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Managing, Planning and Preparation of Repairs and Retrofit  
During Dry-docking

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Patras, Greece, June 2022

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# Managing, Planning and Preparation of Repairs and Retrofit During Dry-docking

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## **Abstract**

Project management during scheduled ship's repairs in a dry-dock is a complex process as it involves many activities such as various repairs, machinery overhauling, spare parts supply, installation of new equipment and commissioning. Co-ordination of all stakeholders (shipyard, suppliers, owner or manager of the vessel) involved in the project is a must in order for repairs to be completed within the agreed timeframe. Ship repairs are part of normal maintenance required to be performed in accordance with Recognized Organizations / Classification Societies and Flag Administration Societies so that the ship complies with the rules, regulations and maintains valid certificates. The certificates prove that the ship meets the standards of International Conventions. Any delay has negative impact both to the contractor (shipyard) and to the owners. As a consequence, it is important to investigate the delay factors on scheduled ship's repairs project. In this thesis, delay factors obtained through literature review are presented. Twenty seven (27) delay factors were identified and were included in the survey. A questionnaire was created and responses from one hundred forty eight (148) participants who work in the maritime industry were obtained. From the results, ranking of delay factors is conducted. The results can assist both owners and contractors to recognize delay factors that take place during a scheduled ship's repairs and avoid re-occurrence. Delay factors took place in a case study are also analyzed to validate the results of the survey.

## **Keywords**

Shipyard industry, delay factors, dry-dock / ship's repairs

# Διαχείριση, Σχεδιασμός και Προγραμματισμός των Επισκευών και των Μετασκευών κατά την Διάρκεια Δεξαμενισμού

Σοφία Ζουντουρίδου

## Περίληψη

Η διαχείριση τεχνικών έργων κατά την διάρκεια δεξαμενισμού είναι μια πολύπλοκη διαδικασία καθώς περιλαμβάνει πολλές δραστηριότητες όπως είναι διάφορες επισκευές, προμήθεια και μεταφορές ανταλλακτικών και νέου εξοπλισμού, τοποθέτηση και θέση σε λειτουργία νέου εξοπλισμού. Απαιτείται καθολική συνεργασία όλων των πλευρών (Ναυπηγείου, προμηθευτών, Ναυτιλιακού γραφείου κλπ) ώστε οι επισκευές να ολοκληρωθούν σύμφωνα με το χρονοδιάγραμμα. Οι επισκευές των πλοίων είναι μέρος συντήρησης ρουτίνας που απαιτείται να πραγματοποιείται σύμφωνα με τους αναγνωρισμένους Οργανισμούς – Νηογνώμονες και τα κράτη/σημαίες πλοίων ώστε το πλοίο να συμμορφώνεται με τους κανόνες και τους κανονισμούς και να διατηρεί έγκυρα πιστοποιητικά. Τα πιστοποιητικά αποδεικνύουν ότι το πλοίο ανταποκρίνεται στα πρότυπα των Διεθνών Συμβάσεων. Οποιαδήποτε καθυστέρηση έχει αρνητικό αντίκτυπο τόσο στον εργολάβο (ναυπηγείο) όσο και στους ιδιοκτήτες. Ως συνέπεια, είναι σημαντικό να διερευνηθούν οι παράγοντες καθυστέρησης που λαμβάνουν χώρα κατά την διάρκεια δεξαμενισμών. Σε αυτή τη διπλωματική εργασία παρουσιάζονται οι παράγοντες καθυστέρησης που προέκυψαν μέσω βιβλιογραφικής ανασκόπησης. Είκοσι επτά (27) παράγοντες καθυστέρησης εντοπίστηκαν και συμπεριλήφθηκαν στην έρευνα. Δημιουργήθηκε ένα ερωτηματολόγιο και λήφθηκαν απαντήσεις από 148 συμμετέχοντες που εργάζονται στη ναυτιλιακή βιομηχανία. Από τα αποτελέσματα αναλύθηκαν ο Δείκτης Συχνότητας, ο Δείκτης Επιπτώσεων και ο Δείκτης Σημασίας και μέσω των αποτελεσμάτων πραγματοποιήθηκε η κατάταξη των λόγων καθυστέρησης. Ο πιο σημαντικός παράγοντας σύμφωνα Δείκτη Σημασίας είναι η «Επίδραση του καιρού στις δραστηριότητες». Τα αποτελέσματα μπορούν να βοηθήσουν τόσο τους ιδιοκτήτες όσο και τους εργολάβους να αναγνωρίσουν τους παράγοντες καθυστέρησης που λαμβάνουν χώρα κατά τις προγραμματισμένες επισκευές ενός πλοίου και να αποφύγουν την επανεμφάνισή

τους. Οι παράγοντες καθυστέρησης που έλαβαν χώρα σε μια μελέτη περίπτωσης αναλύονται επίσης για την επικύρωση των αποτελεσμάτων της έρευνας.

### **Λέξεις – Κλειδιά**

Ναυπηγείο, λόγοι καθυστέρησης, δεξαμενισμοί-επισκευές πλοίων

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## **List of Abbreviations & Acronyms**

- (IMO) International Maritime Organization
- (IMCO) Inter-Governmental Maritime Consultative Organization
- (ABS) American Bureau of Shipping
- (BV) Bureau Veritas
- (CCS) China Classification Society
- (DNV GL) Det Norske Veritas & Germanischer Lloyd
- (PRS) Polish Register of Shipping
- (KR) Korean Register of Shipping
- (LR) Lloyds Register of Shipping
- (NK) Nippon Kaiji Kyokai
- (RINA) Registro Italiano Navale
- (RS) Russian Maritime Register of Shipping
- (CRS) Hrvatski Registar Brodova - Croatian Register of Shipping
- (IRS) Indian Register of Shipping
- (MSC) Maritime Safety Committee
- (MEPC) The Marine Environment Protection Committee
- (IACS) International Association of Classification Societies
- (SOLAS) International Convention for the Safety of Life at Sea
- (MARPOL) The International Convention for the Prevention of Pollution from Ships
- (D/D) Dry-dock
- (P&I) Protection and Indemnity
- (MGPS) Marine Growth Prevention System
- (S.R.M) Shipyard Repair Manager
- (M/E) Main Engine
- (D/G) Diesel Generator
- (LSA) Life Saving Appliances
- (FFB) Free Fall Lifeboat
- (DBT) Double Bottom Tank
- (LNG) Liquefied Natural Gas
- (LPG) Liquefied Petroleum Gas
- (RoRo) Roll-on/roll-off



(S.W.L) Safe Working Load  
(ESD) Energy Saving Devices  
(C/H) Cargo Holds  
(EPA) Environmental Protection Agency  
(HPFW) High-Pressure Filtered Water  
(MTS) Metric Tonnes  
(UV) Ultraviolet  
(F.I.) Frequency Index  
(I.I.) Impact Index  
(IMP.I.) Importance Index

# **1. Introduction**

## **1.1. Background Analysis**

Ship's maintenance/repairs are specified in the Classification Society and Flag State regulations and are mandatory for the vessels. A ship should undergo a periodic survey with an interval of approximately 24–36 months, to carry out docking survey, intermediate survey, and special survey once in 5 years. It is a big and costly operation of a ship-owner. Both Owners and shipyards all eager to reduce the repairing time to cut costs and maximize profits. Shipyards need to be able to handle as many ships as possible in order to maximize their profitability whereas owners try to reduce the repairing time to prevent the loss of income. Therefore, ship repairing should be done in the shortest time possible so as to reduce the negative effects caused by lengthy repairs. (Dev and Saha, 2015).

Ship's repairs time refer to total duration of stay of a vessel under repairs in a shipyard. It is the time between the beginning of the repair and the completion of the work and is called ship repairing time. Repairing is a very important part of a ship's lifecycle as it solves a number of problems that develop during the service life of the ship. However, it can be affected by many factors which can result in delaying the departure of the vessel from the shipyard. Delay refers to a situation wherein progress of a project exceeds its planned schedule (Assaf and Al-Hejji, 2006).

To prevent unforeseen circumstances, there is a need to introduce delay factors which may result to delay the completion of scheduled ship's repairs.

## **1.2. Aims and Objectives**

This thesis aims to outline, both to maritime shore bases personnel of ship-owners/managers and to shipyards personnel the factors which may result to delay the completion of scheduled ship's repairs.

In this thesis, a survey addressed to maritime industry is conducted to identify the most important factors which may result to delay the completion of scheduled ship's repairs.

To achieve that, two (2) questions for each delay factor were requested to be replied by each participant: 1) frequency of occurrence and 2) impact on project.

In addition, as none of the previous studies with reference to delay factors during scheduled ship's repairs has investigated both frequency of occurrence and impact on project, a ranking of delay factors is to be performed to assess the importance of each factor.

Furthermore, a scheduled ship repairing of a bulk carrier is analyzed as a case study where some delay factors have been occurred to confirm the results obtained through the questionnaire.

### **1.3. Challenges**

Data for delay factors during scheduled ship's repairs are incomplete. Only one survey conducted via interviews and meeting was managed to be traced. Some delay factors reported in large construction projects are not included in aforementioned survey. In order to deal with these, an online survey is executed to identify the most important delay factors during scheduled ship's repairs

### **1.4. Methodology and Scope of Thesis**

For the purpose of this study, a quantitative research design with a descriptive approach was applied. The main research methodology of this thesis is based on a survey conducted in the maritime industry. It contained twenty seven (27) factors of delay which were yielded through literature review. A questionnaire was developed in order to evaluate the frequency of occurrence and impact on project of the identified causes gathering responses from owners/managers, shipyard personnel and Classification society surveyors. A total of 54 questionnaires were answered and 148 valuable responses were finally collected.

### **1.5. Literature Review**

Literature review is vital for the success of this research. An analytical literature review was conducted through papers, books, websites relevant to vessel's repairs and maintenance including regulations and review of dry-dock. The most important part of

examination is to identify delay factors delaying the completion of scheduled ship's repairs which are included in the questionnaire.

## **1.6. Structure of the Thesis**

Nine (9) chapters are included in this Thesis whereas chapter No 6, 7 are the most important chapters. In the below table 2, titles of all chapters are presented:

| No | Title of Chapter                 |
|----|----------------------------------|
| 1  | Introduction                     |
| 2  | Literature Review                |
| 3  | Dry-Docks - Introduction         |
| 4  | Repair/Dry-docking Specification |
| 5  | Pre-docking planning             |
| 6  | Questionnaire                    |
| 7  | Case study                       |
| 8  | Conclusion                       |

**Table 1**Title of Chapters

The questionnaire which was created for this Thesis is listed in Appendix A.

## **2. Literature Review**

The importance of maritime shipping as a key component of international trade is undisputed. Over 80% of world merchandise trade by volume was carried by sea in 2018. (Sirimanne et al, 2019). Furthermore, on average, maritime transport costs significantly less than its counterparts in the land and-airborne transport. The fact that shipping is generally considered to be international when it crosses a country, state or even an entire continent's border eventually led to the establishment by the United Nations of the International Maritime Organization (IMO) which is responsible for adopting safety regulations (Kristiansen,2013).

In order to heighten the safety level, there is the requirement that all ships, including all relevant construction material and equipment/installations, and onboard safety management system and security measures, be surveyed by officers of the flag State Administrations or by surveyors of Recognized organizations. The objective is to ensure that ships are designed, constructed, maintained and managed in compliance with applicable IMO Conventions and Codes) (International Maritime Organization,2022)

There are many national and international regulations by IMO which outline the requirements reference certificates which must be on-board. IMO conventions clearly required surveys in regular intervals (IACS, 2006).

One of the requirements is the examinations of the outside of ship's bottom and other relative items, named as dry-dock survey. This survey is normally arranged in dry-dock (IACS, 2006).

Within a five years cycle, a vessel would normally be docked twice at a shipyard for its Bottom Surveys (Rashid & Kadir, 2012)

### **2.1. International Maritime Organization**

The Inter-Governmental Maritime Consultative Organization (IMCO) was established in 1948 and in 1982 was re-named to the IMO (International Maritime Organization) that

deals with safety and security of shipping, the prevention of marine pollution by ships, and the promotion of maritime safety. The IMO was appointed to the Economic and Social Committee of UNO (Blanco-Bazán, 2004).

IMO makes recommendations to member governments on the regulations that have been passed for adoption into their own laws. The IMO itself has no power or authority to enforce Conventions. Enforcement of IMO Convention is the sole responsibility of the Governments of Member States that took the voluntary decision to adopt and integrate them into its individual laws. IMO currently has currently 175 Member States and three Associate Members (International Maritime Organization,2022).

## **2.2. Structure of IMO**

IMO consists of the Assembly, the council, Maritime Safety Committee (MSC), The Marine Environment Protection Committee (MEPC), Sub-Committees, Legal Committee, Technical Cooperation Committee, Facilitation Committee and Secretariat (Karim, 2015). The Assembly is the highest governance body and it consists of representatives from all Member States and meets at least once every two (2) years. The Assembly elects the council and it is responsible for approving the work program, the budget and determining the financial arrangements of the Organization (Karim, 2015).

The Council, on the other hand, is the Executive Organ of IMO elected for two years by the Assembly. It held mainly to perform all the functions of the organization except for making recommendations to Member States on maritime safety and pollution prevention, which are functions reserved for the Assembly. It is also responsible to supervise the work, under the Assembly. Furthermore, it composed of 40 members from among persons distinguished by their high technical qualifications, experience and interest in the field (Karim, 2015).

Greece due to its fleet size, it has been a member of the IMO Council and among the most active members for decades (Konsta, 2013).

### **2.3. Flag State**

International Maritime law requires that every vessel register in a single country called its flag state. The vessel considered as a floating portion of the territory whose flag it flew and that's the reason why the laws of the flag state apply to that vessel and define the regulatory framework with which the vessel and crew must comply (King, 2018).

### **2.4. Implementation of IMO Conventions by Flag States**

Flag states are responsible for implement IMO Conventions. When an IMO Convention is accepted by a Flag state then it will be part of its own national law. IMO regulations are implemented and applied to ships on a global basis through a combination of flag state enforcement and Port State Control. In some conventions after vessel's inspection and in case vessel may comply with requirements then a certificate is provided which must be on-board and accepted by all member states of IMO (Cheng, 2016).

### **2.5. Implementation of IMO Conventions by Recognized Organizations**

For surveys which are carried out on-board, the main responsible is always the Flag State of the vessel even if vessel sails in International waters. The only occasion which coastal states can exercise any interference it wants on a vessel, is the foreign flagged vessel navigating in archipelagic waters, territorial sea, special pollution prevention areas, exclusive economic zone and on the high seas. In such cases, Coastal states may have jurisdiction to foreign flag vessels (Abdulla, 2011).

As per International convention relating to intervention on the high seas, in cases of oil pollution casualties, coastal state is able to take measures on the high sea to prevent any danger to its coastline (Erkebay, 2018).

Valid certificates and documents are proof that vessel comply with IMO conventions and codes. In order its flag state to ensure that vessel fulfill requirements, it must implement procedures for vessel's periodical surveys in order to update validation of certificates.

Surveys are carried out by flag State Administrations or the Recognized organizations (classification societies) authorized to carry out surveys/verifications and issue relevant certificates on behalf of flag State Administrations (<https://www.imo.org>).

Flag States can seek guidance from the International Association of Classification Societies (IACS) for more information on the services provided by classification societies (Julian, 2000).

## **2.6. International Association of Classification Societies (IACS)**

The International Association of Classification Society was established in 1968. It is a nongovernmental organization responsible to provide an advisory service to the maritime industry and co-operate with it. The majority of the world's merchant tonnage is classified by the 12 IACS members that fulfill the criteria of the IACA Chapter.

The primary objective of IACS is to ensure the standard drafting of international conventions worldwide, to submit recommendations to IMO and to standardize parts of the rules for survey and construction (Carlsen & Geest, M., 2017).

As a general rule, a ship-owner has a free choice of classification society. IACS members are presented in below table 3.

| <b><u>Name</u></b>                      | <b><u>Abbreviation</u></b> |
|---|----------------------------|
| American Bureau of Shipping             | ABS                        |
| Bureau Veritas                          | BV                         |
| China Classification Society CCS        | CCS                        |
| Det Norske Veritas & Germanischer Lloyd | DNV GL (since 2013)        |
| Polish Register of Shipping PRS         | PRS                        |
| Korean Register of Shipping             | KR                         |
| Lloyds Register of Shipping             | LR                         |
| Nippon Kaiji Kyokai                     | NK                         |
| Registro Italiano Navale                | RINA                       |
| Russian Maritime Register of Shipping   | RS                         |
| Hrvatski Registar Brodova - Croatian    | CRS                        |



|                             |     |
|-----------------------------|-----|
| Register of Shipping CRS    |     |
| Indian Register of Shipping | IRS |

**Table 2 IACS members**

## **2.7. Recognized organizations - Classification Society**

There are currently around 50 classification societies which deal with marine classification services (Lagoni, 2007).

From the above, only 12 are member of IACS and have a de facto prerequisite to the world wide acceptance of a classification society by flag States and other relevant industry organizations.

Classification societies have various fields of responsibility:

- Classifying ships according to the degree of confidence that the ship deserves at the request of a ship-owner, or a shipyard on behalf of the ship-owner;
- Conducting surveys in accordance with international Conventions on behalf of the flag State;
- Issuing the appropriate certificates - Class Certificates and Statutory Certificates following a satisfied survey ensuring that requirements are met for the vessel (Carlson & Geist, M., 2017).

IMO has recognized that Flag States responsibilities are beyond their capacities and have resulted in the incorporation of certain clauses in the Conventions authorizing Flag States to delegate some of its duties to the recognized organizations (Villanueva, 2004).

In light of the above, the IMO have adopted an amendment to SOLAS and two Resolutions:

- Under the provisions of SOLAS 1974/1988 regulation I/6, MARPOL Annex I regulation 6, MARPOL Annex II regulation 8, MARPOL Annex IV regulation 4, MARPOL Annex VI regulation 5, LLC 1966/1988 article 13, TONNAGE 1969 article 7 and AFS 2001 Annex 4 regulation 1, the inspection and survey of ships shall be carried out by officers of the flag Administration. The flag Administration may, however, entrust the inspections

and surveys either to surveyors nominated for the purpose or to organizations recognized by it.

- Res. A.739 (18): Guidelines for authorization of organizations acting on behalf of the Administration
- Res. A.789 (19): Specifications on the survey and certification functions of recognized organizations acting on behalf of the administration (<https://www.imo.org>).

## **2.8. Requirement for additional inspections – Port State Control**

The IMO gives increased jurisdiction to port authorities to inspect vessels with foreign flag. Primary responsibility for the condition of the ship and its crew has the flag state of the ship. However, many maritime accidents prove that unfortunately the International Conventions are not implemented by all states. Some of them do not have the ability and others are reluctant to meet their international responsibilities, thus making their ships dangerous. There are many events with loss of human lives and great environmental disasters, some widely known and some not, which created the need for additional inspections on ships. The responsibility of inspections will no longer be addressed to the flag of the ship but its flag state to which he wants to sail. These inspections were named Port State Control (Özçayır, 2018).

## **2.9. Delay factors through Literature review**

Various factors resulting in delays have been thoroughly researched in a number of academic focusing both in shipbuilding projects as well as during ship's repairs. As per Pittas (1999) similarity exists in shipbuilding and ship's repairs projects. Some frequently reported factors in large constructions projects are also included in the research. Surveys conducted by Mello et al. (2015) outlined the following factors in shipbuilding project:

- Delay In Delivering The Detailed Engineering Drawings
- Product Changes After The Production Process Starts
- High Number Of Quality Problems
- Self-Over-Evaluation Of Partners On Their Skills

- Delay To Deliver Equipment
- Poor Quality Of Documentation
- Long Time To Find And Correct Errors
- Information Flow Is Not Integrated
- Little Visibility Of Processes
- Occurrence Of Unpredictable Events
- Processes Are Difficult To Follow Up
- Specific Customer Requirements
- The Project Involved Multiple Companies
- Interaction Between Project Partners Was Needed As The Project Evolved
- Companies Shared Incomplete Specifications Of The Product
- There Was A High Number Of Project Activities
- The Product Had Sophisticated Systems Which Had Few Suppliers
- The Product Had Several Innovative Systems That Had Not Been Used Before
- There Was A High Level Of Interdependence Between Different Systems
- The Engineering And Production Was Not Performed In The Same Company
- The Relationship Between Companies Was Driven By Contractual Agreements
- The Engineering And Production Were Performed Concurrently
- Significant Product Changes Had Occurred During The Project.

Dev & Saha (2018) reported that the prevailing situation in the shipyard was completely different for two cases even if scope of work was the same for both vessels such as, one ship was alongside quay, but another ship was alongside another ship (restricted material handling) or one ship was at quay prior to go into a dry-dock but another ship was put into a dry-dock directly on arrival (no time for accessory works for propeller removal/shaft withdrawal) resulted to longer dry-docking time.

Yasin & Osman (2018) reported that one of the problems is the low-quality products, which effect reworks, resulted to late delivery time.

Badrus Zaman et al (2019) pointed out that the following risks are present in ship's repairing schedule

- Bad Weather
- Lack of Material
- Lack of equipment
- New to System design
- Worker Accident

Gard (2011) analyzed a case study where the following issues took place:

- the owners submitting an outdated docking plan
- Use of sub-contractors

Zagan et al (2021) reported that any additional orders entail additional costs for both parties and result in extending the maintenance period of the dock.

Kambase (2020) reported that there was a significant delay in the repaired vessel due to outdated equipment and lack of equipment in Tema dry-dock. Furthermore, he referred that lack of skilled labour is also a treat in the shipbuilding industry which may result to low productivity and delay in the completion of the project.

World Health Organization (2020) prepared a guidance on how covid-19 health event should be managed on-board a ship. The guidance suggested that in case of a positive laboratory result then a quarantine period should be implemented for all contacts.

Oasis P&I Services Company Limited (2020) reported how covid-19 positive cases are handed in China. It has been reported a different approach within China and procedures which must be followed, will be defined by local governments. Possibility of vessel's quarantine for 14 days in the anchorage is also reported.

Ozkok (2013) concluded that machine breakdown often takes place in shipyard and cause delays. He also studied a production process and calculated the impact on project for breakdown scenarios.

Assaf & Al-Hejji (2006) conducted a survey for causes of delay in large construction projects. The survey included seventy three (73) causes which were identified through literature review. Some of the causes are included in our questionnaire as follows:

- Conflicts encountered with sub-contractors schedule in project execution
- Poor site management and supervision by contractor
- Legal disputes b/w various parts
- Original contract duration is too short
- Delay in progress payment by owners
- Slowness in decision making process by owners
- Unavailability of incentives for contractor for finishing ahead of schedule
- Shortage of equipment
- Delay in performing final inspection and certification by a third party
- Changes in government regulations and laws
- Ineffective delay penalties
- Shortage of labors
- Low productivity level of labors
- Late in revising and approving design documents by owner
- Rework due to errors during construction
- Delays in sub-contractors work
- Delay in performing inspection and testing by consultant
- Delay in approving major changes in the scope of work by consultant
- Mistakes and discrepancies in design documents
- Delays in producing design documents
- Delay in material delivery Materials
- Ineffective planning and scheduling of project by contractor
- Change orders by owner during construction
- Damage of sorted material while they are needed urgently
- Slowness in decision making process by owner
- Hot weather effect on construction activities
- Rain effect on construction activities
- Delay in progress payments by owner

- Accident during construction

### 3. Dry-Docks – Introduction

As per statutory requirements, a vessel should be dry-docked in regular intervals for maintenance, repairs or inspection (Dev et al, 2022). In general, dry-dock is a narrow basin, surrounded by sidewalls, closed by dock gates, deep enough to allow a vessel to be floated in and after the water to be pumped out, leaving the vessel to rest on blocks in a dry platform (Kavitha et al, 2015).

Below a vessel docked for maintenance is presented in figure 1:



Figure 1 Dry-dock of a vessel

#### 3.1. Types of Dry-Docks

The two main types of docks are for big size vessels:

- Basin or Graving docks
- Floating Dry Docks (Heger, 2018).

### **3.1.1. Basin or Graving Dry Dock**

Graving dry-dock is a solid basin capable to accommodate all sizes of vessels, constructed into the ground and near to the coastal waters which is separated from the water by a gate (Srinivasreddy et al, 2021).

Vessel is shifted into the basin, rested on blocks. Once vessel is in the desired position, the dock gate is closed and the water is pumped out using a drainage system or using a hydraulic system (Srinivasreddy et al, 2021).



**Figure 2 Vessel is rested on blocks**

#### **Advantages of a Basin – Graving dock**

The main advantages of basin- graving dock are:

- Long lifecycle of the basin
- Size of basin varies and in general can accommodate all size vessels compared to other dry-docking types
- Maintenance requirements are low for dock floor and walls



- No ship's stability with pumping plan is required
- In case of intermediate date, the forward part of the vessel can be dry while the aft part can be flooded (Heger, 2018).

### **3.1.2. Floating Dock**

Floating dry dock is a U shaped structure consists of pontoon and wing walls.

The dock is filled with water so as for the dock to be under the water. Once vessel is shifted in the dock, the water is released so as to lift the vessel from the water using buoyancy (Heger, 2018) (Srinivasreddy et al, 2021).

#### **Advantages of a Floating dock**

The main advantages of floating graving dock are:

- It does not require a shore land close to the water
- Construction of dock can be took place in a small yard at low and keeps high re-sale price
- Vessel can be shifted to dock easier
- It can be transferred closed to the vessel
- Cost of maintenance is lower compared to Graving dock
- Ballasting of dock can be arranged in such a way for aft or forward trim of the floating dock to minimize issues with stability of the vessel (Heger,2018) (Srinivasreddy et al, 2021).

## 4. Repair/Dry-docking Specification

The scope of repair/maintenance works which are performed during a vessel's stay in shipyard including dry-dock varies on the age of the ship. (Zagan, 2021). Many of works included in the specification can be performed while vessel is afloat or in dock.

Repair specification is drawn up based on the following information (Rashid & Kadir, 2012)

- Condition of the vessel
- Company's requirements for the vessel
- Previous dry-dock Spec and other documents (e.g. steel and coating repairs service reports, shipyard's measurements and calibration reports)
- Vessel Inspection Reports and other third-party reports
- Relevant Non Conformity Reports
- Environmental Compliance and Environmental audits recommendations/observations
- Internal audits recommendations/observations
- Class outstanding issues and surveys required
- Flag Administration requirements
- Forthcoming Class, Flag or other regulatory body requirements
- Reported damages unsettled
- Hull and steel coating reports
- Third-party (e.g. such as Oil Major Companies, P&I Club, etc.) requirements
- Outstanding defects
- Insurance and claims issues
- Acceptable maritime industry standards and working procedures

Specification may include regular preventive maintenance, planned preventive maintenance, overhauls and refurbishing/ retrofit of plants and equipment, breakdown maintenance and accident repairs to electrical, electronic and mechanical equipment, paintings and coatings, tanks, rudder, propeller and tail shaft, piping works, hull, heating, air-conditioning, refrigeration systems etc.

In this chapter, the majority of works conducted in a bulk carrier vessel are presented. (Pittas,1999), (Butler,2012) and (The Swedish Club available at [https://www.swedishclub.com/tm\\_emergencies/templates/Invitation%20to%20tender.dot](https://www.swedishclub.com/tm_emergencies/templates/Invitation%20to%20tender.dot)) The specification is divided into 17 sections and main activities are described for better understanding of scope of work for activities required to be performed for the vessel in case study.

#### **4.1. General Services**

Activities such as pilotage for arrival/departure in yard and dock, tugboat for shifting the vessel, a berth for vessel' stay in shipyard when vessel is not in dry-dock (wharfage), shore power supply, disposal of engine room bilges in order holding tanks to be empty during the repair period, crane service to transfer spare parts and stores etc. are included in general services.

