 361.160.120 |
| Davit | 361.110.130 | | | CAMERA BOOM TIP | 361.130.130 | Slewing | 361.140.130 | Sheave | 361.150.130 | | |
| Housing | 361.110.140 | **Junction boxes:** | | JOYSTICK BOX LEFT HAND | 361.130.140 | PROP. VALVE LUFFING MOTOR | 361.140.140 | WIRE WINCH MAIN HOIST | 361.150.140 | **LIGHTS:** | |
| | | Machine house | 361.120.210 | JOYSTICK BOX RIGHT HAND | 361.130.150 | Hoist | 361.140.150 | LOAD CELL HOIST MAIN | 361.150.150 | PACKAGE LIGHTS | 361.160.210 |
| | | CCTV | 361.120.220 | | | Em drive | 361.140.160 | MAIN HOIST SLACKWIRE | 361.150.160 | Floodlight | 361.160.220 |
| | | Battery | 361.120.230 | **Communication:** | | | | WINCH MAIN HOIST | 361.150.170 | Machine house | 361.160.230 |
| | | Winch | 361.120.240 | Radio | 361.130.210 | **Pump:** | | Gear | 361.150.180 | Beacon | 361.160.240 |
| | | Luffing | 361.120.250 | Antenna | 361.130.220 | HYDR. PUMP SLEW SYSTEM | 361.140.210 | | | | |
| | | Angle movement | 361.120.260 | Telephone | 361.130.230 | HYDR. PUMP LUFFING SYSTEM | 361.140.220 | **PROP. VALVE WHIP HOIST MOTOR:** | | **SOCKETS:** | |
| | | Deck crane utility supply | 361.120.270 | Speaker | 361.130.240 | HYDR. PUMP MAIN HOIST SYSTEM | 361.140.230 | WHIP HOIST SLACKWIRE | 361.150.210 | SOCKET OUTL.MACH.HOUSE | 361.160.310 |
| | | Load cells | 361.120.280 | Talkback | 361.130.250 | HYDR. PUMP EMERGENCY DRIVE | 361.140.240 | LOAD CELL HOIST WHIP | 361.150.220 | SOCKET OUTL.AIR CONDITION | 361.160.320 |
| | | Floodlights | 361.120.290 | Horn alarm | 361.130.260 | | | ACCUMULATOR BOOST HOIST WHIP WINCH | 361.150.230 | SOCKET OUTL.CABIN CCTV MONITOR | 361.160.330 |
| | | | | | | **Accumulator:** | | Brake | 361.150.240 | SOCKET OUTL.FAN HEATER | 361.160.340 |
| | | **Sensor/encoder:** | | **Control equipment:** | | ACCUMULATOR EMERGENCY | 361.140.310 | Sheave | 361.150.250 | SOCKET OUTL.FAN HEATER | 361.160.350 |
| | | Temprature | 361.120.310 | Control panel | 361.130.310 | ACCUMULATOR BUFFER | 361.140.320 | Gear | 361.150.260 | | |
| | | Main hoist | 361.120.320 | Start/stop button | 361.130.320 | ACCUMULATOR SEC. BRAKE RELEASE | 361.140.330 | WIRE WINCH WHIP HOIST | 361.150.270 | | |
| | | Whip hoist | 361.120.330 | Panel power distrubution | 361.130.330 | | | SWIVEL WEIGHT WHIPLINE | 361.150.280 | | |
| | | MOP | 361.120.340 | | | **Oil and filtration:** | | WINCH WHIP HOIST | 361.150.290 | | |
| | | Indication lamp | 361.120.350 | **Washer and Wiper:** | | FILTER UNIT CJC FOR HPU | 361.140.410 | | | | |
| | | Wiper parking swich | 361.120.360 | Washer | 361.130.410 | TK HYDR OIL | 361.140.420 | **HOOK BLOCK:** | | | |
| | | Sensor windspeed | 361.120.370 | Wiper | 361.130.420 | | | SHEAVE HOOK BLOCK STBD CRANE | 361.150.310 | | |
| | | Position and angle | 361.120.380 | | | **Heater:** | | SHEAVE HOOK BLOCK STBD CRANE | 361.150.320 | | |
| | | | | **Heat, cooling and air condition:** | | HEATER HYDR OIL | 361.140.510 | | | | |
| | | **Transmitter:** | | Heater | 361.130.510 | HEATER HYDR OIL | 361.140.520 | **WINCH LUFFING:** | | | |
| | | TRANSM PRS MOP ACTIVATED | 361.120.410 | VENT.FAN | 361.130.520 | | | Brake | 361.150.410 | | |
| | | TRANSM PRS HOIST BOOST | 361.120.420 | Air condition | 361.130.530 | **Hose:** | | GEAR WINCH LUFFING | 361.150.420 | | |
| | | TRANSM PRS LUFFING BOOST | 361.120.430 | | | HYDRAULIC HOSE PACKAGE CRANE STBD | 361.140.610 | SHEAVES PACKAGE STBD DECK CRANE | 361.150.430 | | |
| | | TRANSM PRS BOOST P | 361.120.440 | **Equipment:** | | | | WIRE WINCH LUFFING | 361.150.440 | | |
| | | TRANSM PRS HOIST LINE | 361.120.450 | WINDSOCK UNIT W/ AWL | 361.130.610 | **Cylinder:** | | LOAD CELL LUFFING | 361.150.450 | | |
| | | TRANSM PRS SLEWING LINE | 361.120.460 | | | BOOM CYLINDER BACKSTOP | 361.140.710 | LUFFING LIMIT SW. UP ABS. | 361.150.460 | | |
| | | | | | | | | SLIP RING UNIT | 361.150.470 | | |
| | | **Machinary house:** | | | | **Sensors:** | | | | | |
| | | CTRL-P MACHINERY HOUSE | 361.120.510 | | | Temperature and level | 361.140.810 | **Slewing:** | | | |
| | | PANEL POWER DISTRIBUTION MACHINERY HO | 361.120.520 | | | | | GEAR SPLITTER | 361.150.510 | | |
| | | EFGD INLET MACH.H. CLOSED | 361.120.530 | | | **Solenoid valves:** | | Brake | 361.150.520 | | |
| | | EFGD OUTLET MACH.H. CLOSED | 361.120.540 | | | Aops | 361.140.910 | Counter | 361.150.530 | | |
| | | | | | | Hoist | 361.140.920 | Bearing | 361.150.540 | | |
| | | | | | | Luffing | 361.140.930 | | | | |
| | | | | | | Slewing | 361.140.940 | | | | |
| | | | | | | Cooler | 361.140.950 | | | | |
| | | | | | | Constant tension | 361.140.960 | | | | |
| | | | | | | Mop | 361.140.970 | | | | |
| | | | | | | EL | 361.140.980 | | | | |
| | | | | | | Hook park | 361.140.990 | | | | |

## COMPONENT

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Main Lattice Boom:** | | **Emergency system, Power/Control:** | | **Radio:** | | **Main:** | | **Brake, Main hoist, motor:** | | **Damper actuator:** | |
| BOOM, OFFSHORE CRANE STBD | 361.110.111 | EMERGENCY POWER PACK 690V 60HZ | 361.120.111 | RADIO FM | 361.130.211 | MOTOR MAIN 690V 60HZ | 361.140.111 | BRAKE PRIMARY MAIN WINCH HOIST A | 361.150.121 | DAMPER ACTUATOR AIR INLET CABIN | 361.160.111 |
| AWL CRANE BOOM (RD) | 361.110.112 | EMERGENCY LOWERING | 361.120.112 | RADIO UNIT VHF/UHF/FM | 361.130.212 | | | BRAKE PRIMARY MAIN WINCH HOIST B | 361.150.122 | DAMPER ACTUATOR AIR INLET MACH.H. | 361.160.112 |
| AWL CRANE BOOM (RD) | 361.110.113 | STARTER EMG. POWER PACK | 361.120.113 | RADIO VHF | 361.130.213 | **Cooler:** | | | | DAMPER ACTUATOR AIR OUTLET MACH.H. | 361.160.113 |
| AWL CRANE BOOM (RD) | 361.110.114 | | | RADIO UHF | 361.130.214 | COOLER INCLUDING FAN/HYD. MOTOR A | 361.140.121 | **Sheave, Main hoist, motor:** | | | |
| | | **Machine house, junction boxes:** | | | | COOLER INCLUDING FAN/HYD. MOTOR B | 361.140.122 | SHEAVE MAIN HOIST STBD CRANE | 361.150.131 | **Fan:** | |
| **A-frame:** | | JB INLET MACH.H. | 361.120.211 | **Antenna:** | | | | SHEAVE MAIN HOIST STBD CRANE | 361.150.132 | FAN VENT CRANE | 361.160.121 |
| A-FRAME, OFFSHORE CRANE STBD | 361.110.121 | JB OUTLET MACH.H. | 361.120.212 | ANTENNA FM | 361.130.221 | **Slewing:** | | SHEAVE MAIN HOIST STBD CRANE | 361.150.133 | | |
| SERV CRANE IN A-FRAME | 361.110.122 | JUNCTION BOX INLET MACH.H. | 361.120.213 | ANTENNA UHF | 361.130.222 | HYDR. MOTOR SLEW A | 361.140.131 | SHEAVE MAIN HOIST STBD CRANE | 361.150.134 | **Machine house:** | |
| | | JB INLET MACH.H. | 361.120.214 | ANTENNA VHF | 361.130.223 | HYDR. MOTOR SLEW B | 361.140.132 | SHEAVE MAIN HOIST STBD CRANE | 361.150.135 | Main | 361.160.231 |
| **Davit:** | | JUNCTION BOX OUTL.MACH.H. | 361.120.215 | | | HYDR. MOTOR SLEW C | 361.140.133 | | | Outside | 361.160.232 |
| PORTABLE SERV DAVIT | 361.110.131 | JB OUTLET MACH.H. | 361.120.216 | **Telephone:** | | | | **Brake, Whip hoist, motor:** | | Under | 361.160.233 |
| | | | | TELEPHONE CABIN | 361.130.231 | **PROP. VALVE LUFFING MOTOR:** | | BRAKE PRIMARY WHIP WINCH HOIST A | 361.150.241 | | |
| **Housing:** | | **CCTV, Junction boxes:** | | EXPLOSION PROOF TELEPHONE | 361.130.232 | HYDR. MOTOR LUFFING A | 361.140.141 | BRAKE PRIMARY WHIP WINCH HOIST B | 361.150.242 | **PACKAGE LIGHTS:** | |
| Door | 361.110.141 | JB CCTV BOOM | 361.120.221 | | | HYDR. MOTOR LUFFING B | 361.140.142 | BRAKE SECONDARY WHIP WINCH | 361.150.243 | LIGHT SLIPRING AREA UPPER | 361.160.211 |
| | | JB CCTV BOOM TIP | 361.120.222 | **Speaker:** | | | | | | LIGHT A-FRAME MIDDLE | 361.160.212 |
| | | CRANE CONTROL DISPLAY | 361.120.223 | LOADHAILER LOUDSPEAKER | 361.130.241 | **Hoist, motors:** | | **Sheave, Whip hoist, motor:** | | LIGHT A-FRAME TOP | 361.160.213 |
| | | | | 15W EX-PROOF SPEAKER | 361.130.242 | Main | 361.140.151 | SHEAVE WHIP HOIST STBD CRANE | 361.150.251 | LIGHT ACCESS CRANE | 361.160.214 |
| | | **Battery, junction boxes** | | 15W EX-PROOF SPEAKER | 361.130.243 | Whip | 361.140.152 | SHEAVE WHIP HOIST STBD CRANE | 361.150.252 | LIGHT CABIN | 361.160.215 |
| | | JB BATTERY BOX | 361.120.231 | 15W EX-PROOF SPEAKER | 361.130.244 | | | SHEAVE WHIP HOIST STBD CRANE | 361.150.253 | | |
| | | JB MOPS/BACKUP BATTERY | 361.120.232 | 15W EX-PROOF SPEAKER | 361.130.245 | **EM drive:** | | | | **Floodlight:** | |
| | | | | | | EM drive hoist | 361.140.161 | **Gear, Whip hoist, motor:** | | FLOODLIGHT BOOM | 361.160.221 |
| | | **Winch, junction boxes:** | | **Talkback:** | | EM drive slew | 361.140.162 | GEAR WINCH HOIST | 361.150.261 | FLOODLIGHT BOOM | 361.160.222 |
| | | JB WINCHES | 361.120.241 | UNIT,TALKBACK | 361.130.251 | EM drive luffing | 361.140.163 | GEAR WINCH WHIP HOIST | 361.150.262 | FLOODLIGHT SLEW. STRUCTURE | 361.160.223 |
| | | JB WINCH MOTORS | 361.120.242 | LOUDSPEAKER,TALKBACK | 361.130.252 | | | | | FLOODLIGHT SLEW. STRUCTURE | 361.160.224 |
| | | JB WINCH MOTORS | 361.120.243 | FOOTSWITCH TALKBAK | 361.130.253 | **Temprature and level sensor** | | **Brake, Winch Luffing:** | | | |
| | | | | | | HYDR. TANK TEMPERATURE SENSOR | 361.140.811 | BRAKE PRIMARY LUFFING WINCH A | 361.150.411 | **Beacon:** | |