Mainly, the following services are to be provided by shipyard during vessel's stay for repairs:

|     |  |
|-----|--|
| 1.  | Berthing and unberthing                      |
| 2.  | Tugbage for arrival/departure                |
| 3.  | Mooring riggers for arrival/departure        |
| 4.  | Pilotage for arrival/departure               |
| 5.  | Wharfage                                     |
| 6.  | Electric power supply                        |
| 7.  | El. Power connection & disconnection         |
| 8.  | Frequency changer (if applicable)            |
| 9.  | Sea cooling water supply                     |
| 10. | Sea cooling water connection & disconnection |

|     |   |
|-----|---|
| 11. | Fresh water supply  |
| 12. | Fresh water connection & disconnection                      |
| 13. | Compressed air supply                                       |
| 14. | Compressed air connection. & disconnection.                 |
| 15. | Garbage removal   |
| 16. | Crane for owners use  |
| 17. | Fire watchman services                                      |
| 18. | Fire extinguishers per total number required for the vessel |
| 19. | Fire line water supply                                      |
| 20. | Fire line connection & disconnection                        |
| 21. | Fire line keep pressure                                     |
| 22. | Telephone service on board                                  |
| 23. | Gas free certificate  |
| 24. | Gangway installation/removal                                |
| 25. | Scuppers fitting/removing                                   |
| 26. | Drain plugs removing/refitting                              |
| 27. | Drain plug fabrication                                      |
| 28. | Drain plug lead gasket fabrication                          |
| 29. | Drain plug Vacuum Test                                      |
| 30. | Staging for owners account                                  |
| 31. | Cherry pickers including operator for owners use            |
| 32. | Ballast water supply  |

|     |   |
|-----|---|
| 33. | Ballast water connection & disconnection  |
| 34. | Bilge water collection including pumps, hoses and other equipment   |
| 35. | Cleaning of fuel tanks for hot work including ventilation and cleaning material   |
| 36. | Oil sludge collection & disposal including pumps, hoses and other equipment<br>Certificate provided.                    |
| 37. | Cleaning of diesel oil tanks for hot work including ventilation and cleaning material including issuance of Certificate |
| 38. | Cleaning of ballast tanks and topside tanks, removal of mud, including ventilation& disposal)                           |
| 39. | Scale/mud collection & disposal   |
| 40. | Manhole covers opened and re-closed with new gasket and nuts  |
| 41. | M/E Deflection to be taken before & after Dry docking   |
| 42. | Ventilation Fans for Owners use   |
| 43. | Security guards   |
| 44. | General Cleaning of the vessel after repairs  |

**Table 3 General Services**

## **4.2. Dry-docking dues**

Dry-docking dues includes berth preparation such as shifting of keel blocks as per vessel's docking plan. Blocks should be arranged in such a manner to ensure the safety of the vessel and provide adequate height for required works in vessel's bottom. Dock is mainly rent per day.

|    |                           |
|----|---------------------------|
| 1. | Docking/undocking         |
| 2. | Dock Preparation          |
| 3. | Keel block re-arrangement |

|    |                                |
|----|--------------------------------|
| 4. | Side block re-arrangement      |
| 5. | Erection additional side block |

**Table 4 Dry-docking dues**

### **4.3. Dry-docking works**

Dry-docking works includes all activities which can be performed only while vessel is in dry-dock. Examination and measurements of chains, chain lockers cleaning and coating, opening of sea chests for cleaning and painting, anodes installation, propeller dye check for crack detection, stern tube seals renewal etc.

| <b>Anchors and chains</b> |   |
|---------------------------|---|
| 1.                        | Range anchor and cable, wash down chains with fresh water, light scrap, apply one coat with owner's paint, restore. |
| 2.                        | Calibration / Measurement of the diameter   |
| 3.                        | Remarking the cables  |
| 4.                        | Anchors crown pin to be dismantled, clean and refit back  |
| 5.                        | Chain link stud to be welded from one side only   |
| 6.                        | Chain link stud renew   |
| 7.                        | Chain cables renewal  |
| 8.                        | Swivel chain renewal  |
| 9.                        | Kenter shackle renew  |
| 10.                       | D shackle renew   |
| <b>Chain lockers</b>      |   |
| 1.                        | Chain locker to be cleaned by HPFW washing and apply one coat with owner's paint.                                   |
| 2.                        | Mud removal including disposal  |

|                            |  |
|----------------------------|--|
| 3.                         | Removal of remaining water   |
| 4.                         | Hand scraping  |
| 5.                         | Manholes on/off  |
| <b>Sea chests</b>          |  |
| 1.                         | Sea chest grid to remove, interior to clean and apply paint with o/s |
| 2.                         | Remove the grid, clean , paint and refit back                        |
| 3.                         | Staging for above  |
| <b>Cathodic Protection</b> |  |
| 1.                         | Hull anodes owner's supply   |
| 2.                         | Hull Anodes protection   |
| 3.                         | Aluminum anodes to be fitted in top side tanks                       |
| 4.                         | Aluminum anodes to be fitted in DBT                                  |
| 5.                         | Cherry Picker for hull anodes  |
| <b>Rudder</b>              |  |
| 1.                         | Rudder clearances  |
| 2.                         | Check rudder pintle clearance  |
| 3.                         | Checking tightening of the pintle nut and rudder stock nut           |
| 4.                         | Remove and refit inspection cover                                    |
| 5.                         | Rudder drain plug removed/refitted                                   |
| 6.                         | Filling rudder with anticorrosive powder                             |
| 7.                         | Rudder blade to be pressure tested                                   |
| 8.                         | Rudder stock remove and refit  |
| 9.                         | Remove and refit rudder pintle                                       |

|                               |  |
|-------------------------------|--|
| 10.                           | Remove the old pintle bush and refit new one   |
| 11.                           | Skimming the new pintle bush to final diameter   |
| 12.                           | Yard supply bush. To be quoted in situ after checking                                    |
| 13.                           | Rudder Carrier, rudder stock bush and bearing disc clearance to be measured and recorded |
| 14.                           | Rudder Carrier stock to be dismantled, rudder stock bush to be renewed                   |
| <b>Propeller and Shafting</b> |  |
| 1.                            | Propeller Normal Polish  |
| 2.                            | Disconnect propeller, hanging aside and refit back.                                      |
| 3.                            | Propeller covered by oil prior painting  |
| 4.                            | Dye check the propeller hub, blade roots and tips  |
| <b>Tailshaft</b>              |  |
| 1.                            | Measurement of tailshaft wear down   |
| 2.                            | Removal of rope guard, cleaning, painting and refit back                                 |
| 3.                            | Disconnecting propeller, hanging aside, tailshaft withdraw and refit back.               |
| 4.                            | Magnaflux testing of tail shaft taper end  |
| 5.                            | Initial Jack up test of shaft  |
| 6.                            | Seal box (Fore/Aft) overhauling, seals renewal   |
| 7.                            | Seal liner skimming if necessary   |
| 8.                            | Rope guard to be grit blasted & painted 2 coats  |
| 9.                            | Stern tube bearing to be cleaned and measured  |
| 10.                           | Intermediate bearing to be opened up for survey  |
| 11.                           | Stern tube lubrication system to be examined   |



| <b>Sea valves/Overboard Valves</b> |  |
|------------------------------------|--|
| 1.                                 | Fire and GS pump SW inlet and outlet valves      |
| 2.                                 | Aux FW Cooler SW inlet and outlet valves         |
| 3.                                 | FW Expansion Tank valve                          |
| 4.                                 | MGPS SW inlet valve                              |
| 5.                                 | MGPS SW outlet valve                             |
| 6.                                 | Main FW and LO cooler SW inlet and outlet valves |

**Table 5 Dry-docking works**

#### **4.4. Hull Preparation and Hull Painting**

Hull Preparation and Hull Painting includes all activities which must be performed in order to prepare vessel's bottom and sides (vertical sides, bootop, topsides) to be painted. High pressure fresh washing for removal of salt before hydro-blasting or sand blasting is performed and new coatings are applied. A coating inspector is usually appointed by owners/managers to approve the surface before coating.

| <b>Cleaning-painting</b> |   |
|--------------------------|---|
| 1.                       | Washing with high pressure fresh water jet of 400 bar, flat bottom    |
| 2.                       | Washing with high pressure fresh water jet of 400 bar, vertical sides |
| 3.                       | Washing with high pressure fresh water jet of 400 bar, boottopping    |
| 4.                       | Washing with high pressure fresh water jet of 400 bar, topsides       |
| 5.                       | Washing with low pressure fresh water, flat bottom                    |
| 6.                       | Washing with low pressure fresh water, vertical sides                 |
| 7.                       | Washing with low pressure fresh water, boottopping                    |
| 8.                       | Washing with low pressure fresh water, topsides                       |

|                           |  |
|---------------------------|--|
| 9.                        | Scrapping, flat bottom   |
| 10.                       | Scrapping, vertical sides  |
| 11.                       | Scrapping, boottopping   |
| 12.                       | Scrapping, topsides  |
| 13.                       | Touch up coat, flat bottom   |
| 14.                       | Touch up coat, vertical sides  |
| 15.                       | Touch up coat, boottopping   |
| 16.                       | Touch up coat, topsides  |
| 17.                       | Full coat, flat bottom   |
| 18.                       | Full coat, vertical sides  |
| 19.                       | Full coat, boottopping   |
| 20.                       | Full coat, topsides  |
| 21.                       | Repaint plimsol marks, drafts fwd-mid-aft, ships name and port of registry |
| 22.                       | Anti-fouling, flat bottom  |
| 23.                       | Anti-fouling, vertical sides   |
| 24.                       | Anti-fouling, boottopping  |
| <b>Hull grit blasting</b> |  |
| 1.                        | Grit sweeping, flat bottom   |
| 2.                        | Grit sweeping, vertical sides  |
| 3.                        | Grit sweeping, boottopping   |
| 4.                        | Grit sweeping, topsides  |
| 5.                        | Grit blasting SA 1, flat bottom  |

|     |  |
|-----|--|
| 6.  | Grit blasting SA 1, vertical sides   |
| 7.  | Grit blasting SA 1, boottopping  |
| 8.  | Grit blasting SA 1, topsides   |
| 9.  | Grit blasting SA 1.5, topsides   |
| 10. | Grit blasting SA 2, flat bottom  |
| 11. | Grit blasting SA 2, vertical sides   |
| 12. | Grit blasting SA 2, boottopping  |
| 13. | Grit blasting SA 2, topsides   |
| 14. | Disposal of Empty Paint buckets  |
| 15. | Bilge Keel power tooling and paint two coats after repairs, quote per bilge keel |
| 16. | Cherry picker assistance for C/H   |
| 17. | Staging for C/H  |

**Table 6 Hull Preparation and Hull Painting**

#### **4.5. Cargo Holds Treatment**

Same procedure with hull surface is followed. Cargo hold coating does not include anti-fouling coatings.

|    |  |
|----|--|
| 1. | High pressure washing with fresh water |
| 2. | Grit blasting to SA1                   |
| 3. | Grit blasting to SA 2                  |
| 4. | Touch up coat                          |
| 5. | Full coat                              |

|    |                |
|----|----------------|
| 6. | Stripe coating |
|----|----------------|

**Table 7 Cargo Holds Treatment**

#### **4.6. Hatch Covers Treatment**

Hatch covers treatment based on actual condition may be performed if required. Activities are as follows:

|    |  |
|----|--|
| 1. | High pressure washing with fresh water |
| 2. | Sweeping                               |
| 3. | Grit blasting to SA 1                  |
| 4. | Grit blasting to SA 2                  |
| 5. | Touch up coat                          |
| 6. | Full coat                              |
| 7. | Stripe coating per meter               |

**Table 8 Hatch Covers Treatment**

#### **4.7. Pipe works**

Pipe works include renewal of corroded pipes, hydraulic hoses including flanges as required.

|    |  |
|----|--|
| 1. | Pipe renewals in way of deck, double bottoms, engine room, topside tanks, and cargo holds ,2”-20” seamless steel sch 40,sch 80 |
| 2. | Pipe renewal for hydraulic pipes sch 80 -120 18mm-45mm   |
| 3. | <b><u>Heating Coils Pressure Test</u></b><br>The heating coils of double bottom HFO tanks to be pressure tested                |

**Table 9 Pipe works**

## 4.8. Steel Works

Following ultrasonic thickness measurements performed by approved engineer in the vessel, all affected plate of which thickness had been reduced and same must be renewed. (Heger, 2003).

|     |  |
|-----|--|
| 1.  | Mild steel Grade A, / AH32 as well Grade B net fitted in way of decks cargo holds, double bottoms, topside tanks and fore/after peak |
| 2.  | MS or HT 32, net fitted for hatch covers plating, internals, drain channel and compression bars                                      |
| 3.  | Hatch cover panels on/off, per panel   |
| 4.  | Hatch cover rubber packing renewal   |
| 5.  | Hatch cover hose test, price per hold  |
| 6.  | Manhole studs renewal by yard supplied stainless steel studs and nut   |
| 7.  | Fabrication and installation of vertical strait access ladders to Top side & DB Ballast TK As well access to the holds.              |
| 8.  | Cargo hold weather tight hatch steel Fabrication, 600 x 700mm, 8mm mild steel, hinged type, butterfly nut securing                   |
| 9.  | Hatch coaming drain channel repairs (fair up, welding build up)  |
| 10. | Engine room fans dumper inspection / overhauling.  |
| 11. | Engine room fans Flame arrest screen fabrication and replacement.  |
| 12. | Fabrication of new fire damper for engine room vent fan.   |
| 13. | Rudder trunk protecting grid fabrication and fitting.  |

**Table 10 Steel Works**

## 4.9. Machinery Works

Major overhauling repairs which cannot be performed while vessel is in service, must be carried out while vessel in shipyard. Machinery Works include Main Engine piston

overhauling, Main engine bearing measurements of clearances, Boiler inspection and cleaning etc.

| <b>MAIN ENGINE</b>         |   |
|----------------------------|---|
| 1.                         | <p><b><u>Main engine Cylinder Overhauling.</u></b></p> <p>Main engine Cylinder Covers disassembly, cleaning inspection &amp; lapping of sealing surfaces (fuel injectors, exhaust valves, starting valve) and re-assembly.</p> <p>Removed cooling jacket for cleaning renewal the o- rings</p> <p>Piston Overhauling (cleaning ,renewal piston rings , measurements, pressure test) overhauling of the stuffing box</p> <p>Measurement of the cylinder liner and re-assembly.</p> |
| 2.                         | <p><b><u>Main Engine Roller Guides</u></b></p> <p>Disassembly, cleaning, inspection for cracks, dye check and reassembly including pump remove/refit</p>  |
| 3.                         | <p><b><u>Main Engine Bearing &amp; Journal.</u></b> Opened for inspection, measurements of clearances and then assembly.</p>  |
| 4.                         | <p><b><u>Crosshead Pin &amp; Bearing of Main Engine</u></b></p> <p>Opened for inspection, measurements of clearances and then assembly.</p>   |
| 5.                         | <p><b><u>Crank pin &amp; Bearing of Main Engine</u></b></p> <p>Opened for inspection, measurements of clearances and then assembly.</p>   |
| 6.                         | <p><b><u>Main Engine Turbocharger</u></b></p> <p>Turbocharger to be overhauled, Casings to be cleaned inspected. Rotor to be sand/ash blasted &amp; Dynamic balancing tested. Relevant Reports to be provided.</p> <p>Insulation to be Renewed.</p>   |
| 7.                         | <p><b><u>Oil Mist Detector</u></b></p> <p>Oil Mist Detector to be overhauled &amp; tested. Relevant Report to be provided.</p>  |
| 8.                         | <p><b><u>Main engine Air cooler: Removal for chemical cleaning of air &amp; sea side .Pressure test, renewal of anodes &amp; re assembly.</u></b></p>   |
| <b>EXHAUST GAS BOILER.</b> |   |
| 1.                         | <p><b><u>Cleaning/Washing of the Boiler</u></b> exhaust and / water side by water</p>   |
| 2.                         | <p><b><u>Safety valve overhaul</u></b></p> <p>Safety valves to be dismantled and transported to workshop. Valve to be dismantled and parts cleaned. Valve seat to be machined, re-assembled with new</p>  |

|                                 |  |
|---------------------------------|--|
|                                 | packing's and tested under steam pressure with the presence of owner's representative.   |
| 3.                              | Overhauling of the Boiler steam and feed water valves.   |
| 4.                              | Boiler steam Pressure Gauge. To be tested and to be calibrated. Certificate to be issued.  |
| <b>ENGINE ROOM PUMPS</b>        |  |
| 1.                              | <b><u>Pump overhaul</u></b><br>Pump to disconnected and transported to workshop. Complete dismantling, cleaning of all parts and measurements. Shaft to be erected on lathe machine and check for straightness. Pump to be re-closed with new bearings (owner supply), gaskets and bolt & nuts and tested. Pump to be returned to vessel ,connected and tested |
| 2.                              | Fabricate new shaft stainless steel  |
| 3.                              | Fabricate mouth ring bronze  |
| 4.                              | Fabricate bush bronze  |
| 5.                              | Pump Shaft machining and grinding  |
| 6.                              | Fabricate and insert sleeve  |
| <b>HEATERS/COOLER/CONDENSER</b> |  |
| 1.                              | <b><u>Heaters overhaul</u></b><br>Heater to be removed and transported to workshop. Heater element to be pulled out and chemical cleaning. Box up with new gaskets, bolts and nuts, pressure testing and returned to the vessel.   |
| 2.                              | FWG heat exchanger. Cleaning and tubes de clogging. Pressure test after the cleaning to be carried out. In the price to be included all the relevant works (remove / refit pressure test etc.).  |
| 3.                              | Steam Condenser to be removed and transported to workshop. Condenser element to be pulled out and chemical cleaning. Box up with new gaskets, bolts and nuts, pressure testing and returned to the vessel.   |

| <b>DIESEL GENERATORS</b> |  |
|--------------------------|--|
| 1.                       | Diesel generator General overhauling. Cylinder covers overhauling (including necessary part replacement / owner supply) – piston unit removal for inspection cleaning & measurement. Measurement of connecting rod ovality to be included in the price. Cylinder liner cleaning, honing, measurement.<br>Inspection of main bearings, replacement in case needed. Cylinder liner honing. |
| 2.                       | <b><u>Governor</u></b> Overhauling   |
| 3.                       | <b><u>Turbocharger</u></b> Overhauling of turbocharger.<br>Rotor sand blasting and dynamic balancing to be quoted separately.  |
| 4.                       | <b><u>Air cooler cleaning</u></b> : Removal of the cooler for chemical cleaning air & sea side   |
| 5.                       | <b><u>Diesel Generator Alternators:</u></b> Cleaning of Alternators.   |
| 6.                       | Diesel Generator Alternators: Measuring of the Air cup.<br>1.Opening of end covers<br>2.Measurement of the air gap by feeler gauge between rotor and stator<br>3.Closing of end covers   |

**Table 11 Machinery Works**

#### **4.10. Electrical Works**

Electrical works activities are presented below:

|    |  |
|----|--|
| 1. | <b><u>Electric motor rewinding</u></b><br>Electric motor rewinding including removal, transportation to workshop and refitting, megger test and bearing renewal. |
| 2. | <b><u>Electric motor overhaul</u></b><br>Electric motor normal overhauling, including removal, transportation to workshop varnish and re-fitting.                |
| 3. | Recondition of Electric motor bearing pockets.   |
| 4. | Testing of main switchboard over-current, low voltage/frequency and reverse power safety devices by special equipment. provide certificate                       |
| 5. | <b><u>M/E Blowers Motors &amp; Fans Overhauling.</u></b><br>Motors to be overhauled, Fans to be balancing tested and Balancing report to be provided.            |



**Table 12 Electrical Works**

#### **4.11. Life Saving Appliances**

Dynamic load test of lifeboat davits must be performed.

|    |   |
|----|---|
| 1. | Life boats to be landed: ON/OFF   |
| 2. | Life boats/davits dynamic test<br>Dynamic load test at 1.1 Load to be carried out for both life boat davit and life boat.<br>Note: Dynamic Test Certificate to be provided. |

**Table 13 Life Saving Appliances**

#### **4.12. Hatch Covers**

Hatch Covers repairs may be performed during vessel's stay in shipyard as follows:

|     |  |
|-----|--|
| 1.  | Hydraulic cylinders overhaul, diameter including remove/refit per pc, change of Seals/ test. |
| 2.  | Piston rod to be machined and chrome plated  |
| 3.  | Hatch Cover steel renewals   |
| 4.  | Hatch Cover Rubber Packing Replacement   |
| 5.  | Hatch Cover Hose Test  |
| 6.  | Hatch Cover Sealing and Resting Alignment on the resting pads per hatch                      |
| 7.  | Resting Pad Rebuilding per pc in case needed   |
| 8.  | Resting Pad Replacement per pc in case needed  |
| 9.  | Hinges between Panels to be defrosted and greasing restored                                  |
| 10. | Greasing copper tubes replacement  |
| 11. | Replacement / fabrication of the H/C Hydraulic cylinder upper / Lower pin in case needed.    |
| 12. | Hatch cover Double skin .The panels should be kept neutralized in case of                    |

|     |  |
|-----|--|
|     | repairs.   |
| 13. | Hydraulic Cylinder ram reconditioning ( Re chroming ) in case needed   |
| 14. | Hinges link pin - Remove/Clean/Inspect/Refit Pin   |
| 15. | Fabricate Pin including grease channels, nipple, securing plate and bolts SS                                     |
| 16. | Fabricate Bush (Mild Steel)  |
| 17. | Machine Link Hole and Fit Bush including transportation to workshop  |
| 18. | -Link Surface Treatment and Painting three coats   |
| 19. | Upper link Eye<br>Replacement including material, cropping, machining, welding, surface treatment, three coats.  |
| 20. | Lower link Eye<br>Replacement including material, cropping, machining, welding, surface treatment, three coats   |
| 21. | Upper Eye Plate<br>Replacement including material, cropping, machining, welding, surface treatment, three coats. |
| 22. | Remove/Clean/Inspect/Refit Pin (Bearings Owner Supply)   |
| 23. | Fabricate Pin including grease channels, nipple, securing plate and bolts (stainless steel)                      |
| 24. | Lower Eye Plate<br>Replacement including material, cropping, machining, welding, surface treatment, three coats. |
| 25. | Remove/Clean/Inspect/Refit Pin   |
| 26. | Fabricate Pin including grease channels, nipple, securing plate and bolts (stainless steel)                      |
| 27. | Fabrication of new hatch cover of cargo holds access.  |
| 28. | Rebuilding for Fx-stopper on hatch cover   |

|     |  |
|-----|--|
| 29. | Overhaul the Fx-stopper on hatch coaming   |
| 30. | Rebuilding for cleat hole on hatch coaming |
| 31. | Fabricate shim plate (stainless steel)     |
| 32. | Fabricate shim plate (stainless steel)     |

**Table 14 Hatch Covers**

### **4.13. Deck Cranes**

Deck Cranes repairs may be performed during vessel's stay in shipyard as follows:

|     |   |
|-----|---|
| 1.  | Cargo hook swivel. Swivel to be opened for cleaning/inspection, renewal of thrust bearing if required                     |
| 2.  | Crane Jib Lifting Blocks Roller Inspection in situ per Roller   |
| 3.  | Crane Jib Mount Bearing House Inspection / Measurement (Goose Neck)   |
| 4.  | Crane Cabin Steel Work  |
| 5.  | Loading Test of all Cranes (5 Years)  |
| 6.  | Crane sheaves to be checked for shaft clearance and groove wear during the replacement of the wires. Please quote per PC. |
| 7.  | Crane Stabilizer Wire and Electrical Cable Rollers to be checked for shaft clearance.<br>Please quote per PC.             |
| 8.  | E/R Crane Load Test, Certificate to be provided   |
| 9.  | Provision Crane Load Test, Certificate to be provided   |
| 10. | Replacement of deck crane wires.  |
| 11. | Replacement of sheaves roller bearing.  |
| 12. | Replacement of roller bearing.  |
| 13. | Fabrication/repair of cable drum.   |

**Table 15 Deck Cranes**

#### 4.14. Grabs

Grabs repairs may be performed during vessel's stay in shipyard as follows:

|     |   |
|-----|---|
| 1.  | Grabs to be landed. On / Off.   |
| 2.  | Grabs to be sandblasted SA2 / Painted 1 F/C   |
| 3.  | Grabs hydraulic cylinders to be overhauled.   |
| 4.  | Grabs Bolzen pins to be checked /inspected for excessive clearances.                              |
| 5.  | Grabs Bolzen pin fabrication / replacement in case needed.  |
| 6.  | Pins to be dismantle and Reassemble per bush/pin/set  |
| 7.  | Fabricate copper bush for grab  |
| 8.  | Connection rod fabricate copper bush  |
| 9.  | Grab hydraulic cylinder removal and overhauling   |
| 10. | Grab hydraulic cylinder rod re-chroming   |
| 11. | Boring the hole for grab  |
| 12. | Inspection of hydraulic system, hydraulic cylinder overhauling and pressure testing per cylinder. |

**Table 16 Grabs**

#### 4.15. Mooring Winch and Windlass

Mooring Winch and windlass activities which may be performed during vessel's stay in shipyard are as follows:

|    |  |
|----|--|
| 1. | Mooring Winches S.W.L test to be carried out and Certificate to be issued. |
| 2. | Remove/ Refit Mooring Drum and Shaft including transportation to workshop  |
| 3. | Fabrication and replacement of bearing bush                                |

|    |   |
|----|---|
| 4. | Mooring shaft build-up/ machining in way of the bushes    |
| 5. | Build-up and Machining of coupling faces                  |
| 6. | Anchor gypsy build-up welding                             |
| 7. | Replacement of Break Lining,(Lining, Bronze Bolt and Nut) |
| 8. | Boring the hole on spot for portside windlass/winch shaft |
| 9. | Fair leads covers to be renewed.                          |

**Table 17 Mooring Winch and Windlass**

#### **4.16. Accommodation & Pilot Ladders**

Accommodation & Pilot Ladders test and repairs may be performed during vessel's stay in shipyard as follows:

|     |   |
|-----|---|
| 1.  | Load test of accommodation ladder as per new SOLAS requirement      |
| 2.  | Load test of Pilot combination ladder as per new SOLAS requirement. |
| 3.  | Inspection of all upper platforms turn tables pins.                 |
| 4.  | Renewal of turn table pin   |
| 5.  | Sandblasting quote per ladder                                       |
| 6.  | Painting two coats, quote per ladder                                |
| 7.  | Accommodation ladder Remove to workshop/refit                       |
| 8.  | Pilot ladder Remove to workshop/refit                               |
| 9.  | Step renewal  |
| 10. | Frame renewal   |

**Table 18 Accommodation & Pilot Ladders**

#### **4.17. Retrofit – BWTS- Scrubber - ESD Installation**

During dry-docking, vessel may undergo a retrofit such as Ballast water treatment system, scrubber and or energy saving devices installation. (Rivas-Hermann et al 2015).

|    |   |
|----|---|
|    | <b>New Equipment Installation</b>                 |
| 1. | Installation of BWTS- Scrubber - ESD Installation |

**Table 19 Retrofit – BWTS- Scrubber - ESD Installation**

## 5. Pre-docking planning

One of the primary goals during a pre-docking planning is to ensure that all required works are included in the specification report and that a complete scope of work is provided to the shipyard to avoid additional works/orders during dry-docking. Additional works/orders may lead to extending the total repair period and will increase the total cost of repairs (Zagan et al, 2021)

The Master and Chief Engineer shall inform at regular intervals, repair items which are to be included in the specification for the vessel's next scheduled dry docking. All items which are to be repaired in shipyard must be appropriately marked to allow proper review by the vessel's Superintendent (Yasin & Osman, 2018).

Dry Docking activities and repairs must fulfill the requirements of Classification Societies, Flag Administration, IMO, equipment manufacturers and national legislations (EPA NPDES) (Dev et al, 2022).

EPA NPDES states that during required dry-dock period, owners/managers should ensure that the following items have been completed. Reports must be made available to EPA upon request. The report must note that:

- The chain locker has been cleaned for both sediment and living organisms.
- The vessel hull has been inspected for attached living organisms and those organisms have been removed or neutralized.
- Anti-fouling hull coatings have been applied, maintained and removed consistent with FIFRA label if applicable; any exposed existing or any new coating does not contain biocides or toxics that are banned for use in the United States.
- All cathodic protection, anodes or dialectic coatings have been cleaned and/or replaced to reduce flaking.
- All pollution control equipment is properly functioning.
- Record of maintenance performed during dry-dock for the Controllable Pitch Propeller (If applicable) and/or Stern Tube System.
- Company's Copper-based TBT-free anti-fouling hull coating statement.

(US Environmental Protection Agency, 2013).

Dry-docking repair requests normally shall only include items that cannot be carried out during the vessel's normal in- service operation. The repair or overhauling of equipment or machinery, which is normally carried out during the normal operational service of the vessel, can be carried out during the dry docking only if it is more convenient to do so.

Spare part requisitions covering all parts required during dry-dock shall be created well in advance (Zhao & Yang, 2018).

All dry-docking inspection findings shall be recorded in order to ensure that same will be included in vessel's specification and scope of work.

Detailed information shall be given to enable the repair/overhaul requirements to be fully understood including accurate dimensions, descriptive details, available spares and information regarding parts, which require renewal, together with any access and staging requirements. Sketches, drawings and photos are to be included in order for an accurate repair specification to be compiled (Yasin & Osman, 2018).

A draft copy of the Repair Specification can be forwarded to the vessel for review by the vessel's Master and Chief Engineer well in advance prior to the dry-docking. Vessel should inform for any additional items that may arise from the draft copy and items must immediately be reported to the office so as to be included the final specification. Once the onboard review to the specification has been completed the specification will be submitted to the shipyard.

The finalizing specification shall be forwarded to the vessel for reference and proper follow up during repair period in shipyard. The Master and Chief Engineer shall ensure that all specification items are properly identified and marked prior to the vessel's arrival at the shipyard or repair facilities. Any additional jobs that may come out the last days prior to the vessel's arrival at the shipyard or the repair facility must be given to the Technical Superintendent in charge of the dry dock immediately upon boarding the vessel and during the meeting in shipyard (Stewart, 1997).



## 6. Questionnaire

### 6.1. Research methodology

The research methodology contained twenty seven (27) delay factors which were yielded through literature review. A questionnaire was developed in order to evaluate the frequency of occurrence and impact on project of the identified causes. The questionnaire was applied to a sample of owners/managers, shipyard personnel and Classification society surveyors. Factors were grouped to nine (9) categories: Contractors, owners, equipment, materials, external factors, project, labors, consultant, and factors related to design (Table 21).

| <u>A/A</u>  | <u>Factors</u>  | <u>Related Group</u> |
|-------------|---|----------------------|
| Group No 1. |   |                      |
| Q.1         | Use external sub -contractors during work at a yard   | Contractors          |
| Q.2         | Poor site management and supervision by shipyard  | Contractors          |
| Q.3         | High number of quality defects by shipyard that require re-work   | Contractors          |
| Q.4         | Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling ,D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | Contractors          |
| Q.5         | Ineffective planning and scheduling of project by shipyard  | Contractors          |
| Group No 2. |   |                      |
| Q.6         | Late delivery or revising of detailed engineering drawings by owners  | Owners               |
| Q.7         | Poor quality of documentation provided e.g. outdated docking plan   | Owners               |
| Q.8         | Incomplete scope of work/ work done list shared   | Owners               |

|             |  |                  |
|-------------|--|------------------|
|             | by the owners/managers – change orders during repairs  |                  |
| Q.9         | Little insight of progress at shipyard by owners   | Owners           |
| Q.10        | Delay in progress payment by owners  | Owners           |
| Q.11        | Slowness in decision making process by owners  | Owners           |
| Q.12        | Unavailability of incentives for shipyard for finishing ahead of schedule  | Owners           |
| Group No 3. |  |                  |
| Q.13        | Inadequate efficiency of equipment   | Equipment        |
| Group No 4. |  |                  |
| Q.14        | Delay to supply required materials   | Materials        |
| Group No 5. |  |                  |
| Q.15        | Weather effect on activities (hot, rain, etc.)   | External Factors |
| Q.16        | Worker accident during repairs   | External Factors |
| Q.17        | Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | External Factors |
| Q.18        | Delay in performing final inspection and certification by a third party  | External Factors |
| Q.19        | Changes in government regulations and laws   | External Factors |
| Q.20        | Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)   | External Factors |
| Group No 6. |  |                  |
| Q.21        | Original contract duration is too short  | Project          |
| Q.22        | Ineffective delay penalties  | Project          |
| Q.23        | Legal disputes between various parts   | Project          |
| Group No 7. |  |                  |
| Q.24        | Inadequate efficiency of workforce   | Labors           |
| Group No 8. |  |                  |
| Q.25        | Delay in performing inspection and testing by Classification Society   | Consultant       |
| Q.26        | Late in reviewing and approving design documents by Classification Society   | Consultant       |

| Group No 9. |   |        |
|-------------|---|--------|
| Q.27        | Mistakes and discrepancies in design documents and associated difficulty in production. | Design |

**Table 20 Factors delaying the completion of scheduled ship's repairs**

## **6.2. Questionnaire design**

The survey was conducted via an online questionnaire. Research questionnaire is divided into seven main parts. The first part introduces the issue which will be investigated and the purpose of the study. Part two includes confirmation of consent. Part three includes one filter question in order to ensure that participant has been worked for a scheduled dry-dock. Part three is related to Demographics questions whereas part four includes general questions such as participants' background in dry-dock repairs, experience and position. Part five and six includes question for the frequency of occurrence of the potential factors during ship's repairs. The causes are divided into contractors, owners, equipment, materials, external factors, project, labors, consultant and design for better understanding from the participants. Two (2) questions for each factor were asked: 1) what is the frequency of occurrence for each factor? 2) What is the impact on project? The answer for the first question is categorized as "always, often, sometimes and rarely, never" on 5 to 1 point scale. The second question is categorized as "very high, high, medium, low, very low" on 5 to 1 point scale. No leave question is permitted.

## **6.3. Data analysis approach**

The questionnaire has been addressed through Google form to all traced employees in the maritime industry including shipyard employees and classification society surveyors. In total 156 responses received from which 148 respondents have been participated in a scheduled ship's repairs and can be considered as data for analysis. Most of the respondents have been participated to more than 10 dry-dock. The Index assigned for factors relative to frequency of occurrence used, was obtained by Hwang et al, 2013 to respondents. The Index assigned for factors relative to Impact on schedule used, was obtained by Badrus Zaman et al, 2019 who analyzed ship repair scheduling and which index is applicable for our analysis as well.