| | | **Luffing, junction boxes:** | | **Horn alarm:** | | LUBE OIL SPLITTER GEAR TEMPERATURE SENSOR | 361.140.812 | BRAKE PRIMARY LUFFING WINCH B | 361.150.412 | YELLOW FLASHING BEACON | 361.160.241 |
| | | JB LUFFING ENCODER | 361.120.251 | HORN ALARM | 361.130.261 | LEVEL SENSORSOR HYDR.TK | 361.140.813 | BRAKE SECONDARY LUFFING | 361.150.413 | YELLOW FLASHING BEACON | 361.160.242 |
| | | JB LUFFING MOTOR | 361.120.252 | | | | | | | | |
| | | JB LC LUFFING/WINDSPEED | 361.120.253 | **Control panel:** | | **Aops:** | | **SHEAVES PACKAGE STBD DECK CRANE , Luffing:** | | | |
| | | | | CTRL-P CABIN | 361.130.311 | V/V SOLENOID AOPS HP | 361.140.911 | SHEAVE LUFFING STBD CRANE | 361.150.431 | | |
| | | **Angle movement, junction boxes:** | | | | V/V SOLENOID AOPS LP | 361.140.912 | SHEAVE LUFFING STBD CRANE | 361.150.432 | | |
| | | JB DAMPERS | 361.120.261 | **Start/stop button:** | | V/V SOLENOID AOPS MED.PRS | 361.140.913 | SHEAVE LUFFING STBD CRANE | 361.150.433 | | |
| | | JB BOOM ANGLE | 361.120.262 | PUSH BUTTON EMERGENCY STOP PB MUSHRM | 361.130.321 | V/V SOLENOID AOPS BOOST PRS | 361.140.914 | SHEAVE LUFFING STBD CRANE | 361.150.434 | | |
| | | JB SLEW. COUNTER | 361.120.263 | PUSH BUTTON EMERGENCY STOP | 361.130.322 | | | SHEAVE LUFFING STBD CRANE | 361.150.435 | | |
| | | | | EPP START/STOP (CABIN) | 361.130.323 | **Hoist, solenoid:** | | SHEAVE LUFFING STBD CRANE | 361.150.436 | | |
| | | **Deck crane utility supply, junction boxes:** | | | | Brake | 361.140.921 | SHEAVE LUFFING STBD CRANE | 361.150.437 | | |
| | | JUNCTION BOX DK CRANE STBD UTILITY SUPL | 361.120.271 | **Panel power distrubution:** | | Prob. | 361.140.922 | SHEAVE LUFFING STBD CRANE | 361.150.438 | | |
| | | | | PANEL POWER DISTRIBUTION CABIN | 361.130.331 | Selection | 361.140.923 | | | | |
| | | **Load cells, junction boxes:** | | PANEL POWER DISTRIBUTION MAIN MOTOR STARTER | 361.130.332 | V/V SOLENOID HOIST MOT.R CHANGE OVER | 361.140.924 | **GEAR SPLITTER, slewing:** | | | |
| | | JB LOAD CELLS | 361.120.281 | | | | | GEAR A SLEWING | 361.150.511 | | |
| | | | | **Washer:** | | **Luffing, solenoid:** | | GEAR B SLEWING | 361.150.512 | | |
| | | **Floodlights, junction boxes:** | | MOTOR WASHER F-O.NT WINDOW 24VDC | 361.130.411 | Brake | 361.140.931 | GEAR C SLEWING | 361.150.513 | | |
| | | JB FLOODLIGHTS & AWL BOOM | 361.120.291 | MOTOR WASHER SIDE WINDOWS 24VDC | 361.130.412 | Prop. | 361.140.932 | | | | |
| | | | | MOTOR WASHER ROOF WINDOW 24VDC | 361.130.413 | V/V SOLENOID LUFFING MOT.R CHANGE OVER | 361.140.933 | **Brake, Slewing:** | | | |
| | | **Temprature, Sensor/encoder:** | | | | | | BRAKE SLEWING A | 361.150.521 | | |
| | | MACHINERY HOUSE TEMPERATURE SENSOR | 361.120.311 | **Wiper:** | | **Slewing, solenoid:** | | BRAKE SLEWING B | 361.150.522 | | |
| | | | | MOTOR ROOF WIPER 24VDC | 361.130.421 | Brake | 361.140.941 | BRAKE SLEWING C | 361.150.523 | | |
| | | **Main hoist, Sensor/encoder:** | | MOTOR F-O.NT WIPER 24VDC | 361.130.422 | Prop. | 361.140.942 | | | | |
| | | SWITCHES LIMIT MAIN HOIST | 361.120.321 | MOTOR F-O.NT WIPER 24VDC | 361.130.423 | | | **Counter, Slewing:** | | | |
| | | HOIST ENCODER MAIN | 361.120.322 | MOTOR SIDE WIPER 24VDC | 361.130.424 | **Cooler, solenoid:** | | SLEWING COUNTER A | 361.150.531 | | |
| | | | | MOTOR SIDE WIPER 24VDC | 361.130.425 | V/V SOLENOID COOLER SPEED LOW | 361.140.951 | SLEWING COUNTER B | 361.150.532 | | |
| | | **Whip hoist, Sensor/encoder:** | | | | V/V SOLENOID COOLER SPEED HIGH | 361.140.952 | SLEWING COUNTER RESET | 361.150.533 | | |
| | | SWITCHES LIMIT WHIP HOIST | 361.120.331 | **Heater:** | | **Constant tension, solenoid:** | | | | | |
| | | HOIST ENCODER WHIP | 361.120.332 | HEATER FAN CABIN | 361.130.511 | V/V SOLENOID CONSTANT TENSION | 361.140.961 | **Bearing, slewing:** | | | |
| | | | | HEATER CABIN SPACE | 361.130.512 | | | BEARING SLEW | 361.150.541 | | |
| | | **MOP, sensor:** | | HEATER MACH.HOUSE FAN | 361.130.513 | **MOP, Solenoid:** | | BOLTS SLEW BEARING | 361.150.542 | | |
| | | SWITCH PROX MOP ARMED | 361.120.341 | HEATER MACH.HOUSE SPACE | 361.130.514 | V/V SOLENOID MOP ARM | 361.140.971 | | | | |
| | | SWITCH PROX MOP DISARMED | 361.120.342 | CTRL-P CABIN FAN HEATER | 361.130.515 | V/V SOLENOID MOP DISARM | 361.140.972 | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MOP ACTIVATE | 361.120.343 | | | V/V SOLENOID MOP ACTIVATE | 361.140.973 | | | | |
| | | | | **VENT.FAN** | | | | | | | |
| | | **Indication lamp, Sensor/encoder:** | | CRANE VENT. FAN 230V 60HZ | 361.130.521 | **EL, solenoid:** | | | | | |
| | | ESD INDICATION LAMP | 361.120.351 | CRANE CAB.VENT. FAN 230V 60HZ | 361.130.522 | V/V SOLENOID EL ACTIVATE | 361.140.981 | | | | |
| | | F&G INDICATION LAMP | 361.120.352 | | | | | | | | |
| | | | | **Air condition:** | | **Hook park, solenoid:** | | | | | |
| | | **Wiper parking swich, Sensor/encoder:** | | UNIT AIR CONDITION | 361.130.531 | V/V SOLENOID HOOK PARK | 361.140.991 | | | | |
| | | SWITCH PROX PARKING F-O.NT WIPER UPPER | 361.120.361 | | | | | | | | |
| | | SWITCH PROX PARKING F-O.NT WIPER LOWER | 361.120.362 | | | | | | | | |
| | | | | | | | | | | | |
| | | **Sensor windspeed, Sensor/encoder:** | | | | | | | | | |
| | | SENSOR WINDSPEED | 361.120.371 | | | | | | | | |
| | | | | | | | | | | | |
| | | **Position and angle, Sensor/encoder:** | | | | | | | | | |
| | | LUFFING ENCODER | 361.120.381 | | | | | | | | |
| | | ANTI-COLLISION SYSTEM | 361.120.382 | | | | | | | | |
| | | BOOM ANGLE ENCODER | 361.120.383 | | | | | | | | |
| **ITEM** | | | | | | | | | | | |
| **Door:** | | | | | | **Main, Hoist, Motors:** | | | | **Main:** | |
| DOOR,STEEL,SWING, MACH. HOUSE SB CRANE | 361.110.141.100 | | | | | HYDR. MOTOR HOIST MAIN WINCH A | 361.140.151.100 | | | LIGHT MACH. HOUSE RIGHT | 361.160.231.100 |
| DOOR,STEEL,SWING, CRANE CABIN SB CRANE | 361.110.141.200 | | | | | HYDR. MOTOR HOIST MAIN WINCH B | 361.140.151.200 | | | LIGHT MACH. HOUSE MIDDLE | 361.160.231.200 |
| | | | | | | | | | | LIGHT MACH. HOUSE BACK | 361.160.231.300 |
| | | | | | | **Whip, Hoist, Motors:** | | | | LIGHT MACH. HOUSE LEFT | 361.160.231.400 |
| | | | | | | HYDR. MOTOR HOIST WHIP WINCH A | 361.140.152.100 | | | | |
| | | | | | | HYDR. MOTOR HOIST WHIP WINCH B | 361.140.152.200 | | | **Outside:** | |
| | | | | | | | | | | LIGHT OUTSIDE MACH. HOUSE BY DOOR | 361.160.232.100 |
| | | | | | | **Em drive, hoist:** | | | | LIGHT OUTSIDE MACHINERY HOUSE RIGHT | 361.160.232.200 |
| | | | | | | EM DRIVE HOIST DOWN | 361.140.161.100 | | | | |
| | | | | | | EM DRIVE HOIST UP | 361.140.161.200 | | | **Under:** | |
| | | | | | | | | | | LIGHT UNDER MACH. HOUSE LEFT | 361.160.233.100 |
| | | | | | | **Em drive, slew:** | | | | LIGHT UNDER MACH. HOUSE RIGHT | 361.160.233.200 |
| | | | | | | EM DRIVE SLEW LEFT | 361.140.162.100 | | | | |
| | | | | | | EM DRIVE SLEW RIGHT | 361.140.162.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Em drive, luffing:** | | | | | |
| | | | | | | EM DRIVE LUFFING DOWN | 361.140.163.100 | | | | |
| | | | | | | EM DRIVE LUFFING UP | 361.140.163.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Brake, Hoist (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID PRIMARY HOIST BRAKE | 361.140.921.100 | | | | |
| | | | | | | V/V SOLENOID SECONDARY HOIST BRAKE | 361.140.921.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Prob., Hoist (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID PROP.A HOIST P | 361.140.922.100 | | | | |
| | | | | | | V/V SOLENOID PROP.B HOIST P | 361.140.922.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Selection, Hoist (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID MAIN HOIST SELECTION | 361.140.923.100 | | | | |
| | | | | | | V/V SOLENOID WHIP HOIST SELECTION | 361.140.923.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Brake, Luffing (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID PRIMARY LUFFING BRAKE | 361.140.931.100 | | | | |
| | | | | | | V/V SOLENOID SECONDARY LUFFING BRAKE | 361.140.931.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Prop., Luffing (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID PROP.A LUFFING P | 361.140.932.100 | | | | |
| | | | | | | V/V SOLENOID PROP.B LUFFING P | 361.140.932.200 | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | **Brake, Slewing (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID SLEWING BRAKE | 361.140.941.100 | | | | |
| | | | | | | | | | | | |
| | | | | | | **Prop., Slewing (solenoid):** | | | | | |
| | | | | | | V/V SOLENOID PROP.A SLEWING P | 361.140.942.100 | | | | |
| | | | | | | V/V SOLENOID PROP.B SLEWING P | 361.140.942.200 | | | | |