The equation used for calculation of frequency index (F.I.) and impact index (I.I.) as stated in Marzouk & El-Rasas, 2014 and Hwang et al, 2013 is as follows:

$$\text{Frequency Index (F.I.) \%} = \frac{5a_5 + 4a_4 + 3a_3 + 2a_2 + 1a_1}{5N} * 100$$

$$\text{Impact Index (I.I.) \%} = \frac{5a_5 + 4a_4 + 3a_3 + 2a_2 + 1a_1}{5N} * 100$$

Based on the F.I. and I.I., the importance index (IMP.I.) for each factor was calculated following below equation:

$$\text{Importance Index (IMP.I.) \%} = \frac{F.I. * I.I.}{100}$$

Where N refers to the total number of respondents

a5 is the number of responses as “always”, “very high”

a4 is the number of responses as “often”, “high”

a3 is the number of responses as “sometimes”, “medium”

a2 is the number of responses as “rare”, “low”

a1 is the number of responses as “never”, “very low”

## **6.4. Pre-test**

A pre-test was conducted to five (5) respondents to identify any wording issue in the questionnaire. Based on their feedback, minor modifications were made to four (4) questions. The changes were related to the wording. No changes were made to the meaning or content of questions.

## **6.5. Research Results**

### **6.5.1. Respondents profile**

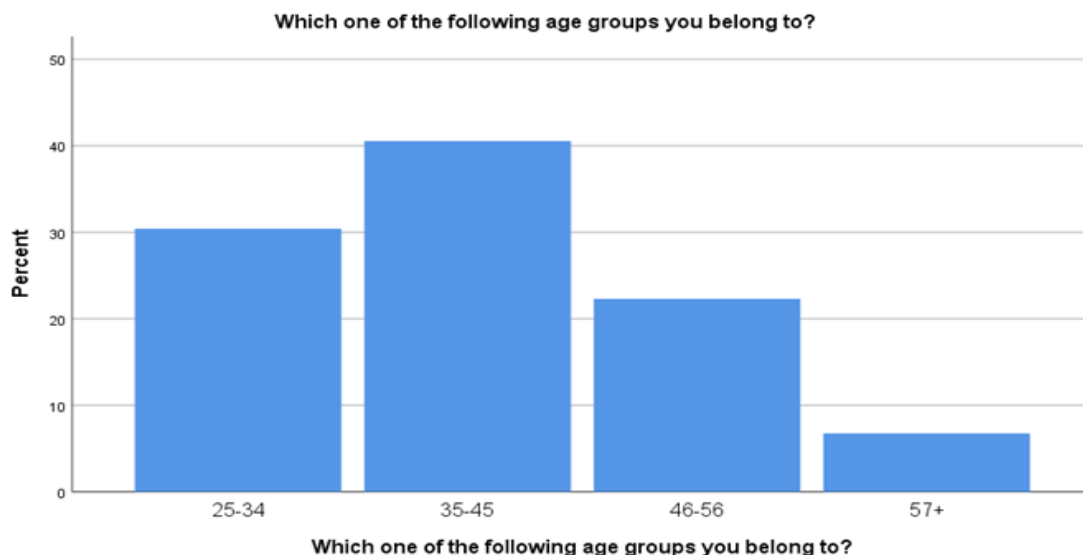
In this chapter, the collected data is analyzed by utilizing the statistical program for social science (SPSS) and Microsoft excel software. Firstly, the demographic information of respondents including their position ,type of ship’s they work and experience in dry-dock repairs are demonstrated providing a more detail profile of participants in the survey.

As per below table 22, from 148 respondents, the majority (40.5%) were within the age of group 35-45, under 25-34 group accounted 30.4% of participants, following the age group of 46-56 (22.3%) and the lower percentage (6.8%) is in the group of persons aged 57 and over.

**Which one of the following age groups you belong to?**

|       |       | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-------|-----------|---------|---------------|--------------------|
| Valid | 25-34 | 45        | 30,4    | 30,4          | 30,4               |
|       | 35-45 | 60        | 40,5    | 40,5          | 70,9               |
|       | 46-56 | 33        | 22,3    | 22,3          | 93,2               |
|       | 57+   | 10        | 6,8     | 6,8           | 100,0              |
|       | Total | 148       | 100,0   | 100,0         |                    |

**Table 21 Which one of the following age groups you belong to?**



**Figure 3 Which one of the following age groups you belong to?**

As far it concerns their education level, as per table 23, most of the participants are holders of Master's degrees with a percentage of 48.6% followed by participants who have

Bachelor's degrees with a percentage of 37.2%. From the total sample size, 10.1% of participants have hold a Diploma on Maritime Affairs and the smallest percentage is in the group of High School holders (4.1%).

### What is the level of your academic qualification?

|       |                                | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|--------------------------------|-----------|---------|---------------|--------------------|
| Valid | High School                    | 6         | 4,1     | 4,1           | 4,1                |
|       | Bachelor's Degree              | 55        | 37,2    | 37,2          | 41,2               |
|       | Master's Degree -<br>Doctorate | 72        | 48,6    | 48,6          | 89,9               |
|       | Diploma on Maritime<br>Affairs | 15        | 10,1    | 10,1          | 100,0              |
|       | Total                          | 148       | 100,0   | 100,0         |                    |

Table 22 What is the level of your academic qualification?

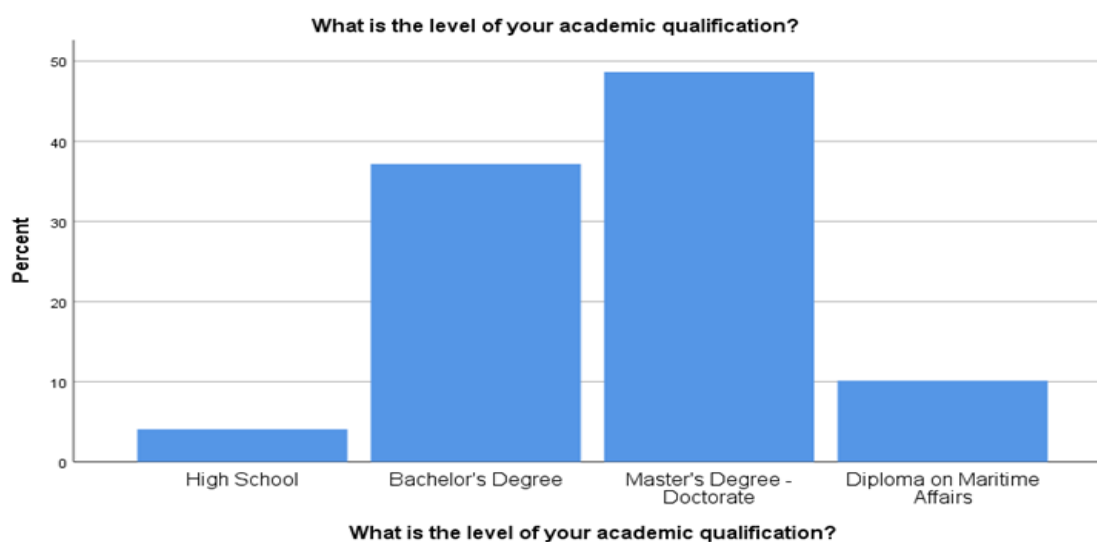


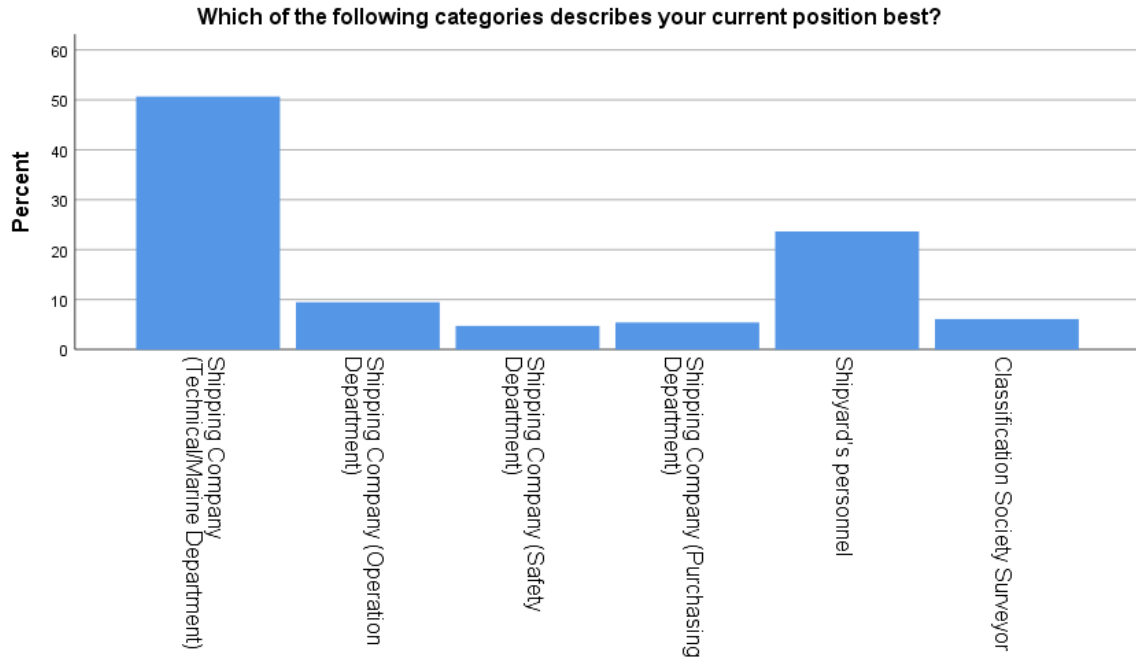
Figure 4 What is the level of your academic qualification?

The majority of the participants in the survey have a position in a Shipping Company (Technical/Marine Department ) with a percentage of 50.7%.Following the respondents who are shipyard's personnel (23.6%).Respondents with a position in a Shipping Company (Operations Department ) accounting for 9.5% while respondents who are Classification Society Surveyor accounting for 6.1%.The lower percentage is for respondents with a position in a Shipping Company (Purchasing Department) 5.4% and with a position in a Shipping Company (Safety Department) 4.7%.

**Which of the following categories describes your current position best?**

|       |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|--|-----------|---------|---------------|--------------------|
| Valid | Shipping Company (Technical/Marine Department) | 75        | 50,7    | 50,7          | 50,7               |
|       | Shipping Company (Operation Department)        | 14        | 9,5     | 9,5           | 60,1               |
|       | Shipping Company (Safety Department)           | 7         | 4,7     | 4,7           | 64,9               |
|       | Shipping Company (Purchasing Department)       | 8         | 5,4     | 5,4           | 70,3               |
|       | Shipyard's personnel                           | 35        | 23,6    | 23,6          | 93,9               |
|       | Classification Society Surveyor                | 9         | 6,1     | 6,1           | 100,0              |
|       | Total  | 148       | 100,0   | 100,0         |                    |

**Table 23 Which of the following categories describes your current position best?**



**Figure 5 Which of the following categories describes your current position best?**

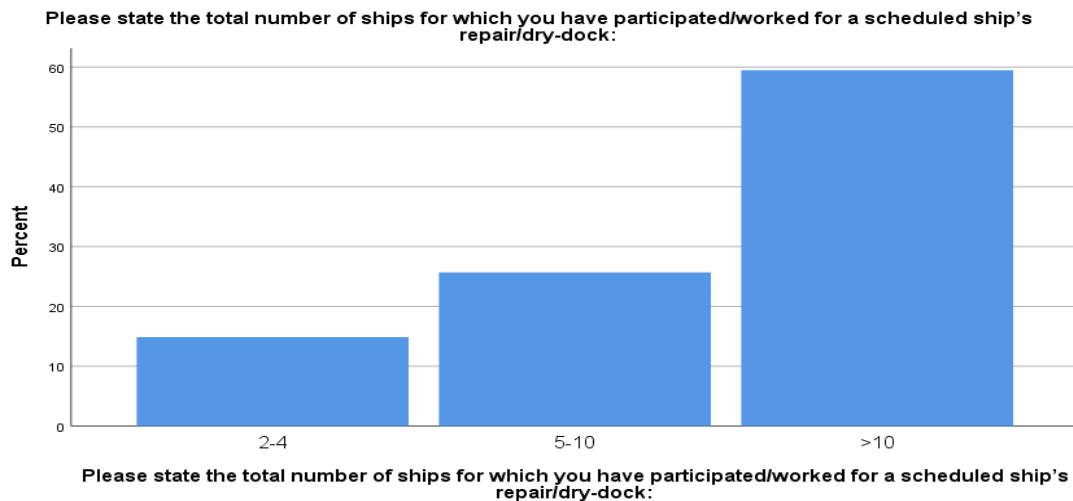
With reference to the total number of ship's for which participants have participated/worked for a dry-dock, the majority of the participants 59.5% have participated to more than 10 dry-docks while 25.7% for 5-10 dry-docks. The smallest percentage 14.9% is for respondents who have participated to 2-4 dry-docks.

**Please state the total number of ships for which you have participated/worked for a scheduled ship's repair/dry-dock:**

|       |       | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-------|-----------|---------|---------------|--------------------|
| Valid | 2-4   | 22        | 14,9    | 14,9          | 14,9               |
|       | 5-10  | 38        | 25,7    | 25,7          | 40,5               |
|       | >10   | 88        | 59,5    | 59,5          | 100,0              |
|       | Total | 148       | 100,0   | 100,0         |                    |

**Table 24 Please state the total number of ships for which you have participated/worked for a scheduled ship's repair / dry-dock**





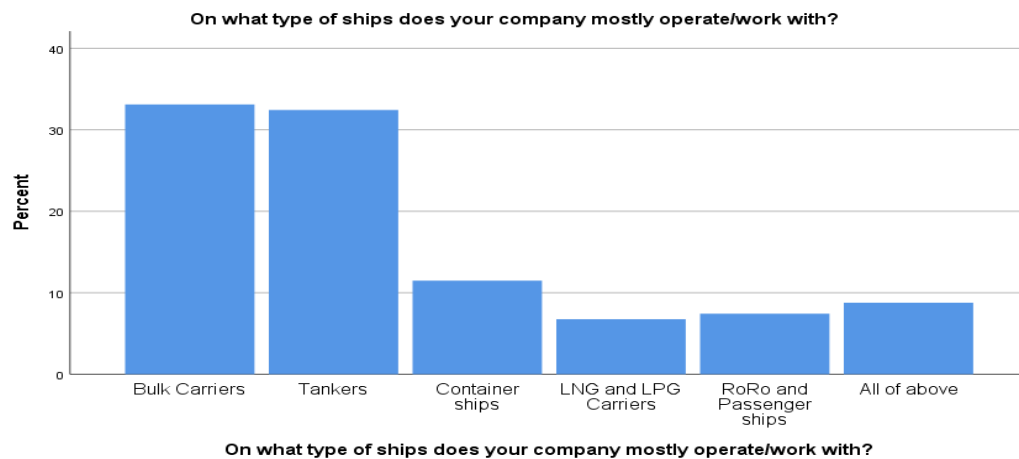
**Figure 6 Please state the total number of ships for which you have participated/worked for a scheduled ship's repair / dry-dock**

Regarding the type of ships mostly operates, 33.1% of the participants work with Bulk carriers vessels while 32.4% with Tankers. 11.5% of participants work with Container ships whereas 7.4% with RoRo and Passenger ships. Finally, 6.8% of the respondents work with LNG and LPG vessels.

**On what type of ships does your company mostly operate/work with?**

|       |                          | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|--------------------------|-----------|---------|---------------|--------------------|
| Valid | Bulk Carriers            | 49        | 33,1    | 33,1          | 33,1               |
|       | Tankers                  | 48        | 32,4    | 32,4          | 65,5               |
|       | Container ships          | 17        | 11,5    | 11,5          | 77,0               |
|       | LNG and LPG Carriers     | 10        | 6,8     | 6,8           | 83,8               |
|       | RoRo and Passenger ships | 11        | 7,4     | 7,4           | 91,2               |
|       | All of above             | 13        | 8,8     | 8,8           | 100,0              |
|       | Total                    | 148       | 100,0   | 100,0         |                    |

**Table 25 On what type of ships does your company mostly operate/work with?**



**Figure 7 On what type of ships does your company mostly operate/work with?**

## 6.6. Delay Factors Analysis

As per literature review, twenty seven (27) delay factors have been identified that may affect the completion of a scheduled ship's repairs/dry-dock. As per responses received, the majority of participants in this survey have deal with such delay factors in the past. Questionnaire objective is to identify both frequency of occurrence and impact for each delay factor so as to establish the importance of each factor.

### 6.6.1. Frequency of Occurrence of delay factors related to Contractors before awarding point scale

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the contractors, happens. Participants in the survey were asked for five (5) delay factors and the results are presented below in table 26 to 30.

#### Q.1-Use external sub-contractors during work at a yard

|       |        | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|--------|-----------|---------|---------------|--------------------|
| Valid | Never  | 8         | 5,4     | 5,4           | 5,4                |
|       | Rarely | 44        | 29,7    | 29,7          | 35,1               |

|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| Sometimes | 63  | 42,6  | 42,6  | 77,7  |
| Often     | 26  | 17,6  | 17,6  | 95,3  |
| Always    | 7   | 4,7   | 4,7   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 26 Q.1-Use external sub-contractors during work at a yard-Frequency of Occurrence**

Question No 1 was the Use external sub-contractors during work at a yard. For this factor and with reference to frequency of occurrence, there were seven (7) participants who answered always, twenty six (26) participants answered often, sixty three (63) answered sometimes, forty four participants (44) answered rarely and there were eight (8) participants answered never.

### **Q.2-Poor site management and supervision by shipyard**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 4         | 2,7     | 2,7           | 2,7                |
|       | Rarely    | 33        | 22,3    | 22,3          | 25,0               |
|       | Sometimes | 64        | 43,2    | 43,2          | 68,2               |
|       | Often     | 43        | 29,1    | 29,1          | 97,3               |
|       | Always    | 4         | 2,7     | 2,7           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 27 Q.2-Poor site management and supervision by shipyard-Frequency of Occurrence-Frequency of Occurrence**

Question No 2 was the poor site management and supervision by shipyard. For this factor and with reference to frequency of occurrence, there were four (4) participants who answered always, forty three (43) participants answered often, sixty four (64) answered sometimes, thirty three participants (33) answered rarely and there were four (4) participants answered never.

### **Q.3-High number of quality defects by shipyard that require re-work**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 6         | 4,1     | 4,1           | 4,1                |
|       | Rarely    | 57        | 38,5    | 38,5          | 42,6               |
|       | Sometimes | 62        | 41,9    | 41,9          | 84,5               |
|       | Often     | 22        | 14,9    | 14,9          | 99,3               |
|       | Always    | 1         | ,7      | ,7            | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 28 Q.2- High number of quality defects by shipyard that require re-work-Frequency of Occurrence**

Question No 3 was the high number of quality defects by shipyard that require re-work. For this factor and with reference to frequency of occurrence, there was one (1) participant who answered always, twenty two (22) participants answered often, sixty two (62) answered sometimes, fifty seven (57) participants answered rarely and there were six (6) participants answered never.

**Q.4-Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal)**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 8         | 5,4     | 5,4           | 5,4                |
|       | Rarely    | 55        | 37,2    | 37,2          | 42,6               |
|       | Sometimes | 47        | 31,8    | 31,8          | 74,3               |
|       | Often     | 34        | 23,0    | 23,0          | 97,3               |
|       | Always    | 4         | 2,7     | 2,7           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 29 Q.4-Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) -Frequency of Occurrence**

Question No 4 was the co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal). For this factor and with reference to frequency of occurrence, there were four (4) participants who answered always, thirty four (34) participants answered often, forty seven (47) answered sometimes, fifty five participants (55) answered rarely and there were eight (8) participants answered never.

#### **Q.5-Ineffective planning and scheduling of project by shipyard**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 7         | 4,7     | 4,7           | 4,7                |
|       | Rarely    | 44        | 29,7    | 29,7          | 34,5               |
|       | Sometimes | 55        | 37,2    | 37,2          | 71,6               |
|       | Often     | 33        | 22,3    | 22,3          | 93,9               |
|       | Always    | 9         | 6,1     | 6,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 30 Q.5-Ineffective planning and scheduling of project by shipyard-Frequency of Occurrence**

Question No 5 was the ineffective planning and scheduling of project by shipyard. For this factor and with reference to frequency of occurrence, there were nine (9) participants who answered always, thirty three (33) participants answered often, fifty five (55) answered sometimes, forty four participants (44) answered rarely and there were seven (7) participants answered never.

#### **6.6.2. Frequency of Occurrence of delay factors related to Owners before awarding point scale**

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the owners, happens. Participants in the survey were asked for seven (7) delay factors and the results are presented below in table 31 to 37.

**Q.6-Late delivery or revising of detailed engineering drawings by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 19        | 12,8    | 12,8          | 12,8               |
|       | Rarely    | 51        | 34,5    | 34,5          | 47,3               |
|       | Sometimes | 51        | 34,5    | 34,5          | 81,8               |
|       | Often     | 24        | 16,2    | 16,2          | 98,0               |
|       | Always    | 3         | 2,0     | 2,0           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 31 Q.6-Late delivery or revising of detailed engineering drawings by owners-Frequency of Occurrence**

Question No 6 was the late delivery or revising of detailed engineering drawings by owners. For this factor and with reference to frequency of occurrence, there were three (3) participants who answered always, twenty four (24) participants answered often, fifty one (51) participants answered sometimes, fifty one (51) participants answered rarely and there were nineteen (19) participants answered never.

**Q.7-Poor quality of documentation provided e.g. outdated docking plan**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 32        | 21,6    | 21,6          | 21,6               |
|       | Rarely    | 62        | 41,9    | 41,9          | 63,5               |
|       | Sometimes | 39        | 26,4    | 26,4          | 89,9               |
|       | Often     | 13        | 8,8     | 8,8           | 98,6               |
|       | Always    | 2         | 1,4     | 1,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 32 Q.7-Poor quality of documentation provided e.g. outdated docking plan-Frequency of Occurrence**

Question No 7 was the poor quality of documentation provided e.g. outdated docking plan. For this factor and with reference to frequency of occurrence, there were two (2) participants who answered always, thirteen (13) participants answered often, thirty nine (39) participants answered sometimes, sixty two (62) participants answered rarely and there were thirty two (32) participants answered never.

**Q.8-Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 5         | 3,4     | 3,4           | 3,4                |
|       | Rarely    | 45        | 30,4    | 30,4          | 33,8               |
|       | Sometimes | 49        | 33,1    | 33,1          | 66,9               |
|       | Often     | 39        | 26,4    | 26,4          | 93,2               |
|       | Always    | 10        | 6,8     | 6,8           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 33 Q.8-Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs-Frequency of Occurrence**

Question No 8 was the incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs. For this factor and with reference to frequency of occurrence, there were ten (10) participants who answered always, thirty nine (39) participants answered often, forty nine (49) participants answered sometimes, forty five (45) participants answered rarely and there were five (5) participants answered never.

**Q.9-Little insight of progress at shipyard by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 20        | 13,5    | 13,5          | 13,5               |
|       | Rarely    | 54        | 36,5    | 36,5          | 50,0               |
|       | Sometimes | 58        | 39,2    | 39,2          | 89,2               |

|  |       |     |       |       |       |
|--|-------|-----|-------|-------|-------|
|  | Often | 16  | 10,8  | 10,8  | 100,0 |
|  | Total | 148 | 100,0 | 100,0 |       |

**Table 34 Q.9-Little insight of progress at shipyard by owners-Frequency of Occurrence**

Question No 9 was the little insight of progress at shipyard by owners. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, sixteen (16) participants answered often, fifty eight (58) participants answered sometimes, fifty four (54) participants answered rarely and there were twenty (20) participants answered never.

#### **Q.10-Delay in progress payment by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 36        | 24,3    | 24,3          | 24,3               |
|       | Rarely    | 58        | 39,2    | 39,2          | 63,5               |
|       | Sometimes | 34        | 23,0    | 23,0          | 86,5               |
|       | Often     | 14        | 9,5     | 9,5           | 95,9               |
|       | Always    | 6         | 4,1     | 4,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 35 Q.10-Delay in progress payment by owners-Frequency of Occurrence**

Question No 10 was the delay in progress payment by owners. For this factor and with reference to frequency of occurrence, there were six (6) participants who answered always, fourteen (14) participants answered often, thirty four (34) participants answered sometimes, fifty eight (58) participants answered rarely and there were thirty six (36) participants answered never.

#### **Q.11-Slowness in decision making process by owners**

|       |       | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-------|-----------|---------|---------------|--------------------|
| Valid | Never | 13        | 8,8     | 8,8           | 8,8                |



|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| Rarely    | 53  | 35,8  | 35,8  | 44,6  |
| Sometimes | 49  | 33,1  | 33,1  | 77,7  |
| Often     | 23  | 15,5  | 15,5  | 93,2  |
| Always    | 10  | 6,8   | 6,8   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 36 Q.11-Slowness in decision making process by owners-Frequency of Occurrence**

Question No 11 was the slowness in decision making process by owners. For this factor and with reference to frequency of occurrence, there were ten (10) participants who answered always, twenty three (23) participants answered often, forty nine (49) participants answered sometimes, fifty three (53) participants answered rarely and there were thirteen (13) participants answered never.

#### **Q.12-Unavailability of incentives for shipyard for finishing ahead of schedule**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 19        | 12,8    | 12,8          | 12,8               |
|       | Rarely    | 64        | 43,2    | 43,2          | 56,1               |
|       | Sometimes | 42        | 28,4    | 28,4          | 84,5               |
|       | Often     | 17        | 11,5    | 11,5          | 95,9               |
|       | Always    | 6         | 4,1     | 4,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 37 Q.12-Unavailability of incentives for shipyard for finishing ahead of schedule-Frequency of Occurrence**

Question No 12 was the unavailability of incentives for shipyard for finishing ahead of schedule. For this factor and with reference to frequency of occurrence, there were six (6) participants who answered always, seventeen (17) participants answered often, forty two (42) participants answered sometimes, sixty four (64) participants answered rarely and there were nineteen (19) participants answered never.

#### **6.6.3. Frequency of Occurrence of delay factors related to Equipment before awarding point scale**

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the equipment, happens. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 38.

#### **Q.13-Inadequate efficiency of equipment**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 8         | 5,4     | 5,4           | 5,4                |
|       | Rarely    | 66        | 44,6    | 44,6          | 50,0               |
|       | Sometimes | 65        | 43,9    | 43,9          | 93,9               |
|       | Often     | 8         | 5,4     | 5,4           | 99,3               |
|       | Always    | 1         | ,7      | ,7            | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 38 Q.13-Inadequate efficiency of equipment-Frequency of Occurrence**

Question No 13 was the inadequate efficiency of equipment. For this factor and with reference to frequency of occurrence, there was one (1) participant who answered always, eight (8) participants answered often, sixty five (65) participants answered sometimes, sixty six (66) participants answered rarely and there were eight (8) participants answered never.

#### **6.6.4. Frequency of Occurrence of delay factors related to materials before awarding point scale**

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the materials, happens. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 39.

#### **Q.14-Delay to supply required materials**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 6         | 4,1     | 4,1           | 4,1                |
|       | Rarely    | 39        | 26,4    | 26,4          | 30,4               |
|       | Sometimes | 57        | 38,5    | 38,5          | 68,9               |
|       | Often     | 39        | 26,4    | 26,4          | 95,3               |
|       | Always    | 7         | 4,7     | 4,7           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 39 Q.14-Delay to supply required materials-Frequency of Occurrence**

Question No 14 was the delay to supply required materials. For this factor and with reference to frequency of occurrence, there were seven (7) participants who answered always, thirty nine (39) participants answered often, fifty seven (57) participants answered sometimes, thirty nine (39) participants answered rarely and there were six (6) participants answered never.

#### **6.6.5. Frequency of Occurrence of delay factors related to external factors before awarding point scale**

From the below questions, we intend to investigate the regularity with which each delay factor, associated with external factors, happens. Participants in the survey were asked for five (5) delay factors and the results are presented below in table 40 to 44.

##### **Q.15-Weather effect on activities (hot, rain, etc.)**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 2         | 1,4     | 1,4           | 1,4                |
|       | Rarely    | 26        | 17,6    | 17,6          | 18,9               |
|       | Sometimes | 57        | 38,5    | 38,5          | 57,4               |
|       | Often     | 57        | 38,5    | 38,5          | 95,9               |

|  |        |     |       |       |       |
|--|--------|-----|-------|-------|-------|
|  | Always | 6   | 4,1   | 4,1   | 100,0 |
|  | Total  | 148 | 100,0 | 100,0 |       |

**Table 40 Q.15-Weather effect on activities (hot, rain, etc.) -Frequency of Occurrence**

Question No 15 was the weather effect on activities (hot, rain, etc.). For this factor and with reference to frequency of occurrence, there were six (6) participants who answered always, fifty seven (57) participants answered often, fifty seven (57) participants answered sometimes, twenty six (26) participants answered rarely and there were two (2) participants answered never.

#### **Q.16-Worker accident during repairs**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 38        | 25,7    | 25,7          | 25,7               |
|       | Rarely    | 79        | 53,4    | 53,4          | 79,1               |
|       | Sometimes | 28        | 18,9    | 18,9          | 98,0               |
|       | Often     | 3         | 2,0     | 2,0           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 41 Q.16-Worker accident during repairs-Frequency of Occurrence**

Question No 16 was the worker accident during repairs. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, three (3) participants answered often, twenty eight (28) participants answered sometimes, seventy nine (79) participants answered rarely and there were thirty eight (38) participants answered never.

#### **Q.17-Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations)**

|       |        | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|--------|-----------|---------|---------------|--------------------|
| Valid | Never  | 10        | 6,8     | 6,8           | 6,8                |
|       | Rarely | 38        | 25,7    | 25,7          | 32,4               |

|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| Sometimes | 45  | 30,4  | 30,4  | 62,8  |
| Often     | 47  | 31,8  | 31,8  | 94,6  |
| Always    | 8   | 5,4   | 5,4   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 42 Q.17-Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) -Frequency of Occurrence**

Question No 17 was the Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations). For this factor and with reference to frequency of occurrence, there were eight (8) participants who answered always, forty seven (47) participants answered often, forty five (45) participants answered sometimes, thirty eight (38) participants answered rarely and there were ten (10) participants answered never.

#### **Q.18-Delay in performing final inspection and certification by a third party**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 23        | 15,5    | 15,5          | 15,5               |
|       | Rarely    | 75        | 50,7    | 50,7          | 66,2               |
|       | Sometimes | 44        | 29,7    | 29,7          | 95,9               |
|       | Often     | 6         | 4,1     | 4,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 43 Q.18-Delay in performing final inspection and certification by a third party-Frequency of Occurrence**

Question No 18 was the delay in performing final inspection and certification by a third party. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, six (6) participants answered often, forty four (44) participants answered sometimes, seventy five (75) participants answered rarely and there were twenty three (23) participants answered never.

#### **Q.19-Changes in government regulations and laws**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 49        | 33,1    | 33,1          | 33,1               |
|       | Rarely    | 71        | 48,0    | 48,0          | 81,1               |
|       | Sometimes | 18        | 12,2    | 12,2          | 93,2               |
|       | Often     | 10        | 6,8     | 6,8           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 44 Q.19-Changes in government regulations and laws-Frequency of Occurrence**

Question No 19 was the changes in government regulations and laws. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, ten (10) participants answered often, eighteen (18) participants answered sometimes, seventy one (71) participants answered rarely and there were forty nine (49) participants answered never.

**Q.20-Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 11        | 7,4     | 7,4           | 7,4                |
|       | Rarely    | 35        | 23,6    | 23,6          | 31,1               |
|       | Sometimes | 50        | 33,8    | 33,8          | 64,9               |
|       | Often     | 44        | 29,7    | 29,7          | 94,6               |
|       | Always    | 8         | 5,4     | 5,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 45 Q.20-Installation of innovative/sophisticated systems (BWTS, Scrubber etc.) -Frequency of Occurrence**

Question No 20 was the installation of innovative/sophisticated systems (BWTS, Scrubber etc. For this factor and with reference to frequency of occurrence, there were eight (8) participants who answered always, forty four (44) participants answered often, fifty (50) participants answered sometimes, thirty five (35) participants answered rarely and there were eleven (11) participants answered never.