Sheet 3 – *FMECA*

| Number | Technical Hierarchy | | | Object code | Function Failure Analysis (FFA) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | System | Equipment | Maintainable Item | | Main Function | Main Function Failure | Secondary Function | Secondary Function Failure | Tertiary Function | Tertiary Functional Failure | Quaternary Function | Quaternary Function Failure | Failure Mode (ISO14224) | Failure Mechanism (ISO14224) | Failure Cause | Hidden / Evident Failure |
| 1 | Hydraulic System | Emergency Drive System (630) | Emergency Drive Pump (Piston) | PURE00 | Initiates and transfers a fluid flow | Unable to transport fluid flow | Produces nessesary flow to maintain a certain pressure | Produces too low flow rate | To contain the fluid on the inside of the system | Leakage | Start and stop when needed | Does not start/stop | AIR | Intrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | | | | ERO | Intrument failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | | | | ELU | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | | | | NOI | Material failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | | | | PDE | Instrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | | | | OTH | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | | | | UNK | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | | | | UST | Miscellaneous | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | | | | INL | Mechanical failure (leakage) | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | | | | VIB | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | | | | ELP | Mechanical failure (leakage) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | | | | BRD | Miscellaneous | Failure related to operation/ maintenance | Evident |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | FTS | Instrument failure/ electric failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | OHE | Material failure (overheating) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | STD | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | LOO | Electrical failure (general) | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | FRO | Material failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | SER | Instrument failure/ Electrical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | PLU | External influence (plugged) | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | HIO | Instrument failure | Failure related to operation/ maintenance | Hidden |
| Electrical Motor | EMDC00 | Convert electricity to mechanical energy | Does not produce mechanical energy | Produce the energy to drive the pump | Does not produce energy to the pump | To contain the fluid on the inside of the system | Leakage | Start and stop when needed | Does not start/stop | AIR | Intrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | BRD | Miscellaneous | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | ERO | Intrument failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | ELU | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | HIO | Instrument failure | Failure related to operation/ maintenance | Hidden |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | LOO | Electrical failure (general) | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | PDE | Instrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | STP | Instrument failure/ electric failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | FTS | Instrument failure/ electric failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | OHE | General material failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | OTH | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | UNK | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | UST | Miscellaneous | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | STD | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | NOI | Material failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | VIB | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | SER | Instrument failure/ Electrical failure | Failure related to operation/ maintenance | Evident |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emergency Pump Cut-off Valve (3/2) | VAXX00 | ow direction cont | Does not control the direction of the flow | Prevents excess pressure by regulating the actuators output | High pressure can cause hoses to burst, leading to leaks | | | | | AIR | Intrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | UNK | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | STD | Mechanical failure (Vibration) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | SPO | Miscellaneous | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | SER | Instrument failure/ Electrical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | PLU | External influence (plugged) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | OTH | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | NOI | Material failure/ Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | LOO | Electrical failure (general) | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | LCP | Mechanical failure | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | HIO | Instrument failure | Failure related to operation/ maintenance | Hidden |
| | | | | | | | | | | FTO | Instrument failure | Failure related to operation/ maintenance | Evident |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | FTC | Instrument failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | ELU | Mechanical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | DOP | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | ELP | | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | INL | Mechanical failure (leakage) | Failure related to operation/ maintenance | Hidden |
| Hose | HOHY00 | Transport viscous fluid inside the system | not transport th | To contain the fluid on the inside of the system | Leakage | | | | | ELP | Mechanical failure (leakage) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | PLU | External influence (plugged) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | STD | Mechanical (Vibration) | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | UKN | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |
| | | | | | | | | | | VIB | mechanical (Vibration) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | SER | Instrument failure/ Electrical failure | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | OHE | Material failure (general) | Failure related to operation/ maintenance | Evident |
| | | | | | | | | | | OTH | Miscellaneous | Failure related to operation/ maintenance | Hidden/ Evident |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | PTF | Intrument failure | Failure related to operation/ maintenance | Hidden |