### 6.6.6. Frequency of Occurrence of delay factors related to project before awarding point scale

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the project, happens. Participants in the survey were asked for three (3) delay factors and the results are presented below in table 46 to 48.

#### Q.21-Original contract duration is too short

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 11        | 7,4     | 7,4           | 7,4                |
|       | Rarely    | 35        | 23,6    | 23,6          | 31,1               |
|       | Sometimes | 51        | 34,5    | 34,5          | 65,5               |
|       | Often     | 43        | 29,1    | 29,1          | 94,6               |
|       | Always    | 8         | 5,4     | 5,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 46 Q.21-Original contract duration is too short-Frequency of Occurrence**

Question No 21 was the original contract duration is too short. For this factor and with reference to frequency of occurrence, there were eight (8) participants who answered always, forty three (43) participants answered often, fifty one (51) participants answered sometimes, thirty five (35) participants answered rarely and there were eleven (11) participants answered never.

#### Q.22-Ineffective delay penalties

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|--|--|-----------|---------|---------------|--------------------|
|  |  |           |         |               |                    |

|       |           |     |       |       |       |
|-------|-----------|-----|-------|-------|-------|
| Valid | Never     | 21  | 14,2  | 14,2  | 14,2  |
|       | Rarely    | 59  | 39,9  | 39,9  | 54,1  |
|       | Sometimes | 44  | 29,7  | 29,7  | 83,8  |
|       | Often     | 21  | 14,2  | 14,2  | 98,0  |
|       | Always    | 3   | 2,0   | 2,0   | 100,0 |
|       | Total     | 148 | 100,0 | 100,0 |       |

**Table 47 Q.22-Ineffective delay penalties-Frequency of Occurrence**

Question No 22 was the ineffective delay penalties. For this factor and with reference to frequency of occurrence, there were three (3) participants who answered always, twenty one (21) participants answered often, forty four (44) participants answered sometimes, fifty nine (59) participants answered rarely and there were twenty one (21) participants answered never.

### **Q.23-Legal disputes between various parts**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 28        | 18,9    | 18,9          | 18,9               |
|       | Rarely    | 71        | 48,0    | 48,0          | 66,9               |
|       | Sometimes | 45        | 30,4    | 30,4          | 97,3               |
|       | Often     | 3         | 2,0     | 2,0           | 99,3               |
|       | Always    | 1         | ,7      | ,7            | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 48 Q.23-Legal disputes between various parts-Frequency of Occurrence**

Question No 23 was the legal disputes between various parts. For this factor and with reference to frequency of occurrence, there was one (1) participant who answered always, three (3) participants answered often, forty five (45) participants answered sometimes, seventy one (71) participants answered rarely and there were twenty eight (28) participants answered never.



### 6.6.7. Frequency of Occurrence of delay factors related to labor before awarding point scale

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the labor, happens. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 49.

#### Q.24-Inadequate efficiency of workforce

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 7         | 4,7     | 4,7           | 4,7                |
|       | Rarely    | 33        | 22,3    | 22,3          | 27,0               |
|       | Sometimes | 64        | 43,2    | 43,2          | 70,3               |
|       | Often     | 38        | 25,7    | 25,7          | 95,9               |
|       | Always    | 6         | 4,1     | 4,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

Table 49 Q.24-Inadequate efficiency of workforce-Frequency of Occurrence

Question No 24 was the inadequate efficiency of workforce. For this factor and with reference to frequency of occurrence, there were six (6) participants who answered always, thirty eight (38) participants answered often, sixty four (64) participants answered sometimes, thirty three (33) participants answered rarely and there were seven (7) participants answered never.

### 6.6.8. Frequency of Occurrence of delay factors related to consultant before awarding point scale

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the consultant, happens. Participants in the survey were asked for two (2) delay factors and the results are presented below in table 50 and 51.

**Q.25-Delay in performing inspection and testing by Classification Society**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 30        | 20,3    | 20,3          | 20,3               |
|       | Rarely    | 80        | 54,1    | 54,1          | 74,3               |
|       | Sometimes | 30        | 20,3    | 20,3          | 94,6               |
|       | Often     | 8         | 5,4     | 5,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 50 Q.25-Delay in performing inspection and testing by Classification Society-Frequency of Occurrence**

Question No 25 was the delay in performing inspection and testing by Classification Society. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, eight (8) participants answered often, thirty (30) participants answered sometimes, eighty (80) participants answered rarely and there were thirty (30) participants answered never.

**Q.26-Late in reviewing and approving design documents by Classification Society**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 27        | 18,2    | 18,2          | 18,2               |
|       | Rarely    | 55        | 37,2    | 37,2          | 55,4               |
|       | Sometimes | 54        | 36,5    | 36,5          | 91,9               |
|       | Often     | 12        | 8,1     | 8,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 51 Q.26-Late in reviewing and approving design documents by Classification Society-Frequency of Occurrence**

Question No 26 was the late in reviewing and approving design documents by Classification Society. For this factor and with reference to frequency of occurrence, there were zero (0) participants who answered always, twelve (12) participants answered often,

fifty five (54) participants answered sometimes, fifty five (55) participants answered rarely and there were twenty seven (27) participants answered never.

### **6.6.9. Frequency of Occurrence of delay factors related to design before awarding point scale**

From the below questions, we intend to investigate the regularity with which each delay factor, associated with the design, happens. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 52.

#### **Q.27-Mistakes and discrepancies in design documents and associated difficulty in production.**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Never     | 20        | 13,5    | 13,5          | 13,5               |
|       | Rarely    | 51        | 34,5    | 34,5          | 48,0               |
|       | Sometimes | 53        | 35,8    | 35,8          | 83,8               |
|       | Often     | 19        | 12,8    | 12,8          | 96,6               |
|       | Always    | 5         | 3,4     | 3,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 52 Q.27-Mistakes and discrepancies in design documents and associated difficulty in production-Frequency of Occurrence**

Question No 27 was the mistakes and discrepancies in design documents and associated difficulty in production. For this factor and with reference to frequency of occurrence, there were five (5) participants who answered always, nineteen (19) participants answered often, fifty three (53) participants answered sometimes, fifty one (51) participants answered rarely and there were twenty (20) participants answered never.

### **6.6.10. Impact on Project of delay factors related to Contractors before awarding point scale**

By replying to the questions below, we intend to investigate the impact on activities for each delay factor related to Contractors. Participants in the survey were asked for five (5) delay factors and the results are presented below in table 53 to 57.

#### **Q.1-Use external sub-contractors during work at a yard**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 13        | 8,8     | 8,8           | 8,8                |
|       | Low       | 39        | 26,4    | 26,4          | 35,1               |
|       | Medium    | 62        | 41,9    | 41,9          | 77,0               |
|       | High      | 28        | 18,9    | 18,9          | 95,9               |
|       | Very High | 6         | 4,1     | 4,1           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 53 Q.1-Use external sub-contractors during work at a yard-Impact on Project**

Question No 1 was the use external sub-contractors during work at a yard. For this factor and with reference to the impact on project, there were six (6) participants who answered very high, twenty eight (28) participants answered high, sixty two (62) participants answered medium, thirty nine (39) participants answered low and there were thirteen (13) participants answered very low.

#### **Q.2-Poor site management and supervision by shipyard**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 7         | 4,7     | 4,7           | 4,7                |
|       | Low       | 22        | 14,9    | 14,9          | 19,6               |
|       | Medium    | 37        | 25,0    | 25,0          | 44,6               |
|       | High      | 55        | 37,2    | 37,2          | 81,8               |
|       | Very High | 27        | 18,2    | 18,2          | 100,0              |

|       |     |       |       |  |
|-------|-----|-------|-------|--|
| Total | 148 | 100,0 | 100,0 |  |
|-------|-----|-------|-------|--|

**Table 54 Q.2-Poor site management and supervision by shipyard-Impact on Project**

Question No 2 was the poor site management and supervision by shipyard. For this factor and with reference to the impact on project, there were twenty seven (27) participants who answered very high, fifty five (55) participants answered high, thirty seven (37) participants answered medium, twenty two (22) participants answered low and there were seven (7) participants answered very low.

### **Q.3-High number of quality defects by shipyard that require re-work**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 9         | 6,1     | 6,1           | 6,1                |
|       | Low       | 26        | 17,6    | 17,6          | 23,6               |
|       | Medium    | 46        | 31,1    | 31,1          | 54,7               |
|       | High      | 50        | 33,8    | 33,8          | 88,5               |
|       | Very High | 17        | 11,5    | 11,5          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 55 Q.3-High number of quality defects by shipyard that require re-work-Impact on Project**

Question No 3 was the high number of quality defects by shipyard that require re-work. For this factor and with reference to the impact on project, there were seventeen (17) participants who answered very high, fifty (50) participants answered high, forty six (46) participants answered medium, twenty six (26) participants answered low and there were nine (9) participants answered very low.

### **Q.4-Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal)**

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|--|--|-----------|---------|---------------|--------------------|
|--|--|-----------|---------|---------------|--------------------|

|       |           |     |       |       |       |
|-------|-----------|-----|-------|-------|-------|
| Valid | Very Low  | 8   | 5,4   | 5,4   | 5,4   |
|       | Low       | 35  | 23,6  | 23,6  | 29,1  |
|       | Medium    | 43  | 29,1  | 29,1  | 58,1  |
|       | High      | 46  | 31,1  | 31,1  | 89,2  |
|       | Very High | 16  | 10,8  | 10,8  | 100,0 |
|       | Total     | 148 | 100,0 | 100,0 |       |

**Table 56 Q.4-Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) -Impact on Project**

Question No 4 was the co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal). For this factor and with reference to the impact on project, there were sixteen (16) participants who answered very high, forty six (46) participants answered high, forty three (43) participants answered medium, thirty five (35) participants answered low and there were eight (8) participants answered very low.

#### **Q.5-Ineffective planning and scheduling of project by shipyard**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 10        | 6,8     | 6,8           | 6,8                |
|       | Low       | 26        | 17,6    | 17,6          | 24,3               |
|       | Medium    | 35        | 23,6    | 23,6          | 48,0               |
|       | High      | 50        | 33,8    | 33,8          | 81,8               |
|       | Very High | 27        | 18,2    | 18,2          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 57 Q.5-Ineffective planning and scheduling of project by shipyard-Impact on Project**

Question No 5 was the ineffective planning and scheduling of project by shipyard. For this factor and with reference to the impact on project, there were twenty seven (27) participants who answered very high, fifty (50) participants answered high, thirty five (35)

participants answered medium, twenty six (26) participants answered low and there were ten (10) participants answered very low.

#### **6.6.11. Impact on Project of delay factors related to Owners before awarding point scale**

By replying to the questions below, we intend to investigate the impact on activities for each delay factor related to Owners. Participants in the survey were asked for seven (7) delay factors and the results are presented below in table 58 to 64.

##### **Q.6-Late delivery or revising of detailed engineering drawings by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 15        | 10,1    | 10,1          | 10,1               |
|       | Low       | 31        | 20,9    | 20,9          | 31,1               |
|       | Medium    | 39        | 26,4    | 26,4          | 57,4               |
|       | High      | 47        | 31,8    | 31,8          | 89,2               |
|       | Very High | 16        | 10,8    | 10,8          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 58 Q.6-Late delivery or revising of detailed engineering drawings by owners-Impact on Project**

Question No 6 was the late delivery or revising of detailed engineering drawings by owners. For this factor and with reference to the impact on project, there were sixteen (16) participants who answered very high, forty seven (47) participants answered high, thirty nine (39) participants answered medium, thirty one (31) participants answered low and there were fifteen (15) participants answered very low.

##### **Q.7-Poor quality of documentation provided e.g. outdated docking plan**

|       |           | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|-------|-----------|-----------|---------|---------------|-----------------------|
| Valid | Very Low  | 21        | 14,2    | 14,2          | 14,2                  |
|       | Low       | 33        | 22,3    | 22,3          | 36,5                  |
|       | Medium    | 52        | 35,1    | 35,1          | 71,6                  |
|       | High      | 32        | 21,6    | 21,6          | 93,2                  |
|       | Very High | 10        | 6,8     | 6,8           | 100,0                 |
|       | Total     | 148       | 100,0   | 100,0         |                       |

**Table 59 Q.7-Poor quality of documentation provided e.g. outdated docking plan-Impact on Project**

Question No 7 was the poor quality of documentation provided e.g. outdated docking plan. For this factor and with reference to the impact on project, there were ten (10) participants who answered very high, thirty two (32) participants answered high, fifty two (52) participants answered medium, thirty three (33) participants answered low and there were twenty one (21) participants answered very low.

**Q.8-Incomplete scope of work/ work done list shared by the  
owners/managers – change orders during repairs**

|       |           | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|-------|-----------|-----------|---------|---------------|-----------------------|
| Valid | Very Low  | 9         | 6,1     | 6,1           | 6,1                   |
|       | Low       | 23        | 15,5    | 15,5          | 21,6                  |
|       | Medium    | 41        | 27,7    | 27,7          | 49,3                  |
|       | High      | 48        | 32,4    | 32,4          | 81,8                  |
|       | Very High | 27        | 18,2    | 18,2          | 100,0                 |
|       | Total     | 148       | 100,0   | 100,0         |                       |

**Table 60 Q.8-Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs-Impact on Project**

Question No 8 was the incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs. For this factor and with reference to the impact on project, there were twenty seven (27) participants who answered very high, forty eight (48) participants answered high, forty one (41) participants answered medium,



twenty three (23) participants answered low and there were nine (9) participants answered very low.

#### **Q.9-Little insight of progress at shipyard by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 15        | 10,1    | 10,1          | 10,1               |
|       | Low       | 39        | 26,4    | 26,4          | 36,5               |
|       | Medium    | 47        | 31,8    | 31,8          | 68,2               |
|       | High      | 36        | 24,3    | 24,3          | 92,6               |
|       | Very High | 11        | 7,4     | 7,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 61 Q.9-Little insight of progress at shipyard by owners-Impact on Project**

Question No 9 was the little insight of progress at shipyard by owners. For this factor and with reference to the impact on project, there were eleven (11) participants who answered very high, thirty six (36) participants answered high, forty seven (47) participants answered medium, thirty nine (39) participants answered low and there were fifteen (15) participants answered very low.

#### **Q.10-Delay in progress payment by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 26        | 17,6    | 17,6          | 17,6               |
|       | Low       | 43        | 29,1    | 29,1          | 46,6               |
|       | Medium    | 44        | 29,7    | 29,7          | 76,4               |
|       | High      | 17        | 11,5    | 11,5          | 87,8               |
|       | Very High | 18        | 12,2    | 12,2          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 62 Q.10-Delay in progress payment by owners-Impact on Project**

Question No 10 was the delay in progress payment by owners. For this factor and with reference to the impact on project, there were eighteen (18) participants who answered very high, seventeen (17) participants answered high, forty four (44) participants answered medium, forty three (43) participants answered low and there were twenty six (26) participants answered very low.

#### **Q.11-Slowness in decision making process by owners**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 11        | 7,4     | 7,4           | 7,4                |
|       | Low       | 29        | 19,6    | 19,6          | 27,0               |
|       | Medium    | 39        | 26,4    | 26,4          | 53,4               |
|       | High      | 39        | 26,4    | 26,4          | 79,7               |
|       | Very High | 30        | 20,3    | 20,3          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 63 Q.11-Slowness in decision making process by owners-Impact on Project**

Question No 11 was the slowness in decision making process by owners. For this factor and with reference to the impact on project, there were thirty (30) participants who answered very high, thirty nine (39) participants answered high, thirty nine (39) participants answered medium, twenty nine (29) participants answered low and there were eleven (11) participants answered very low.

#### **Q.12-Unavailability of incentives for shipyard for finishing ahead of schedule**

|       |          | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|----------|-----------|---------|---------------|--------------------|
| Valid | Very Low | 19        | 12,8    | 12,8          | 12,8               |
|       | Low      | 50        | 33,8    | 33,8          | 46,6               |
|       | Medium   | 42        | 28,4    | 28,4          | 75,0               |

|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| High      | 25  | 16,9  | 16,9  | 91,9  |
| Very High | 12  | 8,1   | 8,1   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 64 Q.12-Unavailability of incentives for shipyard for finishing ahead of schedule-Impact on Project**

Question No 12 was the unavailability of incentives for shipyard for finishing ahead of schedule. For this factor and with reference to the impact on project, there were twelve (12) participants who answered very high, twenty five (25) participants answered high, forty two (42) participants answered medium, fifty (50) participants answered low and there were nineteen (19) participants answered very low.

#### **6.6.12. Impact on Project of delay factors related to Equipment before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to Equipment. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 65.

#### **Q.13-Inadequate efficiency of equipment**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 11        | 7,4     | 7,4           | 7,4                |
|       | Low       | 30        | 20,3    | 20,3          | 27,7               |
|       | Medium    | 45        | 30,4    | 30,4          | 58,1               |
|       | High      | 46        | 31,1    | 31,1          | 89,2               |
|       | Very High | 16        | 10,8    | 10,8          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 65 Q.13-Inadequate efficiency of equipment-Impact on Project**

Question No 13 was the inadequate efficiency of equipment. For this factor and with reference to the impact on project, there were sixteen (16) participants who answered very

high, forty six (46) participants answered high, forty five (45) participants answered medium, thirty (30) participants answered low and there were eleven (11) participants answered very low.

### **6.6.13. Impact on Project of delay factors related to Materials before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to Materials. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 67.

#### **Q.14-Delay to supply required materials**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 9         | 6,1     | 6,1           | 6,1                |
|       | Low       | 19        | 12,8    | 12,8          | 18,9               |
|       | Medium    | 34        | 23,0    | 23,0          | 41,9               |
|       | High      | 48        | 32,4    | 32,4          | 74,3               |
|       | Very High | 38        | 25,7    | 25,7          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 66 Q.14-Delay to supply required materials-Impact on Project**

Question No 14 was the delay to supply required materials. For this factor and with reference to the impact on project, there were thirty eight (38) participants who answered very high, forty eight (48) participants answered high, thirty four (34) participants answered medium, nineteen (19) participants answered low and there were nine (9) participants answered very low.

### **6.6.14. Impact on Project of delay factors related to External factors before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to External factors. Participants in the survey were asked for five (5) delay factors and the results are presented below in table 67 to 72.

#### **Q.15-Weather effect on activities (hot, rain, etc.)**

|       |           | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|-------|-----------|-----------|---------|---------------|-----------------------|
| Valid | Very Low  | 7         | 4,7     | 4,7           | 4,7                   |
|       | Low       | 23        | 15,5    | 15,5          | 20,3                  |
|       | Medium    | 49        | 33,1    | 33,1          | 53,4                  |
|       | High      | 40        | 27,0    | 27,0          | 80,4                  |
|       | Very High | 29        | 19,6    | 19,6          | 100,0                 |
|       | Total     | 148       | 100,0   | 100,0         |                       |

**Table 67 Q.15-Weather effect on activities (hot, rain, etc.) -Impact on Project**

Question No 15 was the weather effect on activities (hot, rain, etc.). For this factor and with reference to the impact on project, there were twenty nine (29) participants who answered very high, forty (40) participants answered high, forty nine (49) participants answered medium, twenty three (23) participants answered low and there were seven (7) participants answered very low.

#### **Q.16-Worker accident during repairs**

|       |           | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|-------|-----------|-----------|---------|---------------|-----------------------|
| Valid | Very Low  | 30        | 20,3    | 20,3          | 20,3                  |
|       | Low       | 42        | 28,4    | 28,4          | 48,6                  |
|       | Medium    | 39        | 26,4    | 26,4          | 75,0                  |
|       | High      | 18        | 12,2    | 12,2          | 87,2                  |
|       | Very High | 19        | 12,8    | 12,8          | 100,0                 |
|       | Total     | 148       | 100,0   | 100,0         |                       |

**Table 68 Q.16-Worker accident during repairs-Impact on Project**

Question No 16 was the worker accident during repairs. For this factor and with reference to the impact on project, there were nineteen (19) participants who answered very high, eighteen (18) participants answered high, thirty nine (39) participants answered medium, forty two (42) participants answered low and there were thirty (30) participants answered very low.

**Q.17-Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations)**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 7         | 4,7     | 4,7           | 4,7                |
|       | Low       | 29        | 19,6    | 19,6          | 24,3               |
|       | Medium    | 44        | 29,7    | 29,7          | 54,1               |
|       | High      | 41        | 27,7    | 27,7          | 81,8               |
|       | Very High | 27        | 18,2    | 18,2          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 69 Q.17-Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) -Impact on Project**

Question No 17 was the Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations). For this factor and with reference to the impact on project, there were twenty seven (27) participants who answered very high, forty one (41) participants answered high, forty four (44) participants answered medium, twenty nine (29) participants answered low and there were seven (7) participants answered very low.

**Q.18-Delay in performing final inspection and certification by a third party**

|       |          | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|----------|-----------|---------|---------------|--------------------|
| Valid | Very Low | 16        | 10,8    | 10,8          | 10,8               |
|       | Low      | 40        | 27,0    | 27,0          | 37,8               |

|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| Medium    | 52  | 35,1  | 35,1  | 73,0  |
| High      | 28  | 18,9  | 18,9  | 91,9  |
| Very High | 12  | 8,1   | 8,1   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 70 Q.18-Delay in performing final inspection and certification by a third party-Impact on Project**

Question No 18 was the delay in performing final inspection and certification by a third party. For this factor and with reference to the impact on project, there were twelve (12) participants who answered very high, twenty eight (28) participants answered high, fifty two (52) participants answered medium, forty (40) participants answered low and there were sixteen (16) participants answered very low.

#### **Q.19-Changes in government regulations and laws**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 33        | 22,3    | 22,3          | 22,3               |
|       | Low       | 54        | 36,5    | 36,5          | 58,8               |
|       | Medium    | 25        | 16,9    | 16,9          | 75,7               |
|       | High      | 23        | 15,5    | 15,5          | 91,2               |
|       | Very High | 13        | 8,8     | 8,8           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 71 Q.19-Changes in government regulations and laws-Impact on Project**

Question No 19 was the changes in government regulations and laws. For this factor and with reference to the impact on project, there were thirteen (13) participants who answered very high, twenty three (23) participants answered high, twenty five (25) participants answered medium, fifty four (54) participants answered low and there were thirty three (33) participants answered very low.

**Q.20-Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 7         | 4,7     | 4,7           | 4,7                |
|       | Low       | 37        | 25,0    | 25,0          | 29,7               |
|       | Medium    | 35        | 23,6    | 23,6          | 53,4               |
|       | High      | 41        | 27,7    | 27,7          | 81,1               |
|       | Very High | 28        | 18,9    | 18,9          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 72 Q.20-Installation of innovative/sophisticated systems (BWTS, Scrubber etc.) -Impact on Project**

Question No 20 was the installation of innovative/sophisticated systems (BWTS, Scrubber etc.). For this factor and with reference to the impact on project, there were twenty eight (28) participants who answered very high, forty one (41) participants answered high, thirty five (35) participants answered medium, thirty seven (37) participants answered low and there were seven (7) participants answered very low.

**6.6.15. Impact on Project of delay factors related to Project before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to the project. Participants in the survey were asked for three (3) delay factors and the results are presented below in table 73 to 76.

**Q.21-Original contract duration is too short**

|       |          | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|----------|-----------|---------|---------------|--------------------|
| Valid | Very Low | 8         | 5,4     | 5,4           | 5,4                |
|       | Low      | 31        | 20,9    | 20,9          | 26,4               |
|       | Medium   | 57        | 38,5    | 38,5          | 64,9               |



|           |     |       |       |       |
|-----------|-----|-------|-------|-------|
| High      | 39  | 26,4  | 26,4  | 91,2  |
| Very High | 13  | 8,8   | 8,8   | 100,0 |
| Total     | 148 | 100,0 | 100,0 |       |

**Table 73 Q.21-Original contract duration is too short-Impact on Project**

Question No 21 was the original contract duration is too short. For this factor and with reference to the impact on project, there were thirteen (13) participants who answered very high, thirty nine (39) participants answered high, fifty seven (57) participants answered medium, thirty one (31) participants answered low and there were eight (8) participants answered very low.

### **Q.22-Ineffective delay penalties**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 18        | 12,2    | 12,2          | 12,2               |
|       | Low       | 59        | 39,9    | 39,9          | 52,0               |
|       | Medium    | 41        | 27,7    | 27,7          | 79,7               |
|       | High      | 25        | 16,9    | 16,9          | 96,6               |
|       | Very High | 5         | 3,4     | 3,4           | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 74 Q.22-Ineffective delay penalties-Impact on Project**

Question No 22 was the ineffective delay penalties. For this factor and with reference to the impact on project, there were five (5) participants who answered very high, twenty five (25) participants answered high, forty one (41) participants answered medium, fifty nine (59) participants answered low and there were eighteen (18) participants answered very low.

### **Q.23-Legal disputes between various parts**

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|--|--|-----------|---------|---------------|--------------------|
|--|--|-----------|---------|---------------|--------------------|

|       |           |     |       |       |       |
|-------|-----------|-----|-------|-------|-------|
| Valid | Very Low  | 19  | 12,8  | 12,8  | 12,8  |
|       | Low       | 49  | 33,1  | 33,1  | 45,9  |
|       | Medium    | 42  | 28,4  | 28,4  | 74,3  |
|       | High      | 28  | 18,9  | 18,9  | 93,2  |
|       | Very High | 10  | 6,8   | 6,8   | 100,0 |
|       | Total     | 148 | 100,0 | 100,0 |       |

**Table 75 Q.23-Legal disputes between various parts-Impact on Project**

Question No 23 was the legal disputes between various parts. For this factor and with reference to the impact on project, there were ten (10) participants who answered very high, twenty eight (28) participants answered high, forty two (42) participants answered medium, fifty nine (59) participants answered low and there were nineteen (19) participants answered very low.

#### **6.6.16. Impact on Project of delay factors related to Labors before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to Labors. Participants in the survey were asked for one (1) delay factor and the results are presented below in table 76.

#### **Q.24-Inadequate efficiency of workforce**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 7         | 4,7     | 4,7           | 4,7                |
|       | Low       | 25        | 16,9    | 16,9          | 21,6               |
|       | Medium    | 38        | 25,7    | 25,7          | 47,3               |
|       | High      | 47        | 31,8    | 31,8          | 79,1               |
|       | Very High | 31        | 20,9    | 20,9          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 76 Q.24- Inadequate efficiency of workforce -Impact on Project**

Question No 24 was the inadequate efficiency of workforce. For this factor and with reference to the impact on project, there were thirty one (31) participants who answered very high, forty seven (47) participants answered high, thirty eight (38) participants answered medium, twenty five (25) participants answered low and there were seven (7) participants answered very low.

#### **6.6.17. Impact on Project of delay factors related to Consultant before awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to Consultant. Participants in the survey were asked for two (2) delay factors and the results are presented below in table 77 and 78.

#### **Q.25-Delay in performing inspection and testing by Classification Society**

|       |           | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------|-----------|-----------|---------|---------------|--------------------|
| Valid | Very Low  | 19        | 12,8    | 12,8          | 12,8               |
|       | Low       | 38        | 25,7    | 25,7          | 38,5               |
|       | Medium    | 46        | 31,1    | 31,1          | 69,6               |
|       | High      | 29        | 19,6    | 19,6          | 89,2               |
|       | Very High | 16        | 10,8    | 10,8          | 100,0              |
|       | Total     | 148       | 100,0   | 100,0         |                    |

**Table 77 Q.25-Delay in performing inspection and testing by Classification Society-Impact on Project**

Question No 25 was the delay in performing inspection and testing by Classification Society. For this factor and with reference to the impact on project, there were sixteen (16) participants who answered very high, twenty nine (29) participants answered high, forty six (46) participants answered medium, thirty eight (38) participants answered low and there were nineteen (19) participants answered very low.

**Q.26-Late in reviewing and approving design documents by  
Classification Society**

|       |           | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|-------|-----------|-----------|---------|---------------|-----------------------|
| Valid | Very Low  | 18        | 12,2    | 12,2          | 12,2                  |
|       | Low       | 35        | 23,6    | 23,6          | 35,8                  |
|       | Medium    | 41        | 27,7    | 27,7          | 63,5                  |
|       | High      | 37        | 25,0    | 25,0          | 88,5                  |
|       | Very High | 17        | 11,5    | 11,5          | 100,0                 |
|       | Total     | 148       | 100,0   | 100,0         |                       |

**Table 78 Q.26-Late in reviewing and approving design documents by Classification Society-Impact on  
Project**

Question No 26 was the late in reviewing and approving design documents by Classification Society. For this factor and with reference to the impact on project, there were seventeen (17) participants who answered very high, thirty seven (37) participants answered high, forty one (41) participants answered medium, thirty five (35) participants answered low and there were eighteen (18) participants answered very low.

**6.6.18. Impact on Project of delay factors related to Design before  
awarding point scale**

By replying to the question below, we intend to investigate the impact on activities for each delay factor related to Design. Participants in the survey were asked for one (1) delay factors and the results are presented below in table 79.

**Q.27-Mistakes and discrepancies in design documents and  
associated difficulty in production**

|  | Frequency | Percent | Valid Percent | Cumulative<br>Percent |
|--|-----------|---------|---------------|-----------------------|
|--|-----------|---------|---------------|-----------------------|

|       |           |     |       |       |       |
|-------|-----------|-----|-------|-------|-------|
| Valid | Very Low  | 11  | 7,4   | 7,4   | 7,4   |
|       | Low       | 23  | 15,5  | 15,5  | 23,0  |
|       | Medium    | 45  | 30,4  | 30,4  | 53,4  |
|       | High      | 47  | 31,8  | 31,8  | 85,1  |
|       | Very High | 22  | 14,9  | 14,9  | 100,0 |
|       | Total     | 148 | 100,0 | 100,0 |       |

**Table 79 Q.27-Mistakes and discrepancies in design documents and associated difficulty in production-Impact on Project**

Question No 27 was the mistakes and discrepancies in design documents and associated difficulty in production. For this factor and with reference to the impact on project, there were twenty two (22) participants who answered very high, forty seven (47) participants answered high, forty five (45) participants answered medium, twenty three (23) participants answered low and there were eleven (11) participants answered very low.