| Number | Technical Hierarchy | | | | Failure Mode (ISO14224) | Critical Item Selection | | | | | | | | | | Risk Evaluation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | System | Equipment | Maintainable Item | Object code | | Functional Significant Item (FSI) | Maintenance cost significant | Likelihood Class | Consequence Safety | Consequence Economic | Consequence Environment | Risk (Safety) | Risk (Economic) | Risk (Environment) | Risk (Maximum) | Risk Status | Comments |
| 1 | Hydraulic System | Emergency Drive System (630) | Emergency Drive Pump (Piston) | PURE00 | AIR | Yes | Yes | 1 | 5 | 1 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | | | | ERO | | | 1 | 3 | 3 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | *Low Risk (Safety) - Not likely to affect workers *Low Risk (Economic) - Affordable to change sensor *Low risk (Environment) - Does not affect the environment |
| | | | | | ELU | | | 3 | 2 | 2 | 2 | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | *Medium Risk (Safety) - Workers can get in eye or slip *Medium Risk (Economic) - Change of part can lead to down-time *Medium Risk (Environment) - Fluid can leak to the sea and affect marine life |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NOI | 4 | 2 | 1 | 3 | 2- MEDIUM | 2- MEDIUM | 3- HIGH | 3- HIGH | 3 - FAIL | *Medium risk (Safety) - High nosie can affect workers close to the pump *Medium risk (economic) - noise indicates that there is something wrong with the pump *High risk (environment) - Due to wildlife noise can be harmful |
| PDE | 2 | 3 | 2 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| OTH | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| UNK | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| UST | 1 | 5 | 4 | 2 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| INL | 2 | 1 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| VIB | 2 | 2 | 2 | 4 | 1- LOW | 1- LOW | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| ELP | 3 | 3 | 2 | 3 | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| BRD | 1 | 5 | 3 | 2 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FTS | 2 | 5 | 5 | 1 | 3- HIGH | 3- HIGH | 1- LOW | 3- HIGH | 3 - FAIL | *High risk (safety) - If failed: Emergency pump will not work<br>*High risk (economic) - Will result in downtime and change of pump<br>*Low risk (environment) - Little to no effect on enviroment |
| OHE | 3 | 2 | 2 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| STD | 3 | 2 | 3 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| LOO | 2 | 4 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| FRO | 2 | 5 | 4 | 2 | 3- HIGH | 2- MEDIUM | 1- LOW | 3- HIGH | 3 - FAIL | *High risk (Safety) - If failed: Emergency pump will not work<br>*Medium risk (Economic) - May result in downtime and change/reparation<br>*Low risk (enviromental) - Little to no effect on enviroment |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SER | | | 2 | 3 | 2 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | PLU | | | 1 | 3 | 3 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | HIO | | | 2 | 3 | 2 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| Electrical Motor | EMDC00 | AIR | Yes | Yes | 1 | 5 | 1 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | *Medium Risk (Safety) - Motor can deliver to much or little power if reading is wrong *Low risk (Economic) - Affordable to change sensor *Low risk (Environment) - Will not affect environment |
| | | BRD | | | 1 | 5 | 3 | 2 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | ERO | | | 1 | 3 | 2 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | ELU | | | 3 | 2 | 2 | 2 | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | HIO | | | 2 | 3 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | LOO | | | 2 | 4 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| | | PDE | | | 2 | 3 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STP | 2 | 4 | 4 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| FTS | 2 | 5 | 5 | 1 | 3- HIGH | 3- HIGH | 1- LOW | 3- HIGH | 3 - FAIL | *High risk (safety) - If failed: Emergency system will not start<br>*High risk (economic) - Result in downtime and change/reparation<br>*Low risk (environment) - Little to no effect on enviroment |
| OHE | 3 | 2 | 2 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OTH | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | *Low Risk (Safety) - Not likely to affect workers due to other failure modes being identified *Low Risk (Economic) -Not likely to affect economics due to other failure modes being identified *Low risk (Environment) - Not likely to affect environment due to other failure modes being identified |
| UNK | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| UST | 1 | 5 | 4 | 2 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| STD | 3 | 2 | 3 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| NOI | 4 | 1 | 1 | 2 | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| VIB | 2 | 1 | 1 | 3 | 1- LOW | 1- LOW | 2- MEDIUM | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |
| SER | 2 | 3 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITIONS | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emergency Pump Cut-off Valve (3/2) | VAXX00 | AIR | Yes | No | 1 | 5 | 1 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | S WITH CONDITIONS | |
| | | UNK | | | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | STD | | | 1 | 3 | 2 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | SPO | | | 1 | 2 | 2 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | SER | | | 1 | 3 | 1 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | PLU | | | 2 | 5 | 1 | 1 | 3- HIGH | 1- LOW | 1- LOW | 3- HIGH | 3 - FAIL | *High risk (safety) - Valve being choked can cause high pressure and stop flow *Low risk (economic) - Affordable to change valve *Low risk (environment) - Will not affect the environment |
| | | OTH | | | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | NOI | | | 2 | 1 | 1 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | LOO | | | 2 | 4 | 1 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | 2 - PASS WITH CONDITION (S) | *Medium risk (Safety) - Can decrease intensity or amount of fluid *Low risk (economic) - Affordable to change valve *Low risk (environment) - Will not affect the environment |
| | | LCP | | | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | HIO | | | 2 | 3 | 2 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | S WITH CONDITIONS | |
| | | FTO | | | 1 | 5 | 5 | 2 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | S WITH CONDITIONS | |
| | | FTC | | | 1 | 4 | 4 | 1 | 2- MEDIUM | 2- MEDIUM | 1- LOW | 2- MEDIUM | S WITH CONDITIONS | |
| | | ELU | | | 2 | 1 | 1 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | DOP | | | 2 | 4 | 1 | 1 | 2- MEDIUM | 1- LOW | 1- LOW | 2- MEDIUM | S WITH CONDITIONS | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ELP | | | 2 | 1 | 1 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| | | INL | | | 2 | 1 | 2 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | *Low risk (Safety) - Will not affect workers<br>*Low risk (Economic) - Affordable to change valve<br>*Low risk (Environment) - Will not afffect the environment |
| Hose | HOHY00 | ELP | Yes | No | 2 | 2 | 2 | 3 | 1- LOW | 1- LOW | 2- MEDIUM | 2- MEDIUM | WITH CONDIT | *Medium Risk (Safety) - Twist, wearing and bending can cause leaking and cause workers to get in eye or slip in fluid<br>*Medium Risk (Economic) - Change of part can lead to down-time<br>*Medium Risk (Environment) - Fluid can leak to the sea and affect marine life |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PLU | 2 | 3 | 5 | 3 | 2- MEDIUM | 3- HIGH | 2- MEDIUM | 3- HIGH | 3 - FAIL | *Medium risk (Safety) - Can burst and cause workers to get in eye or slip on the fluid *High risk (economic) - Reduced flow and change of part will cause down-time *Medium risk (environment) - Fluid can leak to the sea and affect marine life |
| STD | 2 | 3 | 3 | 3 | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | 2- MEDIUM | S WITH CONDITIONS | |
| UKN | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| VIB | 2 | 1 | 1 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| SER | 2 | 1 | 2 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| OHE | 1 | 1 | 1 | 1 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| OTH | 2 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | |
| PTF | 1 | 2 | 2 | 2 | 1- LOW | 1- LOW | 1- LOW | 1- LOW | 1 - PASS | *Low risk (Safety) - Will not affect workers *Low risk (Economic) - Affordable to change valve *Low risk (Environment) - Will not afffect the environment |

| Number | Technical Hierarchy | | | | Failure Mode (ISO14224) | Risk Status | Maintenance activities | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maintenance demands | | | | Analysis result | | Maintenance activities merge |
| | System | Equipment | Maintainable Item | Object code | | | NOV maintenance demands | PSA maintenance demands | DNV maintenance demands | NMD maintenance demands | Recommended maintenance activities | Recommended maintenance intervals | |
| 1 | Hydraulic System | Emergency Drive System (630) | Emergency Drive Pump (Piston) | PURE00 | AIR | 2 - PASS WITH CONDITIONS | Maintenance:<br>- Test of emergency system each 12 months<br>- Filter change each 12 months<br><br>Replacement:<br>- Hydraulic pump after 12000-15000 running hours | The company is responsible for developing a maintenance plan for the maintenance activities. | Annual inspecion of emergency stop function | Inspection each year.<br>Function test.<br><br>Inspection each five year.<br>Complete dismantling and disassembly of devices and equipment.<br><br>Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Inspection | 1 year | *6 months - Close visual inspection<br>*12 months - Testing<br>*12 months - Filter change<br>*Replace after 12000-15000 running hours. |
| | | | | | ERO | 1 - PASS | | | | | | 3 years | |
| | | | | | ELU | 2 - PASS WITH CONDITIONS | | | | | | 3 years | |
| | | | | | NOI | 3 - FAIL | | | | | | 6 months | |
| | | | | | PDE | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | | | | OTH | 1 - PASS | | | | | | 3 years | |
| | | | | | UNK | 1 - PASS | | | | | | 3 years | |
| | | | | | UST | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | INL | 1 - PASS | | | | | | 3 years | |
| | | | | | VIB | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | ELP | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | BRD | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | FTS | 3 - FAIL | | | | | | 6 months | |
| | | | | | OHE | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | | | | STD | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | LOO | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | | | | FRO | 3 - FAIL | | | | | | 6 months | |
| | | | | | SER | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | | | | PLU | 1 - PASS | | | | | | 3 years | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HIO | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| Electrical Motor | EMDC00 | AIR | 2 - PASS WITH CONDITIONS | Maintenance:<br>- IN/draining every year (every 2000 hours)<br>- Lubrication every 24 months (4000 hours)<br><br>Replacement:<br>- After 20 000 running hours | Do not have any spesific demands, other than that<br>the company is responsible for developing<br>a maintenance plan for the maintenance activities. | specion of emergency sto | Inspection each year.<br>Crane function test.<br><br>Inspection each five year.<br>Complete dismantling and disassembly of devices and equipment.<br><br>Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Inspection | 1 year | *6 months - Close Visual Inspection<br>*12 months - Draining<br>*24 months - Lubrication<br>*Replace after 20 000 running hours |
| | | BRD | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | ERO | 1 - PASS | | | | | | 3 years | |
| | | ELU | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | HIO | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | LOO | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | PDE | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | STP | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | FTS | 3 - FAIL | | | | | | 6 months | |
| | | OHE | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | OTH | 1 - PASS | | | | | | 3 years | |
| | | UNK | 1 - PASS | | | | | | 3 years | |
| | | UST | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | STD | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | NOI | 2 - PASS WITH CONDITIONS | | | | | | 1 year | |
| | | VIB | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |
| | | SER | 2 - PASS WITH CONDITIONS | | | | | | 2 years | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Emergency Pump Cut-off Valve (3/2) | VAXX00 | AIR | SS WITH CONDITI | Maintenance:<br>- Testing every 12 months<br><br>Replacement:<br>- Change every 5 years | Do not have any spesific demands, other than that<br>the company is responsible for developing<br>a maintenance plan for the maintenance activities. | specion of emergency sto | Inspection each year.<br>Crane function test.<br><br>Inspection each five year.<br>Complete dismantling and sisassembly of devices and equipment.<br><br>Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Inspection | 1 year | *6 months - Close Visual Inspection<br>*12 months - Testing<br>* 5 year inspection<br>*Replace every five years |
| | | UNK | 1 - PASS | | | | | | 3 years | |
| | | STD | 1 - PASS | | | | | | 3 years | |
| | | SPO | 1 - PASS | | | | | | Correctiv maintenance | |
| | | SER | 1 - PASS | | | | | | 3 years | |
| | | PLU | 3 - FAIL | | | | | | 6 months | |
| | | OTH | 1 - PASS | | | | | | 3 years | |
| | | NOI | 1 - PASS | | | | | | Correctiv maintenance | |
| | | LOO | 2 - PASS WITH CONDITION (S) | | | | | | 1 year | |
| | | LCP | 1 - PASS | | | | | | 3 years | |
| | | HIO | SS WITH CONDITI | | | | | | 2 years | |
| | | FTO | SS WITH CONDITI | | | | | | 1 year | |
| | | FTC | SS WITH CONDITI | | | | | | 2 years | |
| | | ELU | 1 - PASS | | | | | | Correctiv maintenance | |
| | | DOP | SS WITH CONDITI | | | | | | 1 year | |
| | | ELP | 1 - PASS | | | | | | | |
| | | INL | 1 - PASS | | | | | | 3 years | |
| Hose | HOHY00 | ELP | S WITH CONDITIC | Maintenance:<br>- Inspection every 6 months<br><br>Replacement:<br>- Change every 5 years | Do not have any spesific demands, other than that<br>the company is responsible for developing<br>a maintenance plan for the maintenance activities. | specion of emergency sto | Inspection each year.<br>Crane function test.<br><br>Inspection each five year.<br>Complete dismantling and sisassembly of devices and equipment.<br><br>Equipment must be maintained according to the manufacturer's recommendations or recognized methods. | Inspection | 2 years | *6 months - Close visual inspection<br>*Replace every five years<br>*12 months - testing<br>*5 year inspection |
| | | PLU | 3 - FAIL | | | | | | 6 months | |
| | | STD | SS WITH CONDITI | | | | | | 2 years | |
| | | UKN | 1 - PASS | | | | | | 3 years | |
| | | VIB | 1 - PASS | | | | | | 3 years | |
| | | SER | 1 - PASS | | | | | | 3 years | |
| | | OHE | 1 - PASS | | | | | | Correctiv maintenance | |
| | | OTH | 1 - PASS | | | | | | 3 years | |