### **6.7. Results of delay factors with reference to Frequency Index (F.I.) after awarding point scale.**

The results of delay factors for all groups according to Frequency Index (F.I.) are presented in the below table 80. The participants considered that related to Group No 1 – Contractors, the “Poor site Management and supervision by shipyard” is the factor which frequently occurs in the project. With reference to Group No 2 – Owners, the “Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs” has the higher possibility to occur. For Group No 5 – External Factors, the “Weather effect on activities (hot, rain, etc.)” has high possibility to happen. For Group No 6 – Project, participants answered that the “Original contract duration is too short” has been frequently faced in the projects whereas for the rest groups, the “Inadequate efficiency of workforce” of Group No 7 – Labors has the higher possibility to occur.

| <b><u>Question Number</u></b> | <b><u>Factors</u></b> | <b><u>Related Group</u></b> | <b><u>Frequency Index (%)</u></b> | <b><u>Rank</u></b> |
|-------------------------------|-----------------------|-----------------------------|-----------------------------------|--------------------|
| <b>Group No 1.</b>            |                       |                             |                                   |                    |
| Q.1                           | Use external sub -    | Contractors                 | 57.30                             | 10                 |

|             |   |             |       |    |
|-------------|---|-------------|-------|----|
|             | contractors during work at a yard   |             |       |    |
| Q.2         | Poor site management and supervision by shipyard  | Contractors | 61.35 | 2  |
| Q.3         | High number of quality defects by shipyard that require re-work   | Contractors | 53.92 | 13 |
| Q.4         | Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | Contractors | 56.08 | 11 |
| Q.5         | Ineffective planning and scheduling of project by shipyard  | Contractors | 59.05 | 9  |
| Group No 2. |   |             |       |    |
| Q.6         | Late delivery or revising of detailed engineering drawings by owners  | Owners      | 52.03 | 14 |
| Q.7         | Poor quality of documentation provided e.g. outdated docking plan   | Owners      | 45.27 | 22 |
| Q.8         | Incomplete scope of work/ work done list shared by the  | Owners      | 60.54 | 4  |

|             |   |                  |       |    |
|-------------|---|------------------|-------|----|
|             | owners/managers – change orders during repairs  |                  |       |    |
| Q.9         | Little insight of progress at shipyard by owners  | Owners           | 49.46 | 19 |
| Q.10        | Delay in progress payment by owners   | Owners           | 45.95 | 21 |
| Q.11        | Slowness in decision making process by owners   | Owners           | 55.14 | 12 |
| Q.12        | Unavailability of incentives for shipyard for finishing ahead of schedule                                       | Owners           | 50.14 | 17 |
| Group No 3. |   |                  |       |    |
| Q.13        | Inadequate efficiency of equipment  | Equipment        | 50.27 | 16 |
| Group No 4. |   |                  |       |    |
| Q.14        | Delay to supply required materials  | Materials        | 60.27 | 7  |
| Group No 5. |   |                  |       |    |
| Q.15        | Weather effect on activities (hot, rain, etc.)  | External Factors | 65.27 | 1  |
| Q.16        | Worker accident during repairs  | External Factors | 39.46 | 26 |
| Q.17        | Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport | External Factors | 60.68 | 3  |

|             |  |                  |       |    |
|-------------|--|------------------|-------|----|
|             | limitations)   |                  |       |    |
| Q.18        | Delay in performing final inspection and certification by a third party    | External Factors | 44.46 | 23 |
| Q.19        | Changes in government regulations and laws                                 | External Factors | 38.51 | 27 |
| Q.20        | Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)     | External Factors | 60.41 | 5  |
| Group No 6. |  |                  |       |    |
| Q.21        | Original contract duration is too short                                    | Project          | 60.27 | 7  |
| Q.22        | Ineffective delay penalties  | Project          | 50.00 | 18 |
| Q.23        | Legal disputes between various parts                                       | Project          | 43.51 | 24 |
| Group No 7. |  |                  |       |    |
| Q.24        | Inadequate efficiency of workforce   | Labors           | 60.41 | 5  |
| Group No 8. |  |                  |       |    |
| Q.25        | Delay in performing inspection and testing by Classification Society       | Consultant       | 42.16 | 25 |
| Q.26        | Late in reviewing and approving design documents by Classification Society | Consultant       | 46.89 | 20 |
| Group No 9. |  |                  |       |    |
| Q.27        | Mistakes and discrepancies in design                                       | Design           | 51.62 | 15 |



|  |  |  |  |  |
|--|--|--|--|--|
|  | documents and associated difficulty in production. |  |  |  |
|--|--|--|--|--|

**Table 80 Results of delay factors with reference to Frequency Index (F.I.)**

### **6.8. Ranking of delay factors with reference to Frequency Index (F.I.) after awarding point scale.**

The ranking of delay factors for all groups according to Frequency Index (F.I.) are listed in the below table 81.

| <b><u>Factors</u></b>  | <b><u>Related Group</u></b> | <b><u>Question Number</u></b> | <b><u>Frequency Index (%)</u></b> | <b><u>Rank</u></b> |
|--|-----------------------------|-------------------------------|-----------------------------------|--------------------|
| Weather effect on activities (hot, rain, etc.)   | External Factors            | Q.15                          | 65.27                             | 1                  |
| Poor site management and supervision by shipyard   | Contractors                 | Q.2                           | 61.35                             | 2                  |
| Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | External Factors            | Q.17                          | 60.68                             | 3                  |
| Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs                        | Owners                      | Q.8                           | 60.54                             | 4                  |
| Installation of innovative/sophisticated systems (BWTS,  | External Factors            | Q.20                          | 60.41                             | 5                  |

|   |             |      |       |    |
|---|-------------|------|-------|----|
| Scrubber etc.)  |             |      |       |    |
| Inadequate efficiency of workforce  | Labors      | Q.24 | 60.41 | 5  |
| Delay to supply required materials  | Materials   | Q.14 | 60.27 | 7  |
| Original contract duration is too short   | Project     | Q.21 | 60.27 | 7  |
| Ineffective planning and scheduling of project by shipyard  | Contractors | Q.5  | 59.05 | 9  |
| Use external sub - contractors during work at a yard  | Contractors | Q.1  | 57.30 | 10 |
| Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | Contractors | Q.4  | 56.08 | 11 |
| Slowness in decision making process by owners   | Owners      | Q.11 | 55.14 | 12 |
| High number of quality defects by shipyard that require re-work   | Contractors | Q.3  | 53.92 | 13 |
| Late delivery or revising of detailed engineering drawings by owners  | Owners      | Q.6  | 52.03 | 14 |

|  |                  |      |       |    |
|--|------------------|------|-------|----|
| Mistakes and discrepancies in design documents and associated difficulty in production | Design           | Q.27 | 51.62 | 15 |
| Inadequate efficiency of equipment   | Equipment        | Q.13 | 50.27 | 16 |
| Unavailability of incentives for shipyard for finishing ahead of schedule              | Owners           | Q.12 | 50.14 | 17 |
| Ineffective delay penalties  | Project          | Q.22 | 50.00 | 18 |
| Little insight of progress at shipyard by owners                                       | Owners           | Q.9  | 49.46 | 19 |
| Late in reviewing and approving design documents by Classification Society             | Consultant       | Q.26 | 46.89 | 20 |
| Delay in progress payment by owners  | Owners           | Q.10 | 45.95 | 21 |
| Poor quality of documentation provided e.g. outdated docking plan                      | Owners           | Q.7  | 45.27 | 22 |
| Delay in performing final inspection and certification by a third party                | External Factors | Q.18 | 44.46 | 23 |
| Legal disputes between various parts   | Project          | Q.23 | 43.51 | 24 |

|  |                  |      |       |    |
|--|------------------|------|-------|----|
| Delay in performing inspection and testing by Classification Society | Consultant       | Q.25 | 42.16 | 25 |
| Worker accident during repairs                                       | External Factors | Q.16 | 39.46 | 26 |
| Changes in government regulations and laws                           | External Factors | Q.19 | 38.51 | 27 |

**Table 81 Ranking of delay factors with reference to Frequency Index (F.I.)**

### **6.9. Results of delay factors with reference to Impact Index (I.I.) after awarding point scale.**

The results of delay factors for all groups according to Impact Index (I.I.) are presented in the below table 82.

The participants considered that for related to Group No 1 – Contractors, the “Poor site Management and supervision by shipyard” is the factor with the higher impact in the project activities. With reference to Group No 2 – Owners, the “Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs” may have the higher effect on the project whereas for Group No 5 – External Factors, the “Weather effect on activities (hot, rain, etc.)” may have the stronger impact. For Group No 6 – Project, participants answered that the “Original contract duration is too short” has the maximum impact in the projects whereas for the rest groups, the “Inadequate efficiency of workforce” of Group No 7 – Labors has the higher value.

| <b><u>Question Number</u></b> | <b><u>Factors</u></b>                                | <b><u>Related Group</u></b> | <b><u>Impact Index (%)</u></b> | <b><u>Rank</u></b> |
|-------------------------------|--|-----------------------------|--------------------------------|--------------------|
| <b>Group No 1.</b>            |  |                             |                                |                    |
| Q.1                           | Use external sub - contractors during work at a yard | Contractors                 | 56.62                          | 21                 |
| Q.2                           | Poor site management and supervision by shipyard     | Contractors                 | 69.86                          | 2                  |
| Q.3                           | High number of quality                               | Contractors                 | 65.41                          | 11                 |

|             |   |             |       |    |
|-------------|---|-------------|-------|----|
|             | defects by shipyard that require re-work  |             |       |    |
| Q.4         | Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | Contractors | 63.65 | 12 |
| Q.5         | Ineffective planning and scheduling of project by shipyard  | Contractors | 67.84 | 6  |
| Group No 2. |   |             |       |    |
| Q.6         | Late delivery or revising of detailed engineering drawings by owners  | Owners      | 62.43 | 14 |
| Q.7         | Poor quality of documentation provided e.g. outdated docking plan   | Owners      | 56.89 | 20 |
| Q.8         | Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs   | Owners      | 68.24 | 4  |
| Q.9         | Little insight of progress at shipyard by owners  | Owners      | 58.51 | 17 |
| Q.10        | Delay in progress   | Owners      | 54.32 | 24 |

|             |  |                  |       |    |
|-------------|--|------------------|-------|----|
|             | payment by owners  |                  |       |    |
| Q.11        | Slowness in decision making process by owners  | Owners           | 66.49 | 8  |
| Q.12        | Unavailability of incentives for shipyard for finishing ahead of schedule  | Owners           | 54.73 | 22 |
| Group No 3. |  |                  |       |    |
| Q.13        | Inadequate efficiency of equipment   | Equipment        | 63.51 | 13 |
| Group No 4. |  |                  |       |    |
| Q.14        | Delay to supply required materials   | Materials        | 71.76 | 1  |
| Group No 5. |  |                  |       |    |
| Q.15        | Weather effect on activities (hot, rain, etc.)   | External Factors | 68.24 | 4  |
| Q.16        | Worker accident during repairs   | External Factors | 53.78 | 25 |
| Q.17        | Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | External Factors | 67.03 | 7  |
| Q.18        | Delay in performing final inspection and certification by a third party  | External Factors | 57.30 | 19 |
| Q.19        | Changes in government  | External         | 50.41 | 27 |

|             |   |                  |       |    |
|-------------|---|------------------|-------|----|
|             | regulations and laws  | Factors          |       |    |
| Q.20        | Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)                  | External Factors | 66.22 | 9  |
| Group No 6. |   |                  |       |    |
| Q.21        | Original contract duration is too short   | Project          | 62.43 | 14 |
| Q.22        | Ineffective delay penalties   | Project          | 51.89 | 26 |
| Q.23        | Legal disputes between various parts  | Project          | 54.73 | 22 |
| Group No 7. |   |                  |       |    |
| Q.24        | Inadequate efficiency of workforce  | Labors           | 69.46 | 3  |
| Group No 8. |   |                  |       |    |
| Q.25        | Delay in performing inspection and testing by Classification Society                    | Consultant       | 57.97 | 18 |
| Q.26        | Late in reviewing and approving design documents by Classification Society              | Consultant       | 60.00 | 16 |
| Group No 9. |   |                  |       |    |
| Q.27        | Mistakes and discrepancies in design documents and associated difficulty in production. | Design           | 66.22 | 9  |

**Table 82 Results of delay factors with reference to Impact Index (I.I.)**

### 6.10. Ranking of delay factors with reference to Impact Index (I.I.) after awarding point scale.

The ranking of delay factors for all groups according to Impact Index (I.I.) are listed in the below table 83.

| <b><u>Factors</u></b>   | <b><u>Related Group</u></b> | <b><u>Question Number</u></b> | <b><u>Impact Index (%)</u></b> | <b><u>Rank</u></b> |
|---|-----------------------------|-------------------------------|--------------------------------|--------------------|
| Delay to supply required materials  | Materials                   | Q.14                          | 71.76                          | 1                  |
| Poor site management and supervision by shipyard  | Contractors                 | Q.2                           | 69.86                          | 2                  |
| Inadequate efficiency of workforce  | Labors                      | Q.24                          | 69.46                          | 3                  |
| Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs           | Owners                      | Q.8                           | 68.24                          | 4                  |
| Weather effect on activities (hot, rain, etc.)  | External Factors            | Q.15                          | 68.24                          | 4                  |
| Ineffective planning and scheduling of project by shipyard  | Contractors                 | Q.5                           | 67.84                          | 6                  |
| Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport | External Factors            | Q.17                          | 67.03                          | 7                  |



|   |                  |      |       |    |
|---|------------------|------|-------|----|
| limitations)  |                  |      |       |    |
| Slowness in decision making process by owners   | Owners           | Q.11 | 66.49 | 8  |
| Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)  | External Factors | Q.20 | 66.22 | 9  |
| Mistakes and discrepancies in design documents and associated difficulty in production.   | Design           | Q.27 | 66.22 | 9  |
| High number of quality defects by shipyard that require re-work   | Contractors      | Q.3  | 65.41 | 11 |
| Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | Contractors      | Q.4  | 63.65 | 12 |
| Inadequate efficiency of equipment  | Equipment        | Q.13 | 63.51 | 13 |
| Late delivery or revising of detailed engineering drawings by owners  | Owners           | Q.6  | 62.43 | 14 |
| Original contract   | Project          | Q.21 | 62.43 | 14 |

|  |                  |      |       |    |
|--|------------------|------|-------|----|
| duration is too short  |                  |      |       |    |
| Late in reviewing and approving design documents by Classification Society | Consultant       | Q.26 | 60.00 | 16 |
| Little insight of progress at shipyard by owners                           | Owners           | Q.9  | 58.51 | 17 |
| Delay in performing inspection and testing by Classification Society       | Consultant       | Q.25 | 57.97 | 18 |
| Delay in performing final inspection and certification by a third party    | External Factors | Q.18 | 57.30 | 19 |
| Poor quality of documentation provided e.g. outdated docking plan          | Owners           | Q.7  | 56.89 | 20 |
| Use external sub - contractors during work at a yard                       | Contractors      | Q.1  | 56.62 | 21 |
| Unavailability of incentives for shipyard for finishing ahead of schedule  | Owners           | Q.12 | 54.73 | 22 |
| Legal disputes between various parts                                       | Project          | Q.23 | 54.73 | 22 |
| Delay in progress payment by owners  | Owners           | Q.10 | 54.32 | 24 |
| Worker accident during repairs   | External Factors | Q.16 | 53.78 | 25 |

|  |                  |      |       |    |
|--|------------------|------|-------|----|
| Ineffective delay penalties                | Project          | Q.22 | 51.89 | 26 |
| Changes in government regulations and laws | External Factors | Q.19 | 50.41 | 27 |

**Table 83 Ranking of delay factors with reference to Impact Index (I.I.)**

### **6.11. Results of delay factors with reference to Importance Index (IMP.I.) after awarding point scale.**

The results of delay factors according to Importance Index (IMP.I.) are presented in the below table 84. The calculations of Importance Index (IMP.I.) were conducted from Frequency and Impact Index results.

| <b><u>Question Number</u></b> | <b><u>Factors</u></b>  | <b><u>Related Group</u></b> | <b><u>Importance Index (%)</u></b> | <b><u>Rank</u></b> |
|-------------------------------|--|-----------------------------|------------------------------------|--------------------|
| <b>Group No 1.</b>            |  |                             |                                    |                    |
| Q.1                           | Use external sub - contractors during work at a yard   | Contractors                 | 32.44                              | 15                 |
| Q.2                           | Poor site management and supervision by shipyard   | Contractors                 | 42.86                              | 3                  |
| Q.3                           | High number of quality defects by shipyard that require re-work  | Contractors                 | 35.27                              | 12                 |
| Q.4                           | Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling, D/D on arrival - no time for accessory works for | Contractors                 | 35.69                              | 11                 |

|             |  |             |       |    |
|-------------|--|-------------|-------|----|
|             | propeller removal<br>/shaft withdrawal)  |             |       |    |
| Q.5         | Ineffective planning<br>and scheduling of<br>project by shipyard   | Contractors | 40.06 | 7  |
| Group No 2. |  |             |       |    |
| Q.6         | Late delivery or<br>revising of detailed<br>engineering drawings<br>by owners  | Owners      | 32.48 | 14 |
| Q.7         | Poor quality of<br>documentation<br>provided e.g. outdated<br>docking plan   | Owners      | 25.76 | 21 |
| Q.8         | Incomplete scope of<br>work/ work done list<br>shared by the<br>owners/managers –<br>change orders during<br>repairs | Owners      | 41.31 | 5  |
| Q.9         | Little insight of<br>progress at shipyard<br>by owners   | Owners      | 28.94 | 17 |
| Q.10        | Delay in progress<br>payment by owners   | Owners      | 24.96 | 23 |
| Q.11        | Slowness in decision<br>making process by<br>owners  | Owners      | 36.66 | 10 |
| Q.12        | Unavailability of<br>incentives for<br>shipyard for finishing<br>ahead of schedule                                   | Owners      | 27.44 | 19 |
| Group No 3. |  |             |       |    |

|             |  |                  |       |    |
|-------------|--|------------------|-------|----|
| Q.13        | Inadequate efficiency of equipment   | Equipment        | 31.93 | 16 |
| Group No 4. |  |                  |       |    |
| Q.14        | Delay to supply required materials   | Materials        | 43.25 | 2  |
| Group No 5. |  |                  |       |    |
| Q.15        | Weather effect on activities (hot, rain, etc.)   | External Factors | 44.54 | 1  |
| Q.16        | Worker accident during repairs   | External Factors | 21.22 | 26 |
| Q.17        | Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | External Factors | 40.67 | 6  |
| Q.18        | Delay in performing final inspection and certification by a third party  | External Factors | 25.47 | 22 |
| Q.19        | Changes in government regulations and laws   | External Factors | 19.41 | 27 |
| Q.20        | Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)   | External Factors | 40.00 | 8  |
| Group No 6. |  |                  |       |    |
| Q.21        | Original contract duration is too short  | Project          | 37.63 | 9  |
| Q.22        | Ineffective delay  | Project          | 25.95 | 20 |

|             |   |            |       |    |
|-------------|---|------------|-------|----|
|             | penalties   |            |       |    |
| Q.23        | Legal disputes between various parts  | Project    | 23.81 | 25 |
| Group No 7. |   |            |       |    |
| Q.24        | Inadequate efficiency of workforce  | Labors     | 41.96 | 4  |
| Group No 8. |   |            |       |    |
| Q.25        | Delay in performing inspection and testing by Classification Society                    | Consultant | 24.44 | 24 |
| Q.26        | Late in reviewing and approving design documents by Classification Society              | Consultant | 28.14 | 18 |
| Group No 9. |   |            |       |    |
| Q.27        | Mistakes and discrepancies in design documents and associated difficulty in production. | Design     | 34.18 | 13 |

**Table 84 Results of delay factors with reference to Importance Index (IMP.I.)**

### **6.12. Ranking of delay factors with reference to Importance Index (IMP.I.) after awarding point scale.**

The ranking of delay factors according to Importance Index (IMP.I.) are listed in the below table 85.

By reviewing the table, we can observe that the importance of delay factors varies from one factor to another. The most important factor as per questionnaire is “Weather effect on activities” following by “Delay to supply required materials” and “Poor site management and supervision by shipyard”.

| <b><u>Factors</u></b>  | <b><u>Related Group</u></b> | <b><u>Question Number</u></b> | <b><u>Importance Index (%)</u></b> | <b><u>Rank</u></b> |
|--|-----------------------------|-------------------------------|------------------------------------|--------------------|
| Weather effect on activities (hot, rain, etc.)   | External Factors            | Q.15                          | 44.54                              | 1                  |
| Delay to supply required materials   | Materials                   | Q.14                          | 43.25                              | 2                  |
| Poor site management and supervision by shipyard   | Contractors                 | Q.2                           | 42.86                              | 3                  |
| Inadequate efficiency of workforce   | Labors                      | Q.24                          | 41.96                              | 4                  |
| Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs                        | Owners                      | Q.8                           | 41.31                              | 5                  |
| Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | External Factors            | Q.17                          | 40.67                              | 6                  |
| Ineffective planning and scheduling of project by shipyard   | Contractors                 | Q.5                           | 40.06                              | 7                  |
| Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)   | External Factors            | Q.20                          | 40.00                              | 8                  |
| Original contract duration is too short  | Project                     | Q.21                          | 37.63                              | 9                  |
| Slowness in decision making process by owners  | Owners                      | Q.11                          | 36.66                              | 10                 |
| Co-ordination of vessel's position in shipyard   | Contractors                 | Q.4                           | 35.69                              | 11                 |

|   |             |      |       |    |
|---|-------------|------|-------|----|
| (alongside or triple banking<br>– restricted material<br>handling, D/D on arrival -<br>no time for accessory<br>works for propeller<br>removal /shaft withdrawal) |             |      |       |    |
| High number of quality<br>defects by shipyard that<br>require re-work   | Contractors | Q.3  | 35.27 | 12 |
| Mistakes and discrepancies<br>in design documents and<br>associated difficulty in<br>production.  | Design      | Q.27 | 34.18 | 13 |
| Late delivery or revising of<br>detailed engineering<br>drawings by owners  | Owners      | Q.6  | 32.48 | 14 |
| Use external sub -<br>contractors during work at<br>a yard  | Contractors | Q.1  | 32.44 | 15 |
| Inadequate efficiency of<br>equipment   | Equipment   | Q.13 | 31.93 | 16 |
| Little insight of progress at<br>shipyard by owners   | Owners      | Q.9  | 28.94 | 17 |
| Late in reviewing and<br>approving design<br>documents by<br>Classification Society   | Consultant  | Q.26 | 28.14 | 18 |
| Unavailability of incentives<br>for shipyard for finishing<br>ahead of schedule   | Owners      | Q.12 | 27.44 | 19 |
| Ineffective delay penalties   | Project     | Q.22 | 25.95 | 20 |
| Poor quality of<br>documentation provided   | Owners      | Q.7  | 25.76 | 21 |



|   |                  |      |       |    |
|---|------------------|------|-------|----|
| e.g. outdated docking plan  |                  |      |       |    |
| Delay in performing final inspection and certification by a third party | External Factors | Q.18 | 25.47 | 22 |
| Delay in progress payment by owners                                     | Owners           | Q.10 | 24.96 | 23 |
| Delay in performing inspection and testing by Classification Society    | Consultant       | Q.25 | 24.44 | 24 |
| Legal disputes between various parts                                    | Project          | Q.23 | 23.81 | 25 |
| Worker accident during repairs  | External Factors | Q.16 | 21.22 | 26 |
| Changes in government regulations and laws                              | External Factors | Q.19 | 19.41 | 27 |

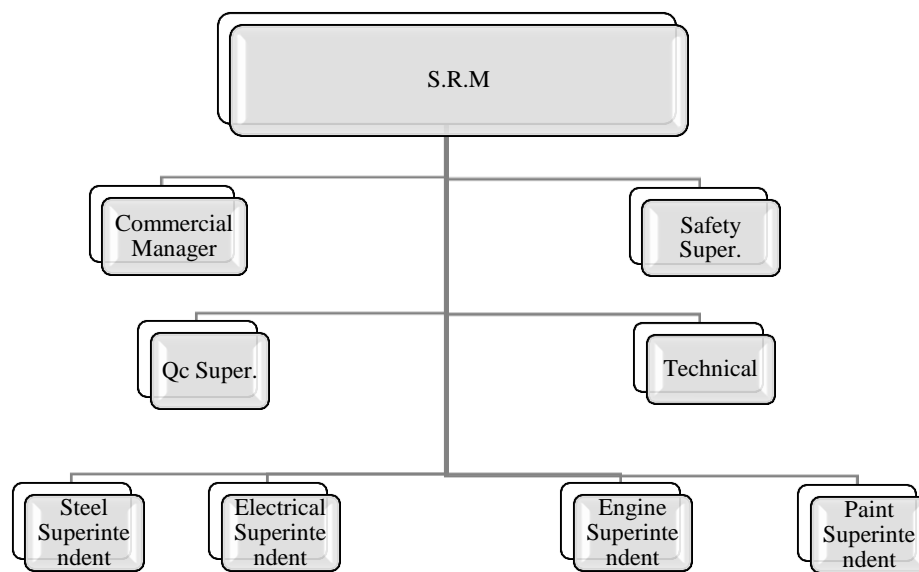
**Table 85 Ranking of delay factors with reference to Importance Index (IMP.I.)**

## 7. Case study

### 7.1. Introduction

The case study presented in this Thesis is focused on a scheduled repair project performed in Far East shipyard to a bulk carrier vessel. Vessel was dry-docked for her 3<sup>rd</sup> special survey.

#### Organization chart of selected shipyard's Repairing Team:



**Figure 8 Organization chart of selected shipyard's Repairing Team**

Shipyard's selection is not investigated in this Thesis. There are many parameters which should be taking into account in order to select a shipyard and many studies which examine shipyard selection can be found in the literature.

Vessel's dry-dock specification was provided by owners/managers to shipyard and relevant quotation was obtained including General Terms and Conditions of Contract of ship's repairs based on provided specification.

Our intention is to identify and analyze delay factors took place during this scheduled repair project.

**Vessel's particulars as follows:**

|                          |  |
|--------------------------|--|
| TYPE                     | BULK CARRIER   |
| DEADWEIGHT               | 58700 MTS  |
| GRT/NT                   | 32381x19353  |
| LOA x BEAM x DEPTH       | 189,99x32.26x18  |
| LIGHTSHIP                | 9000MT   |
| NO. OF CARGO HOLDS       | 5  |
| DECK CRANES              | 4x30 tons each, Electro hydraulic IHI  |
| HATCH COVERS             | Hydraulic, Folding type  |
| MAIN ENGINE              | MAN B&W - 6S 50MC-C MCR RPM 113 / KW 8400 // CSR RPM 107 / KW 7140   |
| MAIN ENGINE TURBOCHARGER | MAN TCA66  |
| MAIN ENGINE GOVERNOR     | ELECTRONIC GOVERNOR (MAG-200 II)   |
| PROPELLER                | TYPE: KEYLESS 4 Blades, Dia. 6000mm, Pitch 4,155 mm material NI-AL Bronze .MAKER NAKASHIMA                                 |
| STERN TUBE SEALS         | COBELCO:AFT DX-560 FRWD CX 560   |
| DIESEL GENERATORS        | 3 SET DAIHATSU – 6DC-17 530 kw / rpm: 900 GENERATOR OUTPUT 480KW KVA   |
| ELECTRIC POWER SUPPLY    | 3x480 KW, 3Ph x 60Hz x 600 KVA   |
| BOILER                   | Vertical Composite Boiler Type (OVS2-110/90-24)<br>Maker: OSAKA Design Press: 7 Bar.<br>Evaporation 1100/900 kg/h. Heating |

|              |                                   |
|--------------|-----------------------------------|
|              | surface19/151 M2                  |
| ANCHOR CHAIN | Dia. 70 mm, Grade 3 x 12 shackles |

**Table 86 Vessel's particulars**

**The main General terms and Conditions for the aforementioned vessel as provided by the shipyard can be reviewed below:**

1. Total repair period: 22 good weather days included 5 days in dock based on Normal docking including Cargo hold treatment by cherry picker (up to 30%/hold) + Hatch cover repairs on board+ BWTS installation with owners supply + Minor steel renewal (up to 5 tons) + Specified mechanical & electrical works.

Note: The repair period should be counted from the next day when the yard get more than 70% of total work scope with confirmed work order from owners side and the vessel should be alongside repair quay meanwhile the vessel should be in the condition of gas free approved by yard and ready for hot works.

2. Payment: 50% to be paid before sailing, the balance to be paid within 60 days after vessel's departure.
3. Penalty: USD 4,000 per day for delay due to yard's reason, but limited to 4% on the final invoice cost.

Recommended draft: 6 meters

Recommended trim for docking: 1% of LOA

## **7.2. Initial scope of work Observations**

By reviewing agreed initial scope of work and quotation received by shipyard, we can observe that:

- 1) A Ballast water treatment system is to be fitted to the vessel. (Sophisticated system installation). To facilitate installation, owners were assigned a BWTS engineer to supervise system's installation.

- 2) Repair period as quoted by shipyard includes cargo holds treatment up to 30%. Percentage of treatment is to be confirmed by owner's representative together with appointed coating inspector by owners/managers. Limit ratio of 30% in quotation may be considered low for a vessel which is dry-docked for her 3rd special survey. If agreed ratio after inspection will be more than 30%, then repair period will be increased.
- 3) Many items if performed, is to be confirmed after inspection especially for Hatch cover repairs (incomplete scope of work)
- 4) Sub-contractors were assigned by owners to perform many activities/services such as:
  - Ultrasonic Thickness Measurements
  - BWTS Maker's engineers for system's commissioning
  - M/E Turbocharger
  - M/E Pneumatic System
  - M/E Governor
  - D/G Turbocharger
  - D/G Governor
  - LSA service (FFB / Rescue Boat)
  - Paints Supervisor
  - Safety Radio Service
  - BWTS Commissioning by maker's engineers
  - General Inspection of Deck Cranes
  - Inspection and Supervision of Hatch Covers repairs
  - Mooring Winches Inspection
  - Alpha Lubricator System
  - Incinerator refractory area repairs
  - Accommodation air condition unit repairs

### **7.3. Initial dry-dock schedule**

The vessel in case study arrived on 11/07 in shipyard and instructed to proceed to dry-dock on 12/07 after required covid-19 test performed to all crew.



**Figure 9 Vessel in dry-dock**



**Figure 10 Vessel in graving dock**

As per quotation received, vessel is expected to complete repairs on 02 Aug and depart from shipyard on 03 Aug.

#### **7.4. Initial dry-dock schedule**

Initial dry-dock schedule which includes only minor repairs in hatch covers and 90% sand blasting in cargo holds can be reviewed below:

| SE | ITEMS  | DURATIONS | START      | FINISH     | PREDECESS | 备注 | PROGRESS |
|----|--|-----------|------------|------------|-----------|----|----------|
| 1  | MV GLASS COAST OVERALL SCHEDULE                              | 25 d      | 2021年7月12日 | 2021年8月5日  |           |    | 0%       |
| 2  | MILESTONES   | 25 d      | 2021年7月12日 | 2021年8月5日  |           |    | 25%      |
| 3  | REPAIR DAY 1   | 1 d       | 2021年7月12日 | 2021年7月12日 |           |    | 100%     |
| 4  | DOCKING IN   | 1 d       | 2021年7月12日 | 2021年7月12日 |           |    | 0%       |
| 5  | UNDocking  | 1 d       | 2021年7月16日 | 2021年7月16日 |           |    | 0%       |
| 6  | DEPARTURE  | 1 d       | 2021年8月5日  | 2021年8月5日  |           |    | 0%       |
| 7  | PRODUCTION SCHEDULE  | 24 d      | 2021年7月12日 | 2021年8月4日  |           |    | 0%       |
| 8  | DOCKING ITEMS  | 5 d       | 2021年7月12日 | 2021年7月16日 |           |    | 0%       |
| 9  | SHIP SIDE VALVES OVERHAULING                                 | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 10 | WITHDRWAL TAIL SHAFT   | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 11 | STERN TUBE SEAL RENEW  | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 12 | PROPELLER REMOVAL  | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 13 | RUDDER CLEARANC CHECKING                                     | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 14 | BOTTON PLUG OPEN/CLOSE/VACUUM TEST                           | 4 d       | 2021年7月12日 | 2021年7月15日 | 4SS       |    | 0%       |
| 15 | HULL ANODES  | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 16 | ANCHOR CHAIN MEASURE/WASH/RENEWAL                            | 4 d       | 2021年7月12日 | 2021年7月15日 | 4SS       |    | 0%       |
| 17 | SLURRY BLASTING  | 1 d       | 2021年7月13日 | 2021年7月13日 | 4         |    | 0%       |
| 18 | HULL PAINTING  | 3 d       | 2021年7月14日 | 2021年7月16日 | 17        |    | 0%       |
| 19 | SEACHEST   | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 20 | CHAIN AND CHAIN LOCKER                                       | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 21 | HULL DAMAGE REPAIR   | 4 d       | 2021年7月13日 | 2021年7月16日 | 4         |    | 0%       |
| 22 | LIFE BOAT DAVIT LOAD TEST                                    | 2 d       | 2021年7月14日 | 2021年7月15日 | 4SS+2 d   |    | 0%       |
| 23 | LADDERS LOAD TEST  | 2 d       | 2021年7月14日 | 2021年7月15日 | 4SS+2 d   |    | 0%       |
| 24 | ENGINE ROOM ITEMS REPAIR                                     | 20 d      | 2021年7月12日 | 2021年7月31日 |           |    | 0%       |
| 25 | ME OVERHAULING(cylinder cover/piston/bearing)                | 14 d      | 2021年7月15日 | 2021年7月28日 | 3SS+3 d   |    | 0%       |
| 26 | ME AIR COOLER CLEANTEST                                      | 10 d      | 2021年7月14日 | 2021年7月23日 | 3SS+2 d   |    | 0%       |
| 27 | FUEL OIL PUMP OVERHAULING                                    | 8 d       | 2021年7月15日 | 2021年7月22日 | 3SS+3 d   |    | 0%       |
| 28 | BOILER CLEANING AND SAFETY VALVES/MOUNTING VALVE OVERHAULING | 13 d      | 2021年7月16日 | 2021年7月28日 | 3SS+4 d   |    | 0%       |
| 29 | DIG AIR COOLER CLEAN/TEST(3SETS)                             | 8 d       | 2021年7月15日 | 2021年7月22日 | 3SS+3 d   |    | 0%       |
| 30 | PUMPS OVERHUAL   | 15 d      | 2021年7月17日 | 2021年7月31日 | 3SS+5 d   |    | 0%       |
| 31 | HEATER CLEAN/TEST  | 12 d      | 2021年7月14日 | 2021年7月25日 | 3SS+2 d   |    | 0%       |
| 32 | OIL TANK CLEANING  | 9 d       | 2021年7月15日 | 2021年7月23日 | 3SS+3 d   |    | 0%       |
| 33 | SEA WATER PIPE RENEWAL                                       | 14 d      | 2021年7月13日 | 2021年7月26日 | 3SS+1 d   |    | 0%       |
| 34 | DECK ITEMS REPAIR  | 18 d      | 2021年7月12日 | 2021年7月29日 |           |    | 0%       |
| 35 | FORWARD WINDLASS AND WINCH LAND TO WORKSHOP AND OVERHUAL     | 11 d      | 2021年7月17日 | 2021年7月27日 | 16        |    | 0%       |
| 36 | HATCH COVER CYLINDER OVERHAUL(NOT CONFIRM)                   | 13 d      | 2021年7月12日 | 2021年7月24日 |           |    | 0%       |
| 37 | WINCH BREAK TEST   | 2 d       | 2021年7月22日 | 2021年7月23日 | 3SS+10 d  |    | 0%       |
| 38 | DECK CRANE OVERHAUL  | 7 d       | 2021年7月18日 | 2021年7月24日 | 3SS+6 d   |    | 0%       |
| 39 | DECK CRANS LOAD TEST   | 2 d       | 2021年7月25日 | 2021年7月26日 | 38        |    | 0%       |
| 40 | GRAB OVERHAUL(4SETS)   | 16 d      | 2021年7月14日 | 2021年7月29日 | 3SS+2 d   |    | 0%       |
| 41 | STEEL JOB IN TST(NO.1/2/3/4/5)                               | 10 d      | 2021年7月14日 | 2021年7月23日 | 3SS+2 d   |    | 0%       |
| 42 | STEEL JOB IN DBT(NO.1/2/3/4/5)                               | 4 d       | 2021年7月14日 | 2021年7月17日 | 3SS+2 d   |    | 0%       |
| 43 | CARGO HOLDS TREATMENT  | 18 d      | 2021年7月18日 | 2021年8月4日  |           |    | 0%       |
| 44 | CARGO HOLDS BLASTING(90%)                                    | 8 d       | 2021年7月18日 | 2021年7月25日 |           |    | 0%       |

八月

The Gantt chart displays the schedule for various tasks. Key milestones include 'REPAIR DAY 1' completed on July 12, 'DOCKING IN' on July 12, and 'UNDocking' on July 16. Major tasks like 'SHIP SIDE VALVES OVERHAULING' and 'WITHDRWAL TAIL SHAFT' are scheduled from July 13 to 16. The 'ENGINE ROOM ITEMS REPAIR' task spans from July 12 to July 31. The 'CARGO HOLDS TREATMENT' task runs from July 18 to August 4.

page 1



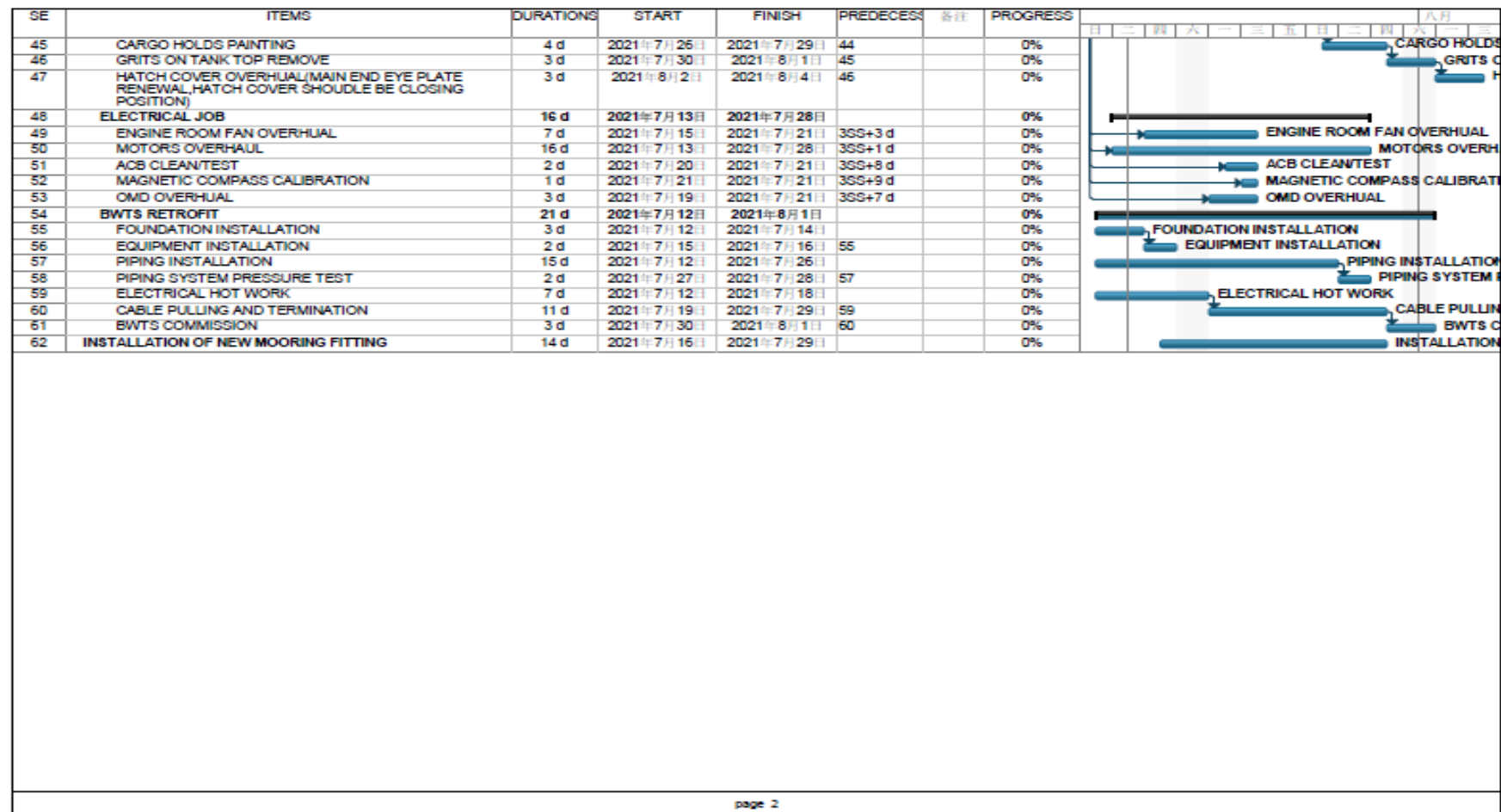


Figure 11 Initial dry-dock schedule

## **7.5. Case study analysis of observations**

### **7.5.1. Dry-dock on arrival**

The vessel was instructed to proceed to the dry-dock on-arrival.

However, due to covid-19 new regulations for required covid tests to all crew, there was enough time for the vessel to achieve the pre-docking draft and trim.

Required spare parts for stern tube repairs has been supplied to the vessel by owners/managers before vessel's arrival in shipyard and no delay of scheduled plan was observed by dry-docking the vessel on arrival.

### **7.5.2. Hatch Covers Inspection**

On 12/07 Hatch covers maker's engineer attended the vessel for inspection of the system.

In most cases a pre-docking inspection of Hatch Covers is arranged by owners/managers well before vessel's arrival in shipyard. The inspection is critical to ensure that all required items for repairs will be included in scope of work and required spare parts will be supplied on time to the vessel.

The London P&I published a guide book "Holds and Hatch Covers" which was produced by A. Bilbrough & Co. Ltd. for maintenance of Cargo Holds. They suggested that a pre-docking inspection three months prior dry-dock must be performed including thickness measurements and hydraulic hose test. All repairs to be included in vessel's specification and spares to be ordered.

However, due to covid restrictions attendance was not feasible to be arranged by the owners.



**Figure 12 Hatch Covers Operation Test**

Service report issued on 14/07 by attended engineer who suggested the below works to be performed to Hatch Covers.

**A. For mechanical and rubber packing system:**

1. Operational problem for the hatch covers as below :

Hatch Covers No 1 FWD; No 2 FWD; No 2 AFT; No 3 FWD; No 3 FWD; No 4 FWD cannot fully open and cannot be properly secured by opening stowage stoppers.

No 3 FWD and No 3 AFT cannot be fully closed due to wear and tear of the hinges system.

During hatch cover operational test there is a noise in No 1 and No 3 hatch covers.

2. Intermediate hinge pin and hole with >5mm clearance in Cargo holds No 1, 2.  
Other hinges observed with tear and wear.



Figure 13 Intermediate hinge pin rotation with stopper plate damaged.

### **Solution 1:**

No 2 AFT; No 3 FWD; No 3 AFT; No 4 FWD; No 5 FWD; No 5 AFT - all hatch covers will lift away to shore for overhauling.

- (1) Renew all the end hinge pins, intermediate hinge pins, cylinder pins.
- (2) Welding build up and machining for the intermediate hinges holes.
- (3) Welding build up and machining End hinge link eye plates.
- (4) Welding build up and machining cylinder hinge upper eye plates.

Renew the cylinder lower hinge eye plates.

After disassembling the entire hatch covers, and sit at shore properly, we should measure the intermediate hinge holes size and end hinge holes size at deck side.

### **Solution 2:**

In order repairs to Hatch covers not to affect the total duration of dry-dock, then none welding build up and machining for the intermediate hinges holes and end hinge holes is to be performed. Instead the following repair suggested:

- (1) Renew required end hinge pins, intermediate hinge pins, cylinder pins.
- (2) Renew the links and the complete hinge system.

Greasing and test all the hinges.

(3) If after renewal of the pins, still hatch covers cannot be opened properly and in order to compensate the cylinder stroke we may add a welding plate at end hinge side.

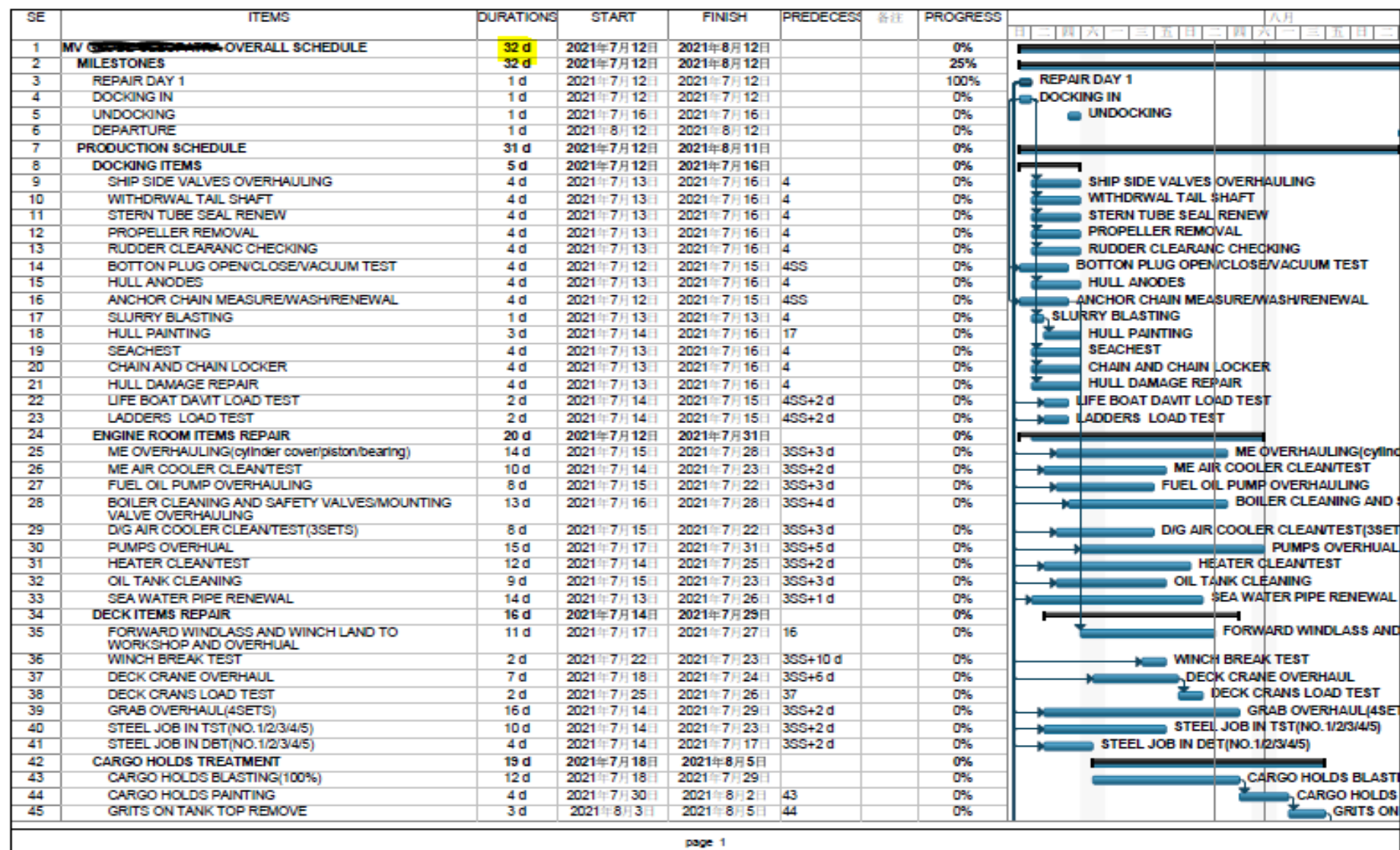
The plate Thickness will be about 10mm to 14mm depending on the final test.

(4) To avoid the hinge joint leakage, it is suggested to add a 5 or 10mm shim rubber.

**B. Final commission operation test and hose test should be performed**

On 14/07 owners handed over to shipyard, the report including all suggested works relative to hatch cover repairs and shipyard provided an updated D/D schedule.

Duration of project may have been altered to 32 days in case solution No 1 has been followed as per below D/D schedule.





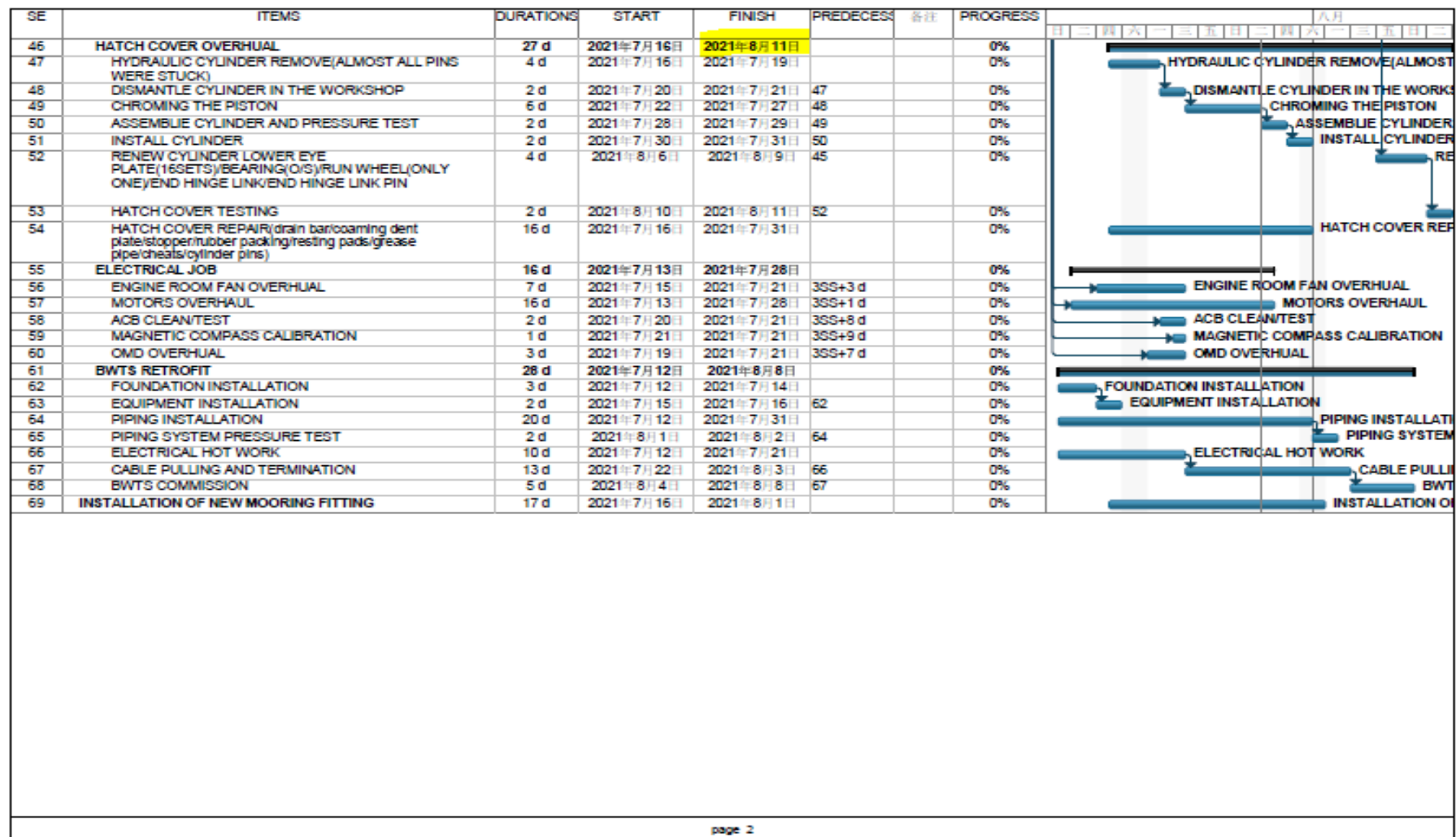


Figure 14 Updated D/D schedule including hatch covers repairs

Following solution No 2, Hatch cover repairs finally last 22 days and delayed the project for about 1 day.

### 7.5.3. Cargo Holds Treatment

For each cargo hold two (2) cherry pickers were put into service for sand blasting & painting application.

The sand blasting ratio was agreed between yard and owners superintendent as follows:

SA 1.0 5% SA 2.0 85%

The sand blasting operation in all cargo holds performed from 17th July till 29th July.

After completion of sand blasting a High Pressure Fresh Water Washing was carried out in all cargo holds and air was blown to dry quickly for painting.

Agreed ratio of Cargo Holds and Hatch Covers grit-blasting as follows:

| Location                    | Area (Sq. m) | SA2.0 | SA1.0 |
|-----------------------------|--------------|-------|-------|
| No. 1-5 cargo holds         | 20218        | 85%   | 5%    |
| No. 1-5 hatch Covers        | 2500         | 20%   | 5%    |
| Hatch Covers rubber channel |              | 100%  |       |

**Table 87 Cargo Holds and Hatch Covers grit-blasting percentage**



**Figure 15 Sand blasting in cargo holds**





**Figure 16 After HPFWW in cargo holds**



**Figure 17 Apply 2nd coat in cargo holds**



**Figure 18 Cargo holds final condition**

As per initial scheduled plan provided by shipyard, the increased percentage (more than 30%) of cargo holds treatment, increased the total repair period for about 2 days.

#### **7.5.4. BWTS Retrofit**

In this case study a Ballast Water Treatment system installation was planned to be performed to the vessel.

As per Alfa Laval maker “Preparing and retrofitting a ballast water treatment system”, a successful installation of the Ballast Water Treatment System requires good preparation from all involved parties. In general two weeks required for installation, any unforeseen circumstances may delay the departure of the vessel and may increase the total repair period.

([https://www.alfalaval.com/globalassets/documents/microsites/pureballast/pdf/alfa\\_laval\\_pureballast\\_chapter\\_extract\\_retrofit.pdf](https://www.alfalaval.com/globalassets/documents/microsites/pureballast/pdf/alfa_laval_pureballast_chapter_extract_retrofit.pdf))

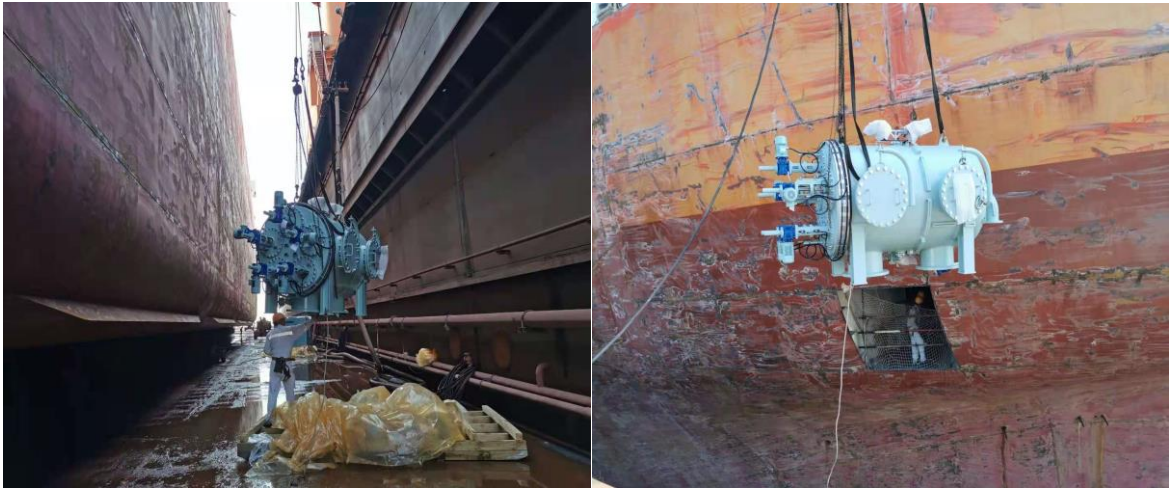
In this case study, all requires steps before vessel’s dry-docking and system installation had been successfully completed.

- Initial phase with maker with agreed scope of supply of the system
- Review of vessel documentation/drawings
- Onboard 3D scanning
- Preparation of engineering drawings
- Class approval of drawings and documents
- Prefabrication of piping based on engineering drawings by shipyard
- Delivery of the system’s components to shipyard’s facilities

The last step of system retrofit is the installation on board. If the 3D scanning and engineering have been performed with high accuracy then all prefabricated pipings will be fitted on-board without any delay.

#### 7.5.4.1. B.W.T.S Photos during Installation on board

Below can be reviewed some indicative photos from the installation on-board.



**Figure 19 BWTS filter shifting**



**Figure 20 BWTS filter shifting**





**Figure 21 UV power supply panel shifting**

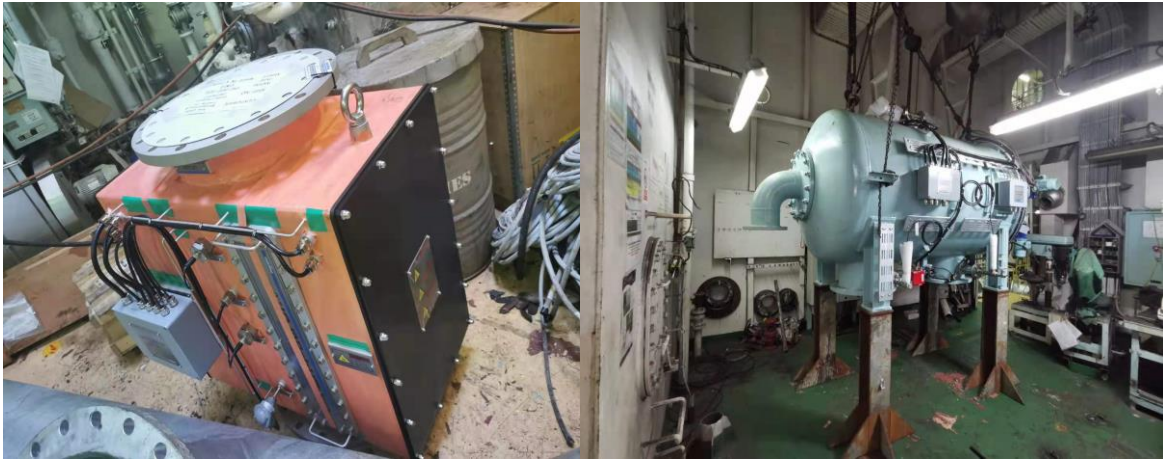


**Figure 22 BWTS new pipes transfer in dry dock**



**Figure 23 BWTS old pipes dismantle**





**Figure 24 UV and BWTS Installation**



**Figure 25 UV power supply panel installation**



**Figure 26 Cables lay out**

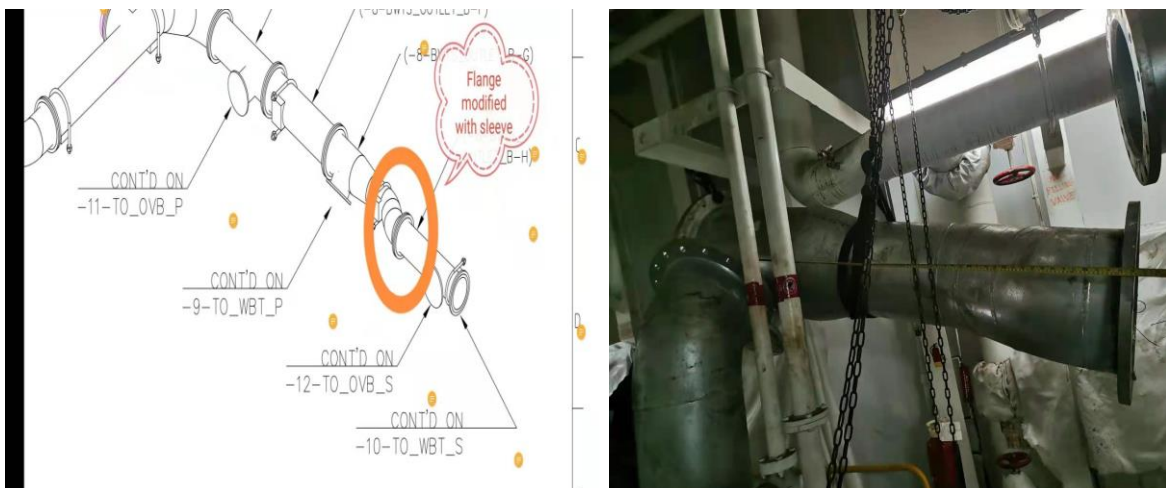


**Figure 27 New pipes installation**

#### **7.5.4.2. Piping modifications**

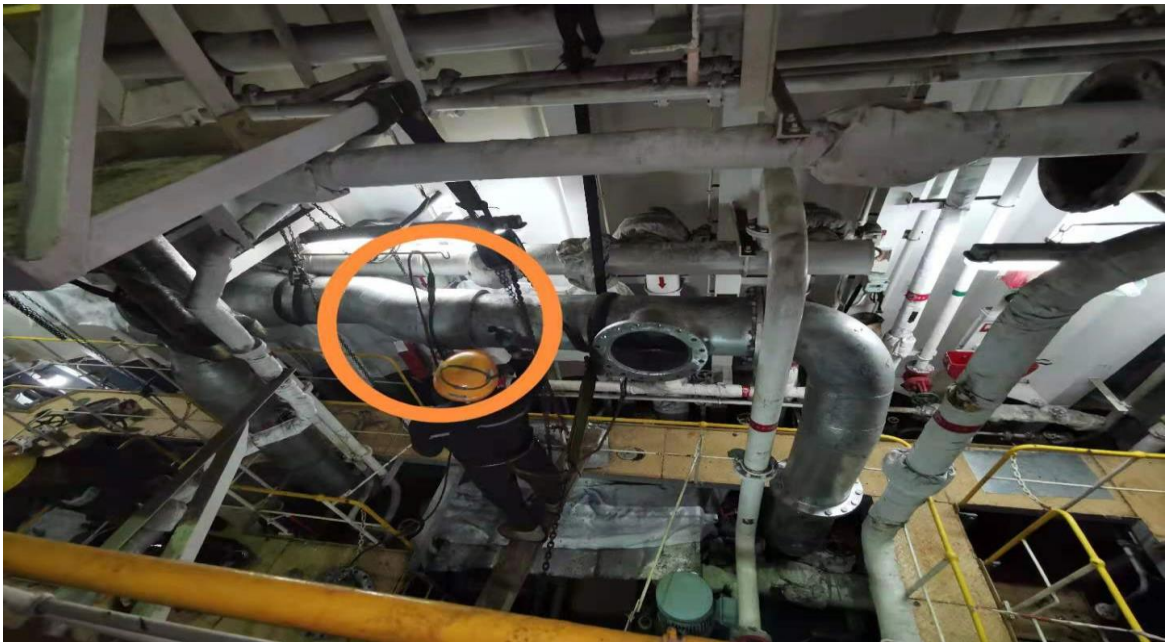
Below are presented some minor piping modifications which have been occurred during installation on board:

1. Two (2) flanges were modified to one (1) sleeve due to wrong pipe pre-fabrication by shipyard. According to the engineering drawings one (1) pipe should be fabricated on board during installation, but shipyard has wrongly fully welded the flanges on the pipe. As a result, two (2) pipes flanges has been modified with one (1) sleeve.