| PTF | 1 - PASS |
|---|---|

Correctiv maintenance

Sheet 4 – *Route example*

**Object code**

| Example of Route (1) - Sockets | | | | | | |
|---|---|---|---|---|---|---|
| SOCK | C10684936 | SOCKET OUTL.FAN HEATER | 361-MA-001-EI _361 | _361.160.000 | _361.160.300 | _361.160.340 |
| SOCK | C10684789 | SOCKET OUTL.MACH.HOUSE | 361-MA-001-EI _361 | _361.160.000 | _361.160.300 | _361.160.310 |
| SOCK | C10684928 | SOCKET OUTL.AIR CONDITION | 361-MA-001-EI _361 | _361.160.000 | _361.160.300 | _361.160.320 |
| SOCK | C10685011 | SOCKET OUTL.CABIN CCTV MONITOR | 361-MA-001-EI _361 | _361.160.000 | _361.160.300 | _361.160.330 |
| SOCK | C10684929 | SOCKET OUTL.FAN HEATER | 361-MA-001-EI _361 | _361.160.000 | _361.160.300 | _361.160.350 |

| Example of Route (2) - Lights | | | | | | | |
|---|---|---|---|---|---|---|---|
| LTMH | C10684913 | LIGHT MACH. HOUSE RIGHT | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 |
| LTMH | C10684835 | LIGHT MACH. HOUSE MIDDLE | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 |
| LTMH | C10685055 | LIGHT MACH. HOUSE BACK | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 |
| LTMH | C10684911 | LIGHT MACH. HOUSE LEFT | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.231 |
| LTMH | C10684982 | LIGHT OUTSIDE MACH. HOUSE BY DOOR | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.232 |
| LTMH | C10685099 | LIGHT OUTSIDE MACHINERY HOUSE RIGHT | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.232 |
| LTMH | C10685101 | LIGHT UNDER MACH. HOUSE RIGHT | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.233 |
| LTMH | C10685054 | LIGHT UNDER MACH. HOUSE LEFT | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.230 | _361.160.233 |
| LTGR | C10685057 | LIGHT ACCESS CRANE | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.214 |
| LTGR | C10684910 | LIGHT SLIPRING AREA UPPER | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.211 |
| LTGR | C10684836 | LIGHT A-FRAME MIDDLE | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.212 |
| LTGR | C10684983 | LIGHT A-FRAME TOP | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.213 |
| LTGR | C10684984 | LIGHT CABIN | 361-MA-001-EI _361 | _361.160.000 | _361.160.200 | _361.160.210 | _361.160.215 |

**This sheet is an example to show how a route is build up. The result of these examples are not a part of the result of the assignment.**
**The tags are copied from thesheet "Hierarchy". The object codes are examples for understanding.**

Sheet 5 – *PoF/CoF – Professor Maneesh Singh*

| | | CoF Ranking | | | | |
|---|---|---|---|---|---|---|
| CoF - Environmenta | | A - Slight Pollution | B - Minor Pollution | C - Moderate Pollution | D - Major Pollution | E - Massive Pollution |
| CoF - Economical | | A - Slight Damage | B - Minor Damage | C - Moderate Damage | D - Major Damage | E - Massive Damage |
| CoF - Economical | | A - Slight Loss | B - Minor Loss | C - Moderate Loss | D - Major Loss | E - Massive Loss |
| CoF - Safety | | A - No Injury | B - Minor Injury | C - Major Injury | D - Single Fatality | E - Mulitple Fatality |
| PoF Ranking | 5 - Expected | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail | 3 - Fail | 3 - Fail |
| | 4 - High | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail | 3 - Fail |
| | 3 - Medium | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail | 3 - Fail |
| | 2 - Low | 1 - Pass | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) | 3 - Fail |
| | 1 - Negligible | 1 - Pass | 1 - Pass | 1 - Pass | 2 - Pass with Condition(s) | 2 - Pass with Condition(s) |

| | | CoF Ranking | | | | |
|---|---|---|---|---|---|---|
| CoF - Environmenta | | A - Slight Pollution | B - Minor Pollution | C - Moderate Pollution | D - Major Pollution | E - Massive Pollution |
| CoF - Economical | | A - Slight Damage | B - Minor Damage | C - Moderate Damage | D - Major Damage | E - Massive Damage |
| CoF - Economical | | A - Slight Loss | B - Minor Loss | C - Moderate Loss | D - Major Loss | E - Massive Loss |
| CoF - Safety | | A - No Injury | B - Minor Injury | C - Major Injury | D - Single Fatality | E - Mulitple Fatality |
| PoF Ranking | 5 - Expected | 1-year | 6-month | 3-month | 2-month | 1-month |
| | 4 - High | 2-year | 1-year | 6-month | 3-month | 2-month |
| | 3 - Medium | 3-year | 2-year | 1-year | 6-month | 3-month |
| | 2 - Low | Corrective Maintenance | 3-year | 2-year | 1-year | 6-month |
| | 1 - Negligible | Corrective Maintenance | Corrective Maintenance | 3-year | 2-year | 1-year |