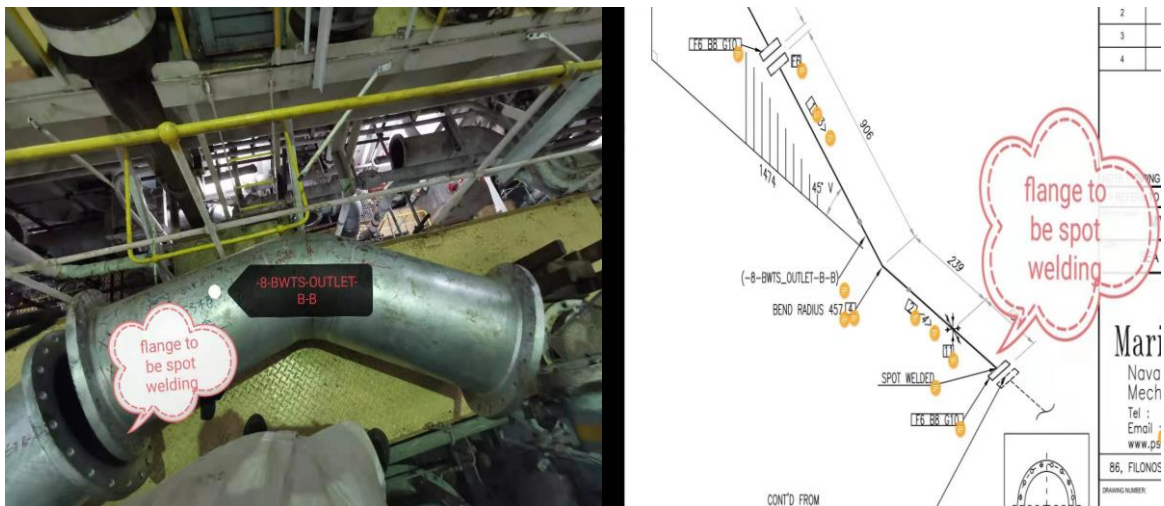


**Figure 28 Modification No 1.**



**Figure 29 Final arrangement of Modification No 1.**

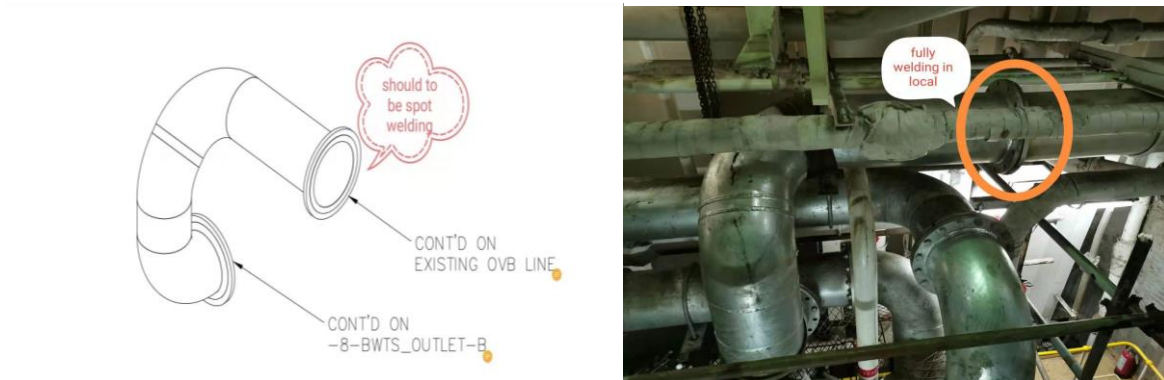
2. The flanges on one (1) pipe on board are to be welded on board during installation, but shipyard has wrongly fully welded the flanges on the pipe.



**Figure 30 Modification No 2.**

3. The flanges on one (1) pipe on board are to be welded on board during installation, but shipyard has wrongly fully welded the flanges on the pipe. As a result, the

flange cannot be connected to existed old pipe on board during installation and therefore the flanges were modified with sleeve (DN350\*200).



**Figure 31 Modification No 3.**



**Figure 32 Final arrangement of Modification No 3.**

4. As per engineering drawings the nominal pressure in one (1) pipe and the flange specification should be JIS 5K. However as per actual condition the flanges should be 10K. As a result, two (2) flanges had been changed from 5K to 10K.





Figure 33 Modification No 4.

#### 7.5.4.3. B.W.T.S Modifications effect on project

As per initial schedule plan which has been provided by shipyard, B.W.T.S retrofit requires 21 days for installation.

|    |                               |      |           |           |    |
|----|-------------------------------|------|-----------|-----------|----|
| 54 | BWTS RETROFIT                 | 21 d | 2021-7-12 | 2021-8-1  |    |
| 55 | FOUNDATION INSTALLATION       | 3 d  | 2021-7-12 | 2021-7-14 |    |
| 56 | EQUIPMENT INSTALLATION        | 2 d  | 2021-7-15 | 2021-7-16 | 55 |
| 57 | PIPING INSTALLATION           | 15 d | 2021-7-12 | 2021-7-26 |    |
| 58 | PIPING SYSTEM PRESSURE TEST   | 2 d  | 2021-7-27 | 2021-7-28 | 57 |
| 59 | ELECTRICAL HOT WORK           | 7 d  | 2021-7-12 | 2021-7-18 |    |
| 60 | CABLE PULLING AND TERMINATION | 11 d | 2021-7-19 | 2021-7-29 | 59 |
| 61 | BWTS COMMISSION               | 3 d  | 2021-7-30 | 2021-8-1  | 60 |

Figure 34 BWTS schedule plan

There were only few piping modifications during this project which did not affect schedule plan.

#### 7.5.5. Weather effect on project

During the repair period a Typhoon reached shipyard area which had increased the total repair period.

Below description is Typhoon condition on 26th July at 8:00lt,

- Wind Speed : 33m/s ,

- Shifting Speed : 7Km/hour .

Shipyards region was remained in effect area for 24 hours due to the fact that Typhoon shifting speed was very slow.

As a result, shipyard had stopped all activities and arranged 24 hours safety man power to be on duty to deal with typhoon.

Repair period had increased for 1 day.



**Figure 35 Typhoon in Shipyards**

In addition, Heavy rain took place on 01 Aug in shipyard. However, rainy weather did not affect the total repair period as cargo holds painting had already been completed.

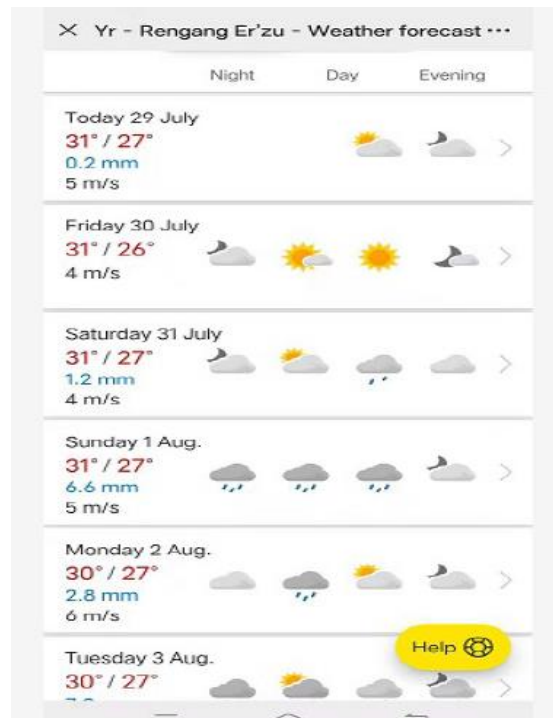
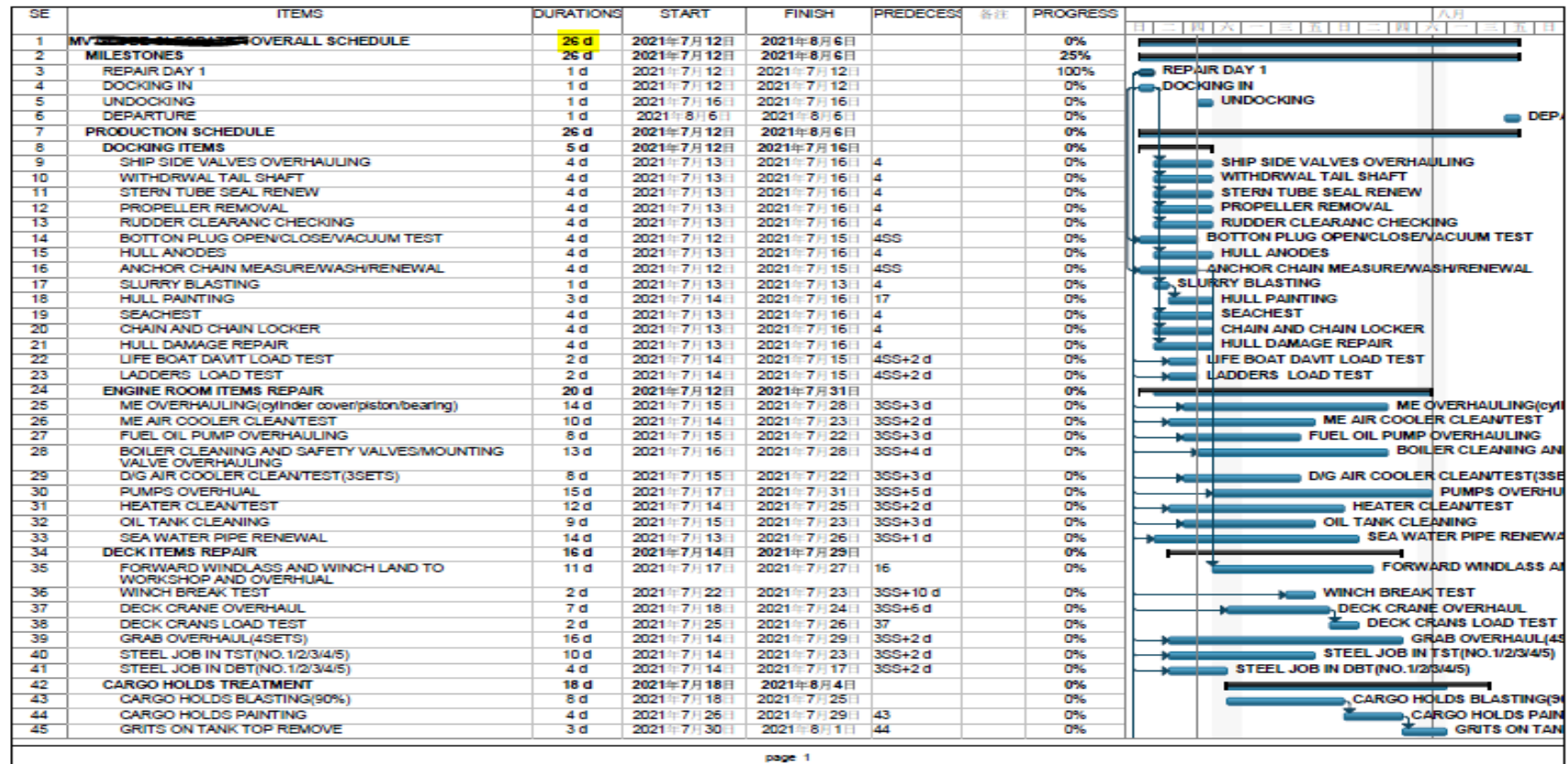


Figure 36 Weather prediction during repair period

## 7.6. Final Repair Schedule:



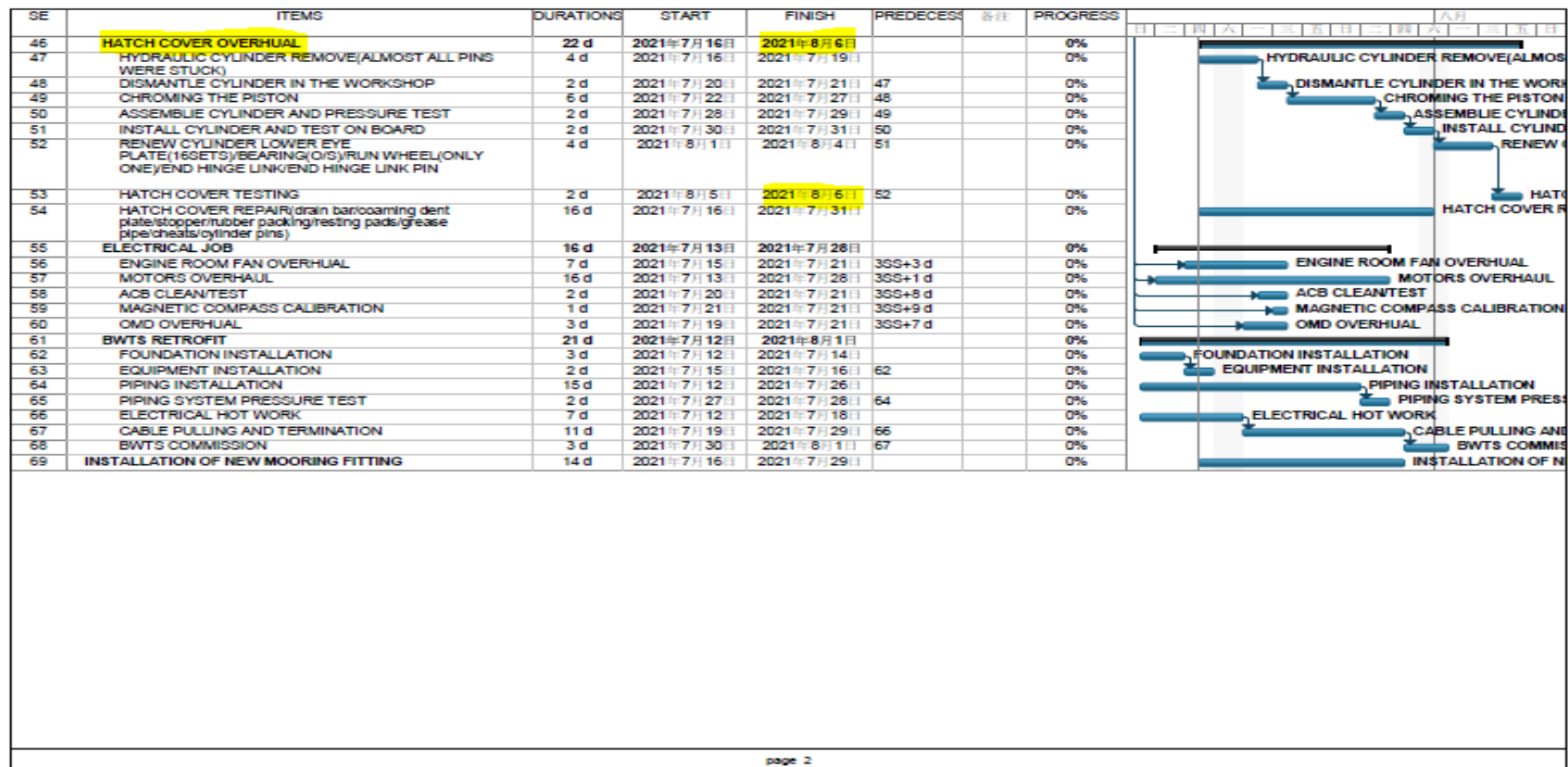


Figure 37 Final Repair Schedule

## **7.7. Case Study Conclusion**

The purpose of this case study is to validate the results of the survey for factors delaying the completion of scheduled ship's repair.

The following delay factors have been observed during this project resulted to delay the completion:

1. Weather effect on activities (hot, rain, etc.)
2. Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs

Furthermore, the following factors have been noted as potential delay factors:

1. Installation of innovative/sophisticated systems (BWTS, Scrubber etc.)
2. Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling ,D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal)
3. Use external sub-contractors during work at a yard.

## 8. Conclusion

In this thesis, delay factors in dry-dock – ships repair projects are discussed. Through literature review, twenty seven (27) delay factors have been identified. Those delay factors were included in a questionnaire of nine (9) groups where participants were asked for frequency of occurrence and impact on project. One hundred forty eight (148) valid responses have been obtained. From the participants, seventy five (75) work in a Shipping Company (Technical/Marine Department), fourteen (14) in a Shipping Company (Operation Department), seven (7) in a Shipping Company (Safety Department), eight (8) in a Shipping Company (Purchasing Department) whereas thirty five (35) are Shipyard's personnel and nine (9) are Classification Society Surveyors. Calculation of Importance Index was performed through Frequency Index and Impact Index. Delay factors were ranked according to the higher value. The results highlight that the three (3) most important factors are 1. Weather effect on activities (hot, rain, etc.), 2. Delay to supply required materials and 3. Poor site management and supervision by shipyard. A case study was also analyzed to confirm that some delay factors which were included in the questionnaire are indeed a threat for such projects.

It will be useful if future studies analyze the results for each group of respondents in order to investigate the degree of agreement of each group with reference to the ranking of factors. Furthermore, future studies may include mitigation measures for each factor in order to minimize the delay.



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## **Appendix**

### **Appendix A. Questionnaire**

#### **Factors delaying the completion of scheduled ship's repairs**

Dear participant,

As part of my postgraduate studies in M.Sc "Engineering Project Management" at the Hellenic Open University, a survey is conducted for my master's dissertation.

The purpose of this study is to examine the factors delaying the completion of scheduled ship's repairs.

This questionnaire is relevant to shore-based personnel such as Vessel's Managers, Technical Superintendents and/or Shipyard's Managers/Officers etc.

The survey should take approximately 10 minutes to complete. All of the responses in this survey will be recorded anonymously and will remain private.

Please feel free to share this questionnaire among your colleagues in the maritime industry as their input is duly valuable.

If you have any questions concerning this study please do not hesitate to contact me by email at [s.zountouridou@gmail.com](mailto:s.zountouridou@gmail.com).

A copy of the statistical analysis can be provided to respondents who are interested.

Thank you for taking the time to assist in my study and complete this questionnaire.

Sincerely yours,

Sofia Zountouridou

#### **Form of Consent**

Please check below boxes to give your consent:

1. By participating in this study, I agree to provide the most honest answers I can. My participation in this survey is voluntary. I may refuse to take part in the research or withdraw at any time without penalty. I consent to my personal data being used for this study and other research. No names or identifying information would be included in any publications or presentations based on these data. I understand that my responses to this survey will remain confidential.

Mark only one oval.

☐ Yes

☐ No -> Skip to final section (Thank you for your participation! Please click submit to finish.)

## **Filter Question**

2. Have you ever participated/worked for a scheduled ship's repair/dry-dock?

Mark only one oval.

☐ Yes

☐ No -> Skip to final section (Thank you for your participation! Please click submit to finish.).

## **Demographics**

3. Which one of the following age groups you belong to?

Mark only one oval.

☐ 18-24

☐ 25-34

☐ 35-45

☐ 46-56

☐ 57+

4. What is the level of your academic qualification?

Mark only one oval.

☐ High School

☐ Bachelor's Degree

☐ Master's Degree - Doctorate

☐ Diploma on Maritime Affairs

### **A-General**

5. Which of the following categories describes your current position best?

Mark only one oval.

☐ Shipping Company (Technical/Marine Department)

☐ Shipping Company (Operation Department)

☐ Shipping Company (Safety Department)

☐ Shipping Company (Purchasing Department)

☐ Shipyard's personnel

☐ Classification Society Surveyor

☐ Other: (       )

6. Please state the total number of ships for which you have participated/worked for a scheduled ship's repair/dry-dock:

Mark only one oval.

- ☐ 1  
☐ 2-4  
☐ 5-10  
☐ >10

7. On what type of ships does your company mostly operate/work with?

Mark only one oval.

- ☐ Bulk Carriers  
☐ Tankers  
☐ Container ships  
☐ Reefer Vessels  
☐ LNG and LPG Carriers  
☐ RoRo and Passenger ships  
☐ Other: (       )

## **B - Frequency of Occurrence**

8. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Contractors).

Mark only one oval per row.

|  | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Use external sub-contractors during work at a yard | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Poor site management                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



|   |                          |                          |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| and supervision by shipyard   |                          |                          |                          |                          |                          |
| High number of quality defects by shipyard that require re-work   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling ,D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ineffective planning and scheduling of project by shipyard  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

9. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Owners).

Mark only one oval per row.

|  | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Late delivery or revising of detailed engineering drawings by owners | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|   |                          |                          |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Poor quality of documentation provided e.g. outdated docking plan                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Little insight of progress at shipyard by owners  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Delay in progress payment by owners   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Slowness in decision making process by owners   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Unavailability of incentives for shipyard for finishing ahead of schedule                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

10. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Equipment).

Mark only one oval per row.

|                                    | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Inadequate efficiency of equipment | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

11. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Materials)

*Mark only one oval per row.*

|                                    | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Delay to supply required materials | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

12. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (External Factors).

*Mark only one oval per row.*

|  | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Weather effect on activities (hot, rain, etc.)   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Worker accident during repairs   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel restrictions, transport limitations) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Delay in performing  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|  |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| final inspection and certification by a third party                    |                          |                          |                          |                          |                          |
| Changes in government regulations and laws                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Installation of innovative/sophisticated systems (BWTS, Scrubber etc.) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

13. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to the Project).

*Mark only one oval per row.*

|   | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Original contract duration is too short | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ineffective delay penalties             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Legal disputes between various parts    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

14. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Labors).

*Mark only one oval per row.*

|                       | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|-----------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Inadequate efficiency | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|              |  |  |  |  |  |
|--------------|--|--|--|--|--|
| of workforce |  |  |  |  |  |
|--------------|--|--|--|--|--|

15. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Consultant).

*Mark only one oval per row.*

|  | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Delay in performing inspection and testing by Classification Society       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Late in reviewing and approving design documents by Classification Society | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

16. Please indicate the frequency of occurrence of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Design).

*Mark only one oval per row.*

|   | Never                    | Rarely                   | Sometimes                | Often                    | Always                   |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Mistakes and discrepancies in design documents and associated difficulty in production. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## **C – Impact on Project**

17. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Contractors).

*Mark only one oval per row.*

|   | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Use external sub-contractors during work at a yard  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Poor site management and supervision by shipyard  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| High number of quality defects by shipyard that require re-work   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Co-ordination of vessel's position in shipyard (alongside or triple banking – restricted material handling ,D/D on arrival - no time for accessory works for propeller removal /shaft withdrawal) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ineffective planning and scheduling of project by shipyard  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

18. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Owners).

*Mark only one oval per row.*

|   | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Late delivery or revising of detailed engineering drawings by owners                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Poor quality of documentation provided e.g. outdated docking plan                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Incomplete scope of work/ work done list shared by the owners/managers – change orders during repairs | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Little insight of progress at shipyard by owners  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Delay in progress payment by owners   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Slowness in decision making process by owners   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Unavailability of incentives for shipyard for finishing   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                   |  |  |  |  |  |
|-------------------|--|--|--|--|--|
| ahead of schedule |  |  |  |  |  |
|-------------------|--|--|--|--|--|

19. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Equipment).

*Mark only one oval per row.*

|                                    | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Inadequate efficiency of equipment | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

20. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Materials)

*Mark only one oval per row.*

|                                    | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Delay to supply required materials | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

21. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (External Factors).

*Mark only one oval per row.*

|  | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Weather effect on activities (hot, rain, etc.) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Worker accident during repairs                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



|  |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Covid-19 disruptions<br>(e.g. virus testing,<br>quarantine,<br>subcontractor<br>limitations, travel<br>restrictions, transport<br>limitations) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Delay in performing<br>final<br>inspection and<br>certification by a third<br>party  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Changes in government<br>regulations and laws  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Installation of<br>innovative/sophisticated<br>systems (BWTS,<br>Scrubber etc.)  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

22. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to the Project).

Mark only one oval per row.

|  | Very<br>Low              | Low                      | Medium                   | High                     | Very High                |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Original contract<br>duration is too short | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ineffective delay<br>penalties             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Legal disputes                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                       |  |  |  |  |  |
|-----------------------|--|--|--|--|--|
| between various parts |  |  |  |  |  |
|-----------------------|--|--|--|--|--|

23. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Labors).

*Mark only one oval per row.*

|                                    | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Inadequate efficiency of workforce | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

24. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Consultant).

*Mark only one oval per row.*

|  | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Delay in performing inspection and testing by Classification Society       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Late in reviewing and approving design documents by Classification Society | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

25. Please indicate the impact on project of the below factors which may result to delay the completion of a scheduled ship's repairs/dry-dock (Factors related to Design).

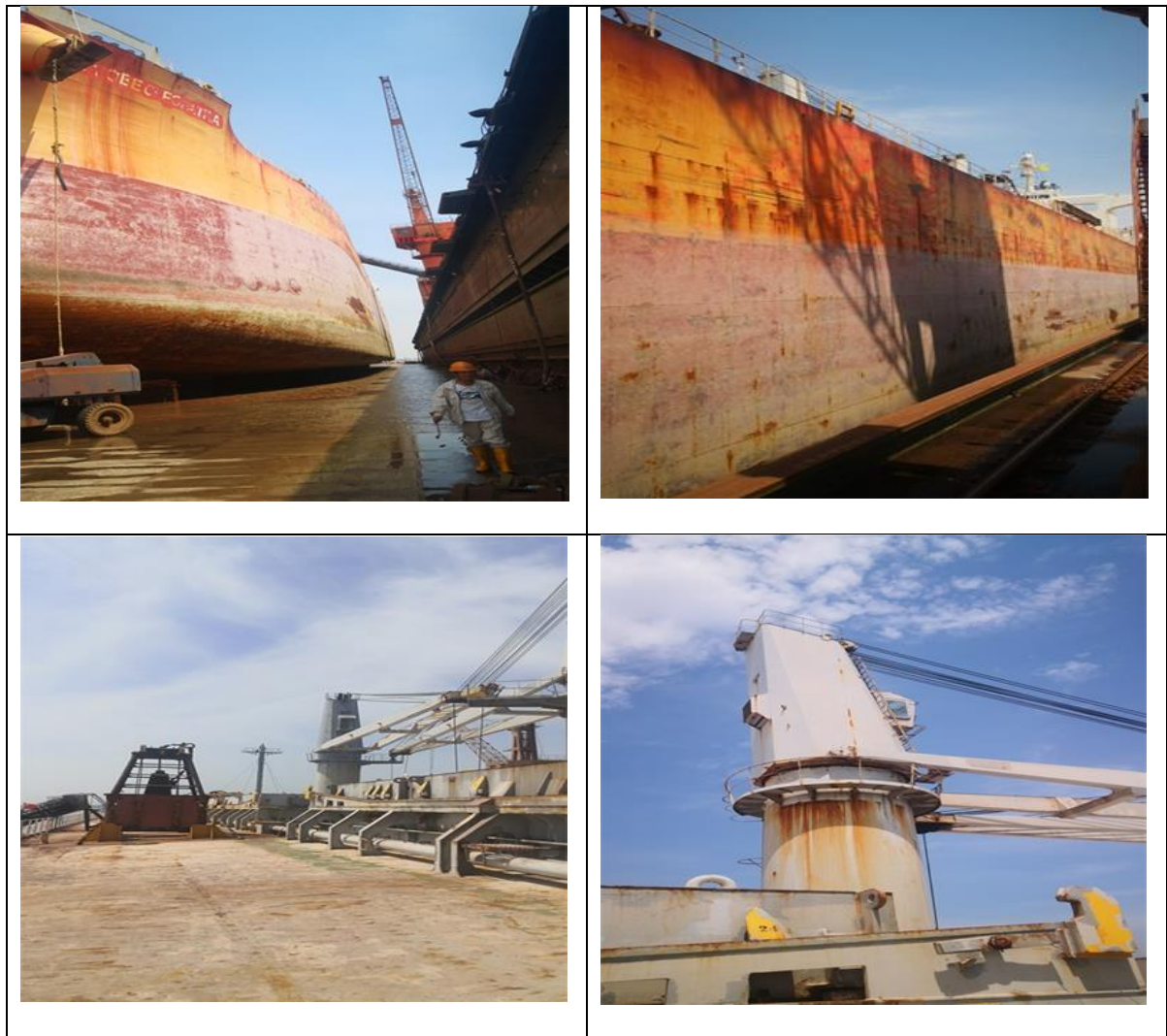
*Mark only one oval per row.*

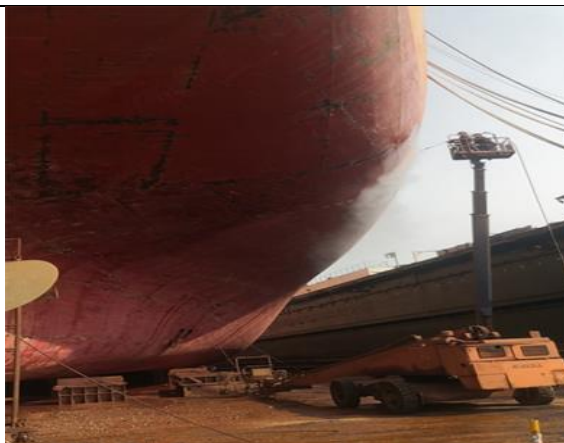
|   | Very Low                 | Low                      | Medium                   | High                     | Very High                |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Mistakes and discrepancies in design documents and associated difficulty in production. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Thank you for your participation! Please click submit to finish.

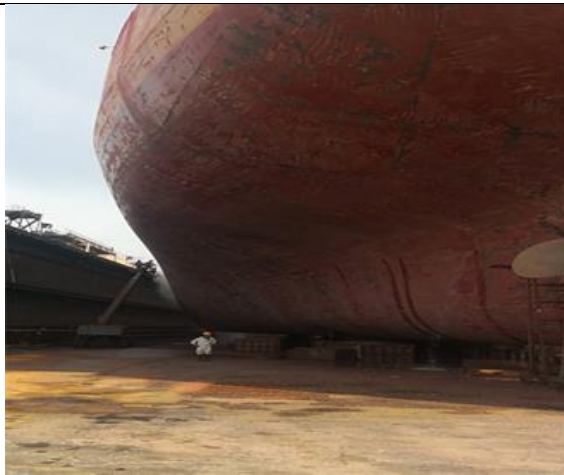
☐ Submit

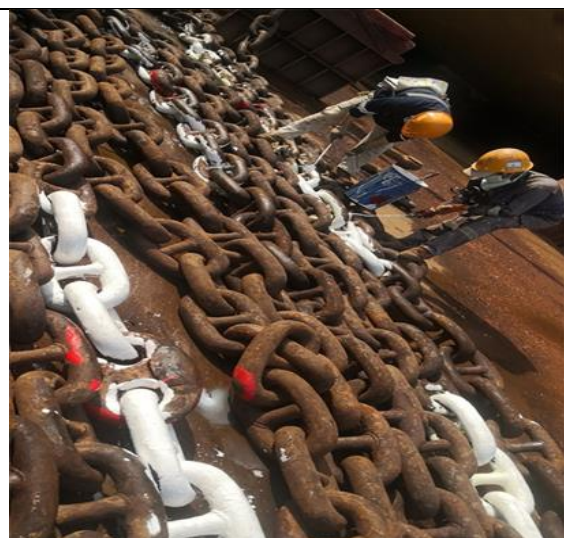
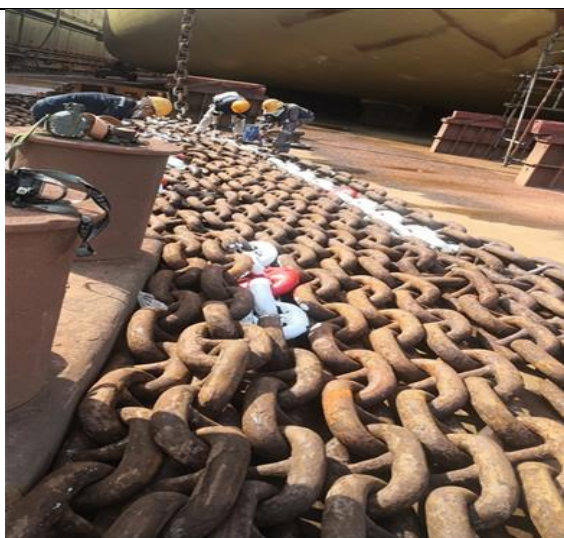
### Appendix B. Photos during Dry-dock









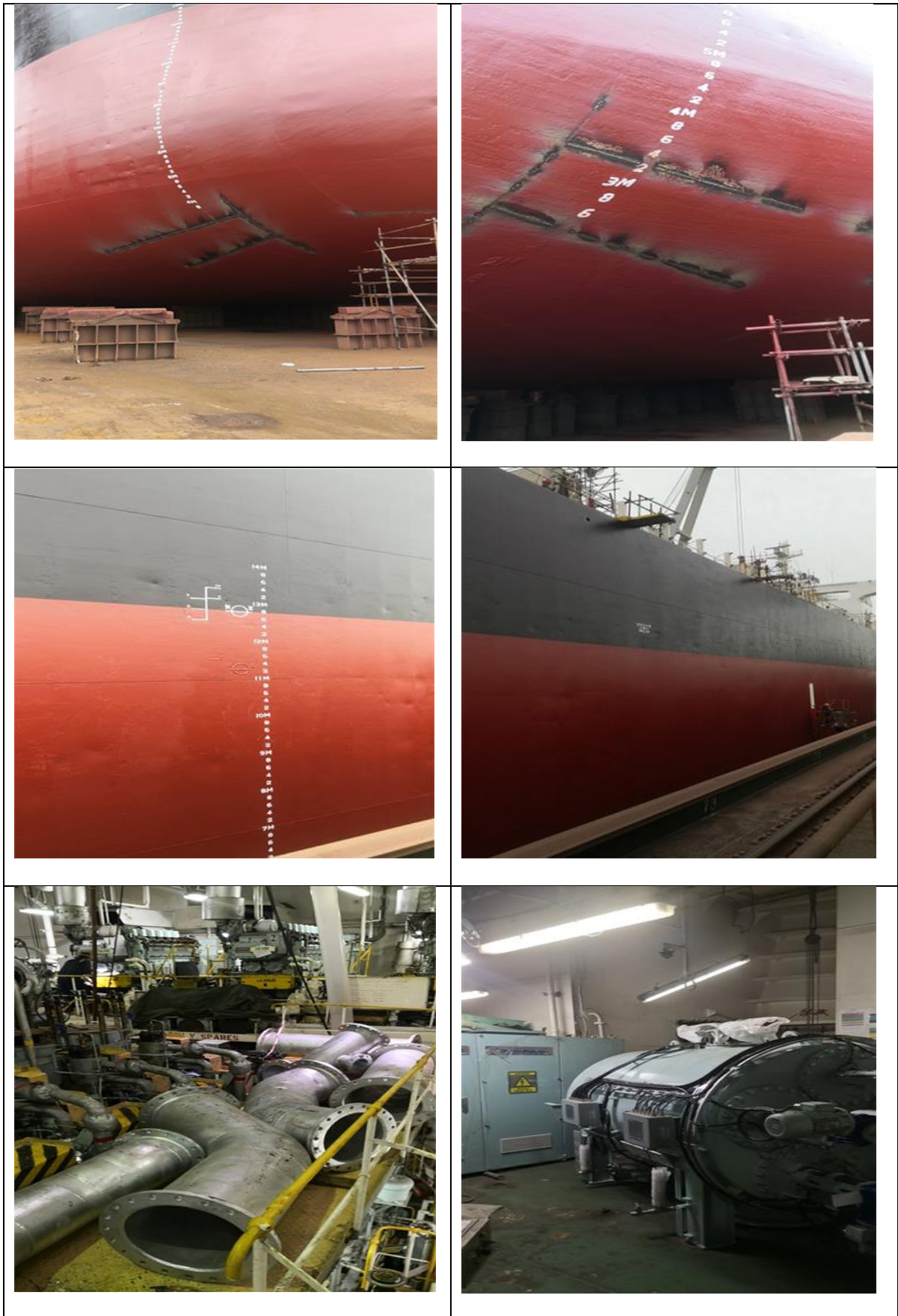


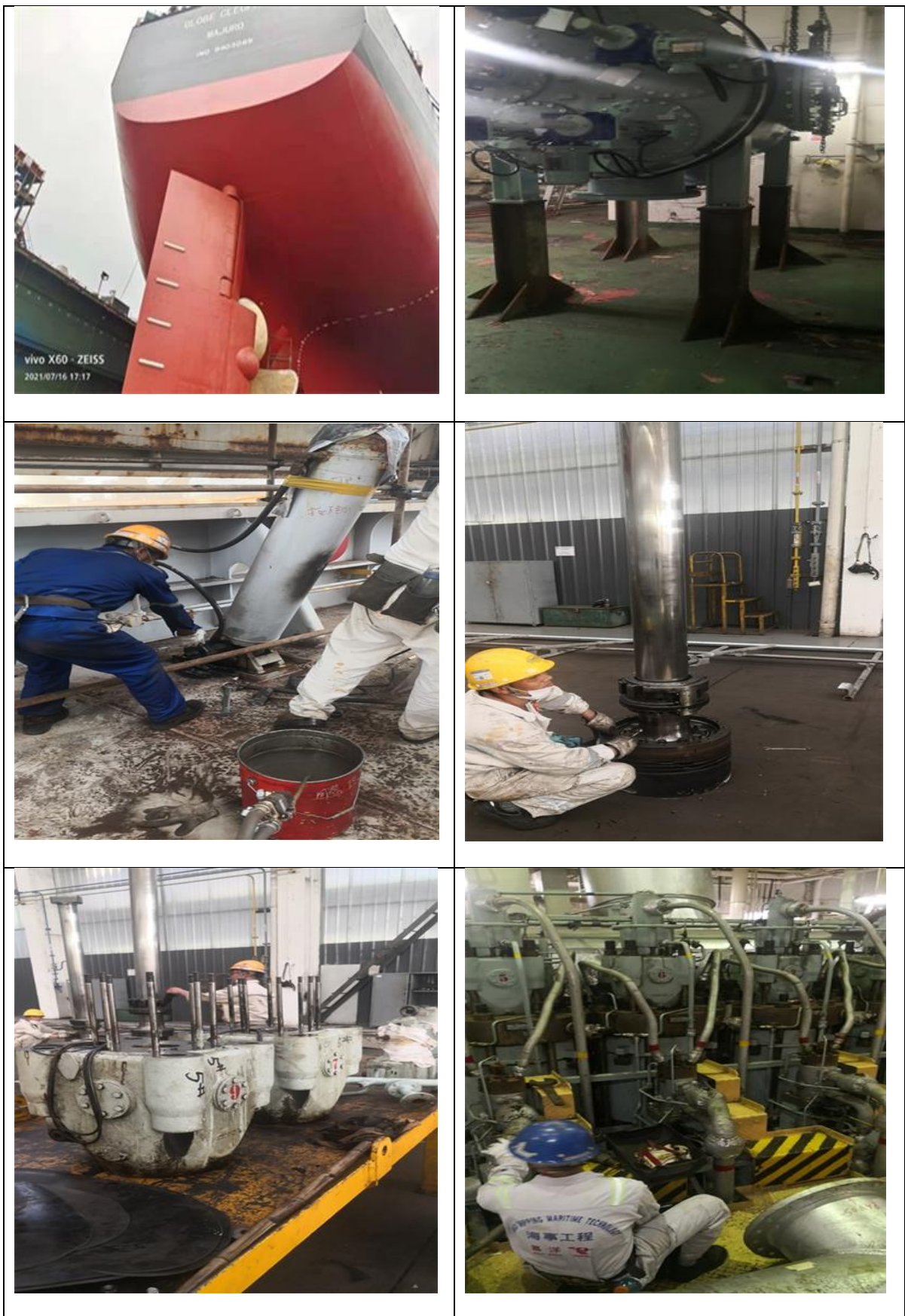




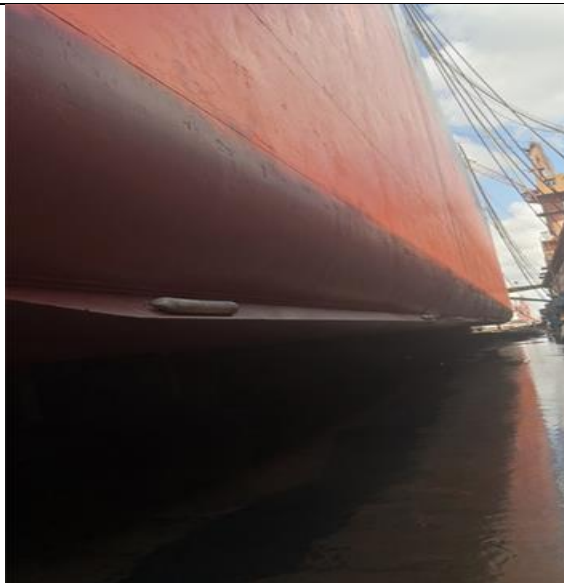
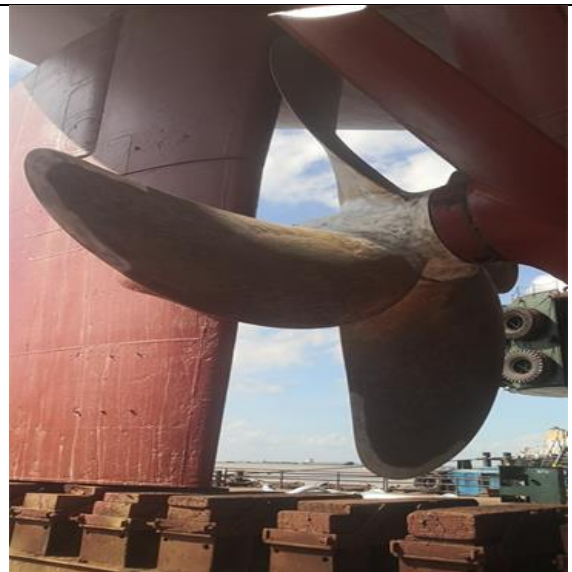














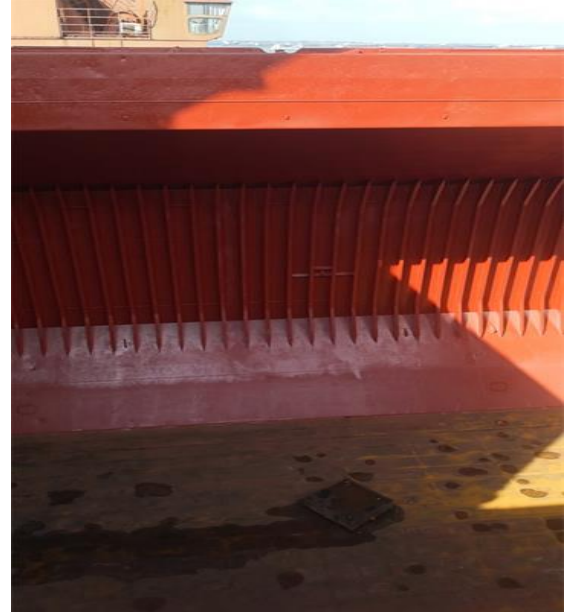
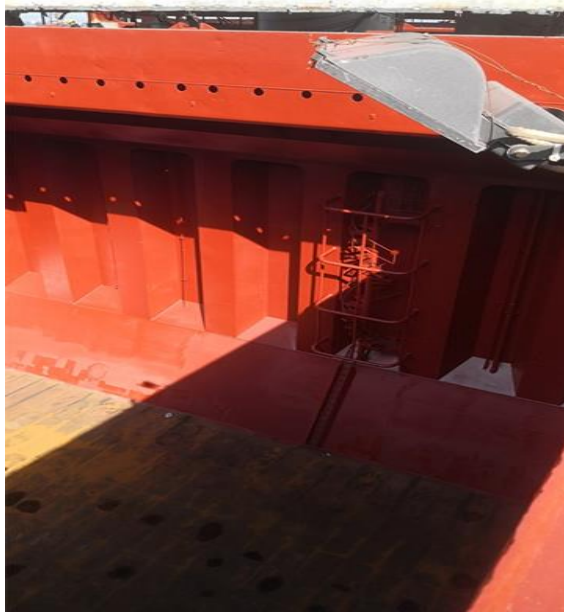
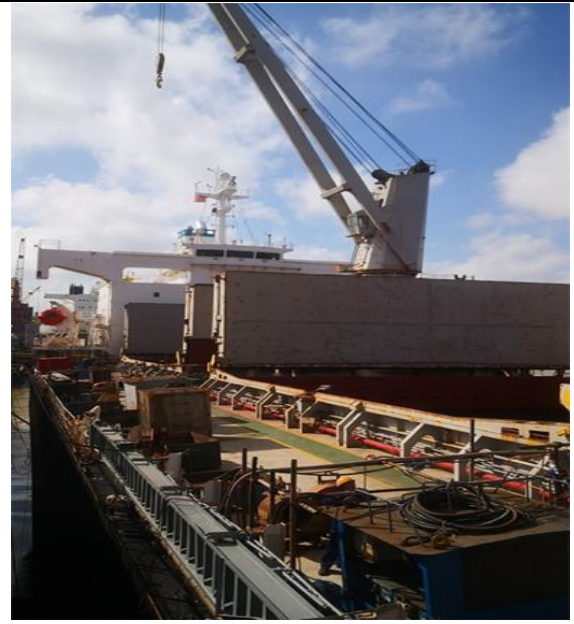






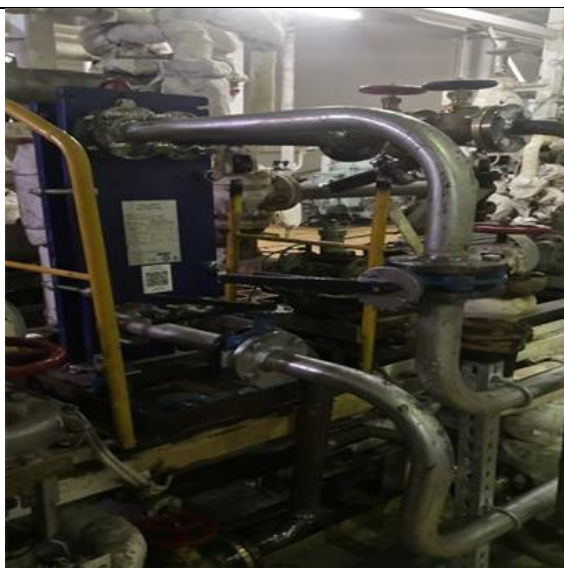
















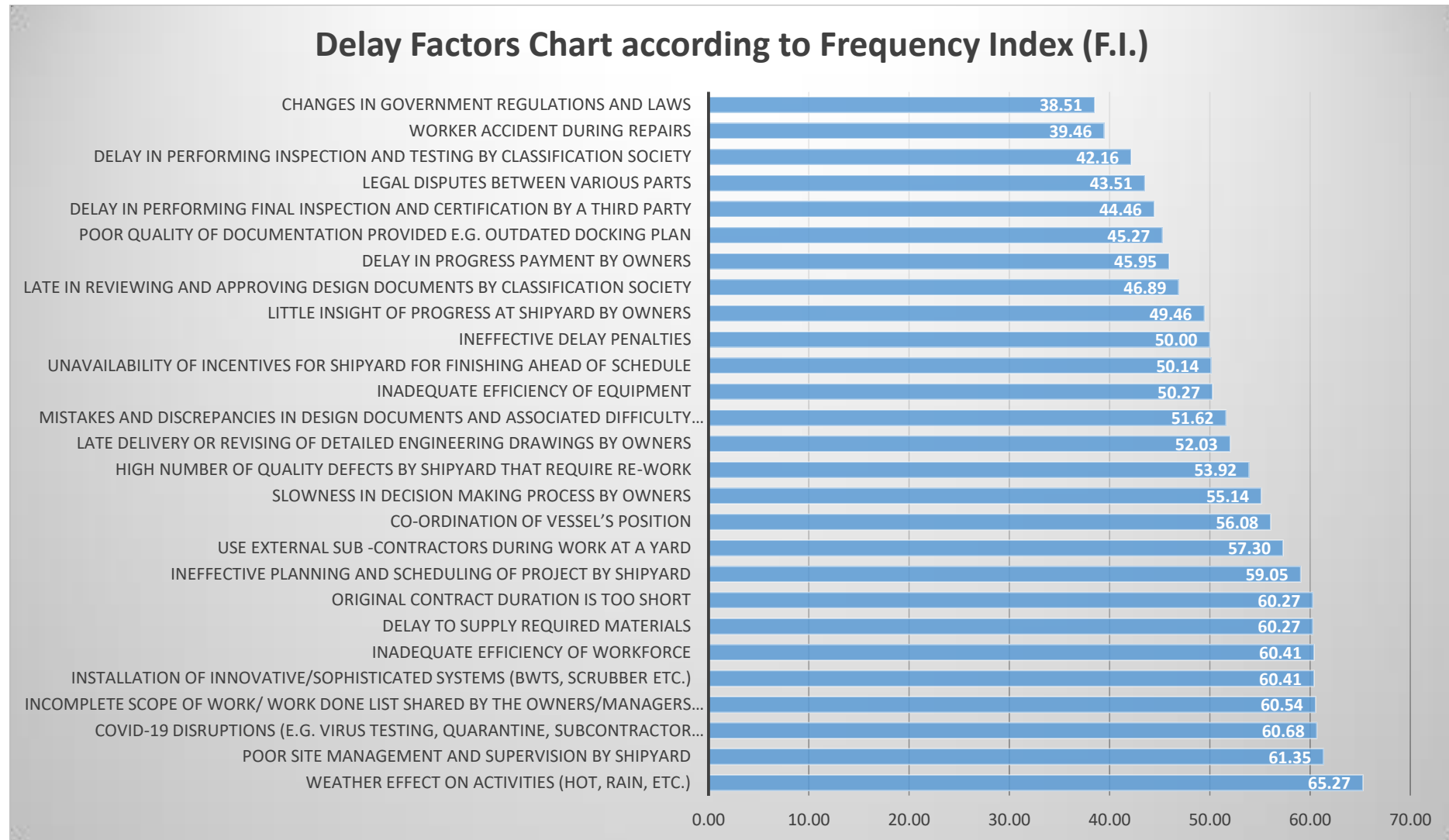
## Appendix C. Delay Factors Results

| <u>A/A</u>  | <u>Factors</u>   | <u>Related Group</u> | <u>Frequency Index (%)</u> | <u>Rank</u> | <u>Impact Index (%)</u> | <u>Rank</u> | <u>Importance Index (%)</u> | <u>Rank</u> |
|-------------|--|----------------------|----------------------------|-------------|-------------------------|-------------|-----------------------------|-------------|
| Group No 1. |  |                      |                            |             |                         |             |                             |             |
| Q.1         | Use external sub -contractors during work at a yard                                    | Contractors          | 57.30                      | 10          | 56.62                   | 21          | 32.44                       | 15          |
| Q.2         | Poor site management and supervision by shipyard                                       | Contractors          | 61.35                      | 2           | 69.86                   | 2           | 42.86                       | 3           |
| Q.3         | High number of quality defects by shipyard that require re-work                        | Contractors          | 53.92                      | 13          | 65.41                   | 11          | 35.27                       | 12          |
| Q.4         | Co-ordination of vessel's position   | Contractors          | 56.08                      | 11          | 63.65                   | 12          | 35.69                       | 11          |
| Q.5         | Ineffective planning and scheduling of project by shipyard                             | Contractors          | 59.05                      | 9           | 67.84                   | 6           | 40.06                       | 7           |
| Group No 2. |  |                      |                            |             |                         |             |                             |             |
| Q.6         | Late delivery or revising of detailed engineering drawings by owners                   | Owners               | 52.03                      | 14          | 62.43                   | 14          | 32.48                       | 14          |
| Q.7         | Poor quality of documentation provided e.g. outdated docking plan                      | Owners               | 45.27                      | 22          | 56.89                   | 20          | 25.76                       | 21          |
| Q.8         | Incomplete scope of work/ work done list shared by the owners/managers – change orders | Owners               | 60.54                      | 4           | 68.24                   | 4           | 41.31                       | 5           |

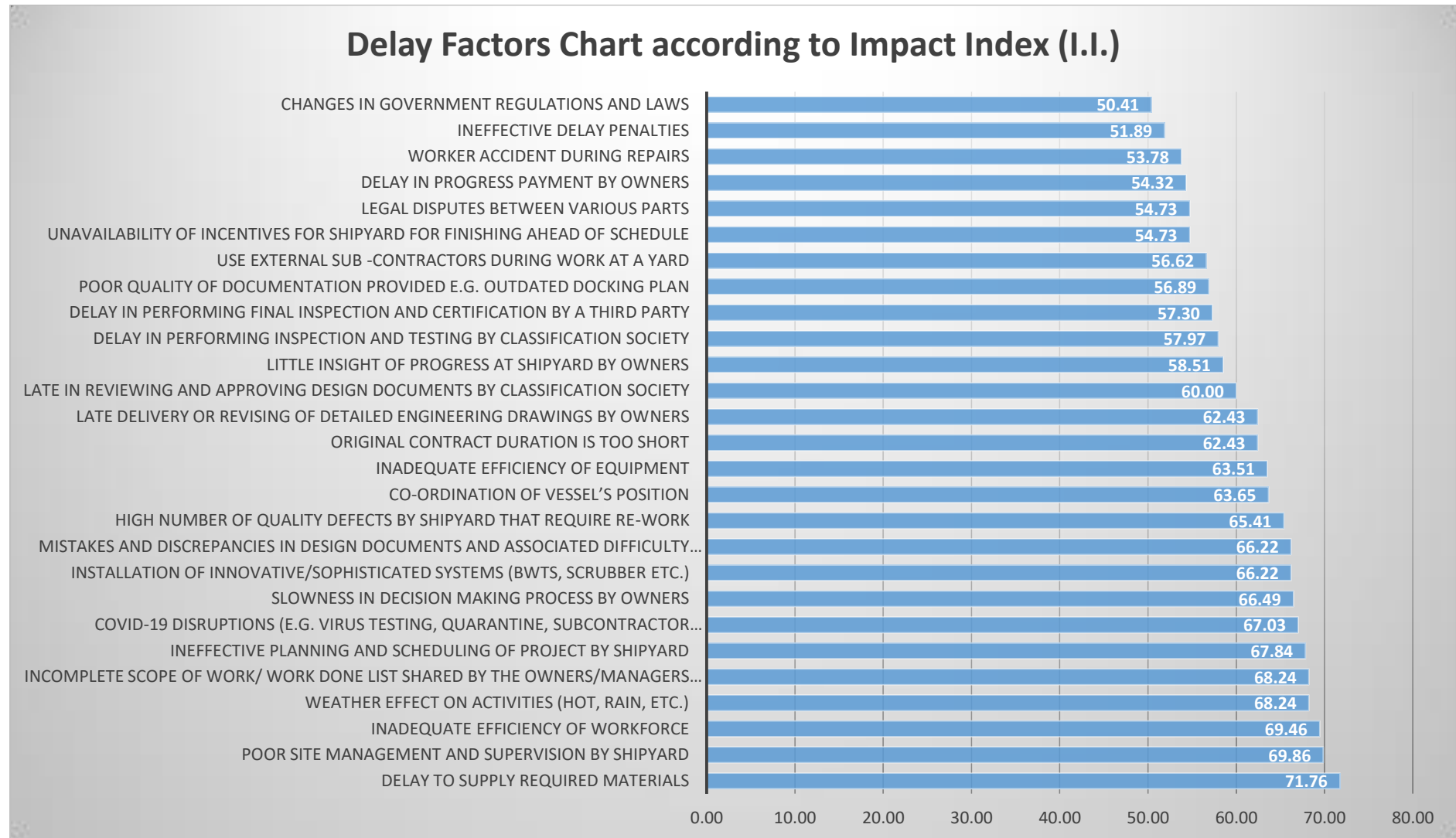
|             |   |                  |       |    |       |    |       |    |
|-------------|---|------------------|-------|----|-------|----|-------|----|
|             | during repairs  |                  |       |    |       |    |       |    |
| Q.9         | Little insight of progress at shipyard by owners  | Owners           | 49.46 | 19 | 58.51 | 17 | 28.94 | 17 |
| Q.10        | Delay in progress payment by owners   | Owners           | 45.95 | 21 | 54.32 | 24 | 24.96 | 23 |
| Q.11        | Slowness in decision making process by owners   | Owners           | 55.14 | 12 | 66.49 | 8  | 36.66 | 10 |
| Q.12        | Unavailability of incentives for shipyard for finishing ahead of schedule               | Owners           | 50.14 | 17 | 54.73 | 22 | 27.44 | 19 |
| Group No 3. |   |                  |       |    |       |    |       |    |
| Q.13        | Inadequate efficiency of equipment  | Equipment        | 50.27 | 16 | 63.51 | 13 | 31.93 | 16 |
| Group No 4. |   |                  |       |    |       |    |       |    |
| Q.14        | Delay to supply required materials  | Materials        | 60.27 | 7  | 71.76 | 1  | 43.25 | 2  |
| Group No 5. |   |                  |       |    |       |    |       |    |
| Q.15        | Weather effect on activities (hot, rain, etc.)  | External Factors | 65.27 | 1  | 68.24 | 4  | 44.54 | 1  |
| Q.16        | Worker accident during repairs  | External Factors | 39.46 | 26 | 53.78 | 25 | 21.22 | 26 |
| Q.17        | Covid-19 disruptions (e.g. virus testing, quarantine, subcontractor limitations, travel | External Factors | 60.68 | 3  | 67.03 | 7  | 40.67 | 6  |
| Q.18        | Delay in performing final inspection and certification by a third party                 | External Factors | 44.46 | 23 | 57.30 | 19 | 25.47 | 22 |
| Q.19        | Changes in government regulations and laws  | External Factors | 38.51 | 27 | 50.41 | 27 | 19.41 | 27 |
| Q.20        | Installation of innovative/sophisticated systems  | External Factors | 60.41 | 5  | 66.22 | 9  | 40.00 | 8  |

|             |   |            |       |    |       |    |       |    |
|-------------|---|------------|-------|----|-------|----|-------|----|
|             | (BWTS, Scrubber etc.)   |            |       |    |       |    |       |    |
| Group No 6. |   |            |       |    |       |    |       |    |
| Q.21        | Original contract duration is too short   | Project    | 60.27 | 7  | 62.43 | 14 | 37.63 | 9  |
| Q.22        | Ineffective delay penalties   | Project    | 50.00 | 18 | 51.89 | 26 | 25.95 | 20 |
| Q.23        | Legal disputes between various parts  | Project    | 43.51 | 24 | 54.73 | 22 | 23.81 | 25 |
| Group No 7. |   |            |       |    |       |    |       |    |
| Q.24        | Inadequate efficiency of workforce  | Labors     | 60.41 | 5  | 69.46 | 3  | 41.96 | 4  |
| Group No 8. |   |            |       |    |       |    |       |    |
| Q.25        | Delay in performing inspection and testing by<br>Classification Society                       | Consultant | 42.16 | 25 | 57.97 | 18 | 24.44 | 24 |
| Q.26        | Late in reviewing and approving design<br>documents by Classification Society                 | Consultant | 46.89 | 20 | 60.00 | 16 | 28.14 | 18 |
| Group No 9. |   |            |       |    |       |    |       |    |
| Q.27        | Mistakes and discrepancies in design<br>documents and associated difficulty in<br>production. | Design     | 51.62 | 15 | 66.22 | 9  | 34.18 | 13 |

## Appendix C. Delay Factors Chart according to Frequency Index (F.I.)

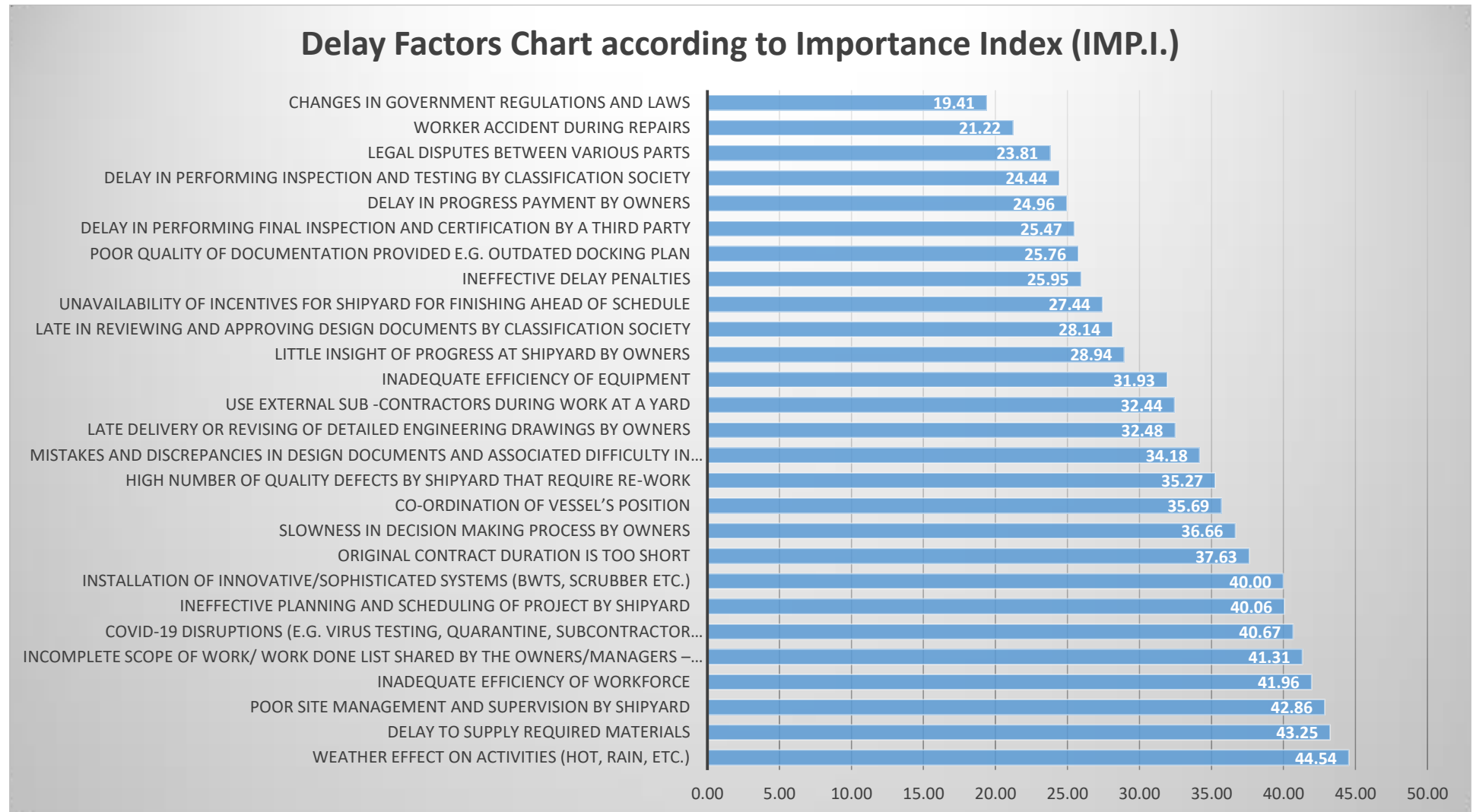


## Appendix D. Delay Factors Chart according to Impact Index (I.I.)





## Appendix E. Delay Factors Chart according to Importance Index (IMP.I.)



Author's Statement:

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